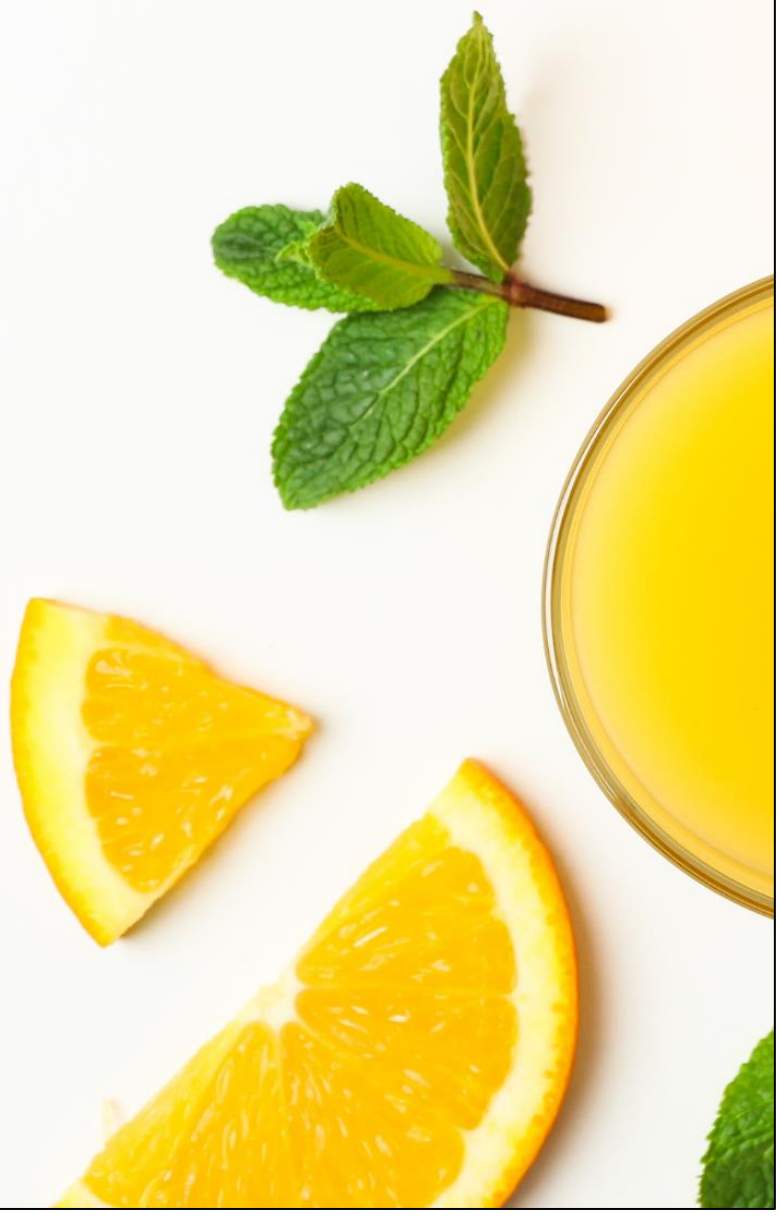
ISBN: 978-93-88901-46-8

NUTRITION FOR HEALTH: REVIEWS

Editors:
Dr. D. Brindha
Dr. K. Kanjana



Bhumi Publishing
First Edition: 2023

Nutrition for Health: Reviews

(ISBN: 978-93-88901-46-8)

Editors

Dr. D. Brindha

M.Sc., M.Phil., PhD., MA (Yoga)

Professor and Principal

PSG College of Arts & Science,

Coimbatore, Tamil Nadu, India

Dr. K. Kanjana

M.Sc., M.Phil., DOA, RD, Ph.D.

Adjunct Professor,

Department of Nutrition and Dietetics,

PSG College of Arts & Science,

Coimbatore, Tamil Nadu, India

Bhumi Publishing

2023

First Edition: April, 2023

ISBN: 978-93-88901-46-8

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/book/

PREFACE

PSG College of Arts & Science established in 1947, is a premier ranking educational institution that provides quality higher education on par with international standards in the state of Tamil Nadu, India. Being the largest Higher Education Institutions of South India, PSG CAS offers 43 Undergraduate Programmes, 4 BVoc Programmes, 29 Postgraduate Programmes, 1 Five year Integrated Postgraduate Programme, 3 PG Diploma Programmes, M.Phil and Ph.D Programmes are offered in 24 Disciplines. In addition to this, 12 Career Oriented Add-On courses are offered for enhancing the life skills of students. Excellence in research and teaching has been the hallmark of PSGCAS ever since its inception.

The Department of Nutrition and Dietetics had its inception in 1980. It offers UG, PG and Research Programmes (M.Phil and Ph.D) in Food and Nutrition. The mission of the department is to transfer academic inputs for the benefit of the community thereby nurturing social commitment.

The book "Nutrition for Health: Reviews" is written for students who are not majoring in nutrition, but want to learn about the fundamental aspects of nutrition and how it applies to their own lives. Nutrition is a science-based discipline, so all the review material included is backed up by rigorous scientific research, and is presented in a clear, easy-to-understand.

This book can be used as a reference for all who are interested in nutrition and wish to keep pace with the latest developments.

Our sincere thanks go to all authors.

Editors

TABLE OF CONTENT

Nutrition for Health: Reviews
(ISBN: 978-93-88901-46-8)

BIOACTIVITIES AND HEALTH BENEFITS OF RARE INDIAN FRUITS

T. K. Anushiha*, L. Uthira and V. Sathiya
Department of Nutrition & Dietetics,
PSG College of Arts & Science, Coimbatore-641014
*Corresponding author E-mail: tkanushiha@gmail.com

Abstract:

Rare Indian fruits are exotic or underutilized. The selected rare fruits contain many bioactive compounds, such as anthocyanins and flavonoids. Many studies have shown that the fruits possess various bioactivities and health benefits, such as free radical scavenging, antioxidant, anti-inflammatory, antimicrobial, and anticancer activities. Therefore, the selected fruits havethe potential to be developed into functional foods or pharmaceuticals to prevent and treat several chronic diseases. In the present article, we review current knowledge about the bioactivities and health benefits of the selected fruits that are valuable for the exploitation and utilization of the fruits.

Keywords: Rare Indian fruits, bioactivities and health benefits

Introduction:

From cereals to vegetables, demand for healthier and safer food products has exploded in recent decades (Das *et al.*, 2012; Ashaolu and Ashaolu, 2020; Reale and Ashaolu, 2020). According to Chen *et al.* (2016), Xu *et al.* (2018) and Gowd *et al.* (2019), many health-related food components can enhance people's quality of life by preventing diseases. Fruits with a variety of nutrients and biological activity make up a large portion of these functional foods (Cai, 2019). Despite the fact that numerous allopathic medications are being developed daily, the long-term cure for diseases and the avoidance of their secondary complications debated whether or not the patient was aroused while taking the medication (Edzard Ernst, 1998).

Nutritionists advise eating plenty of fruits and vegetables because they are high in phytochemicals (Baliga, M.S *et al.*, 2011; Deng, G.F *et al.*, 2013; Fu, L. *et al.*, 2010; Li, A.N *et al.*, 2014), dietary fiber, vitamins, and minerals, and have other health benefits (Giampieri F *et al.*, 2014; Hoffmann G *et al.*, 2016). Phytochemicals in these natural products are thought to be the cause of the beneficial health effects. It is well known that plants produce lot of antioxidants, in particular, to protect themselves from the oxidative stress that oxygen and light in the environment cause (Lobo V *et al.*, 2010). Oxidative stress performs a crucial role in multiple chronic diseases (Forbes-Hernandez T.Y *et al.*, 2014; Huang W.J *et al.*, 2016).

Rare Indian fruits are frequently unusual, underused, or less popular. Many fruits are safe to eat, and some of them have even been turned into medicines. Fruits contain a variety of genotypes and abundant phytochemicals like flavonoids and anthocyanin due to environmental concerns and environmental factors. As a result, the chosen rare fruits are frequently regarded as nutritious foods. Rare fruits have drawn more attention in recent years, and accumulative investigations have been performed for their bioactive effects including, antioxidant, antimicrobial anti-inflammatory, and anticancer effects. These studies

pointed out that fruits could have the potential to prevent and treat some chronic diseases (Lock K *et al.,* 2005; Gescher A *et al.,* 1998). This review summarizes the bioactivities and health benefits of rare Indian fruits.

Rare Indian fruits

1. *Ziziphus jujuba*

The nutritional jujube (*Ziziphus jujube* Mill.) fruit belonging to the Rhamnaceous family grows mostly in Europe, southern and eastern Asia, and Australia, especially the inland region of northern China. Jujube has a long history of usage as a fruit and remedy. The main biologically active components are vitamin C, phenolics, flavonoids, triterpenic acids, and polysaccharides (Qing-Han Gao *et al.,* 2013).

Local Name: Elantha palam

Anticancer activity

Numerous experimental investigations have demonstrated that bioactive compounds found in jujube fruit can reduce the risk of developing and occurrence of certain malignancies by causing cellular apotosis, preventing the related signalling pathways, and controlling gut microflora.

Consumption of jujube fruit for 62 consecutive days by mice with colorectal cancer caused by dextran sodium sulphate (DSS)/azoxymethane (AOM) was reported to reduce colon aberrant crypt foci and postpone the development of colon cancer (Periasamy *et al.,* 2015).

Antioxidant activity

According to several studies (Brieger *et al.,* 2012; Diebold and Chandel, 2016; Forrester *et al.,* 2018), reactive oxygen species (ROS), a general term for oxygen ions, free radicals, and peroxides of both inorganic and organic compounds, are involved in a number of biological pathways, including cell proliferation, apoptosis, and signal transduction. The use of jujube fruit as an antioxidant has a long history. According to tests using DPPH, hydroxyl, hydrogen peroxide, and superoxide radicals, two homologous active polysaccharides (LZJP3 and LZJP4) isolated from *Z. jujuba* cv. Linzexiaozao have high antioxidant properties (Wang *et al.,* 2018).

Anti-inflammatory activity

According to Kuprash and Nedospasov (2016), inflammation is the body's natural defensive mechanism against infections and tissue damage. Diabetes, stroke, cardiovascular disease, and even cancer can all be brought on by chronic inflammation (Mantovani *et al.,* 2008; Medzhitov, 2008, 2010). According to Tanideh *et al.* (2016), a hydroalcoholic extract of Z. jujube fruit decreases GSH peroxidase and IL-1 levels in 3% acetic acid-induced UC mice and has a healing effect on colonic tissue that has been injured.

Anti-hyperglycemic and anti-hyperlipidemic activity

The impact of jujube fruit on the control of glucose and lipids has been demonstrated in several *in-vivo* studies. Jeong and Kim (2019) examined the outcomes of a dietary intervention using dried jujube fruit and chokeberries in mice fed a high-fat, high-fructose diet (HFFD) for 11 weeks. According to the findings, the diet considerably lowered the body weight of the mice and reduced their blood sugar and triglyceride levels.

Neuroprotection

Chen *et al.* (2015) contrasted the neuroprotective properties of jujube fruit grown in Cangzhou, Hebei Province, China, and those of unripe fruit. They discovered that in PC12 cells, aqueous extracts from the jujube fruit's two growth stages enhanced the expression of neurofilament 68, a cytoskeleton protein specific to neuronal cells. The mature jujube fruit extract's neuroprotective activity was its most notable property.

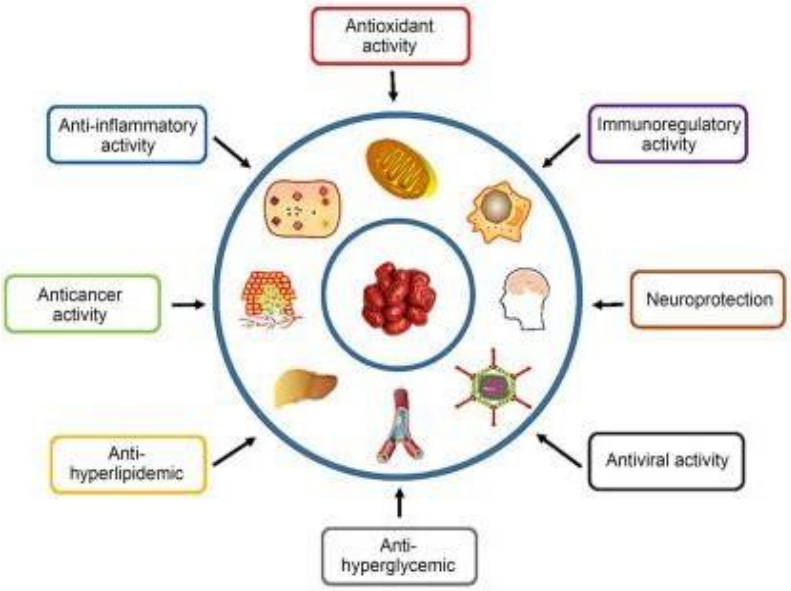


Plate 1: Bioactive functions of jujube

2. *Pithecellobium dulce*

Pithecellobium dulce (*P. dulce*) is an important fruit of American origin and it belongs to the family of Fabaceae, a native of tropical America, and is cultivated throughout India and Andaman, which is also an evergreen medium-sized, spiny tree. Phytochemical investigation of *Pithecellobium dulce* has revealed the presence of various phytoconstituents such as Alkaloids, Flavanoids, Glycosides, Saponins, Fatty acids, Steroids, Tannins, Terpenoids (Rao *et al.*, 2011).

Local name: Kodukkapuli/ Seeni puliyanga

Antidiabetic activity

Diabetes develops as a result of either improper insulin activity or secretion (Chaudhury *et al.*, 2017). More detrimental side effects, such as secondary organ damage, are being caused by the synthetic medications recommended for these illnesses. The methanolic crude extract of *P. dulce* fruit was examined in Streptozotocin (STZ)-induced diabetic rat (albino Wistar male model) and the extract has the capacity to protect the functional β-cells that produce and maintain the insulin level in the blood (Fu *et al.*, 2013).

Anti-hyperlipidemic activity

According to Vergeer *et al.*, (2010), high-density lipoprotein cholesterol (HDLC) transfers extra cholesterol from the body and plays an important role in protecting against heart disorders, including atherosclerosis. The effects of the methanolic crude extract of

P. dulce fruit on the STZ-induced diabetes rat model were examined by Nagmoti *et al.* (2015) and the histopathological examination revealed elevated HDLC levels.

Anti-diarrheal effect

In the castor oil-induced mice, the ethanolic extract of *P. dulce* demonstrated an antidiarrheal activity. The standard anti-diarrheal medication used to compare the outcomes is loperamide. According to Rashid *et al.* (2014), the phytochemicals in *P. dulce* have the powerto lengthen the latent period, delay and reduce the frequency of faeces.

Anti-ulcer activity

The production of reactive oxygen species (ROS) and hypersecretion of HCL are associated with oxidative stress, which contributes to the formation of ulcers (Osefo *et al.*, 2009; Suzuki *et al.*, 2012). H+/K+-ATPase activity is the cause of the hypersecretion of HCL. In an acetylsalicylic acid (ASA)-induced rat model using male albino Wistar rats, the aqueous crude extract of *P. dulce* was administered orally. The phytocompounds reacted and blocked the H+, K+-ATPase in the gastric mucosa (Megala and Geetha, 2009).

Anti-venom effect

From *P. dulce* fruit, the tannin was removed using aqueous extraction. This crude extract reduced the venom's ability to necrotize tissue and hindered its lethality. Due to the extract's greater tannin concentration or combined hydrolyzable tannin concentration, it also successfully inhibited 90% of acetylcholine esterase activity. The plant extract non-selectively precipitates the venom protein while blocking the nicotinic acetylcholine receptor (Pithayanukul *et al.*, 2005).

3. *Carissa carandas*

Carissa carandas, is an evergreen deciduous, generally 2-4 m tall shrub of the dogbane family Apocynaceae. It is found to be widely distributed throughout India. The shrub is commonly known as karonda. Its fruits are berry-sized, which are commonly used as a condiment or additive to Indian pickles and spices (Wani RA *et al.*, 2013).

Local name: Kalakkai

Antidiabetic activity

Alloxan-induced and normoglycemic Wistar rats were used in evaluation of the effects of the aqueous extract of *C. carandas by* Gaurav *et al.* (2010) and discovered that doses of 500 and 1000 mg/kg of the extract significantly (p0.05) decreased blood glucose levels of alloxan diabetic Wistar rats at 4, 8, and 24 hours. The researchers came to the conclusion that the doses of plant extract exhibited significant (p0.05) hypoglycemic and antihyperglycemic effects.

Anti-Diuretic activity

Methanolic extracts of *C. carandas* were examined by Saha R *et al.* (2010). While the Na+/K+ excretion ratio, which was 1.46 and 1.43 at dosages of 200 and 400 mg/kg, respectively, as that of the conventional diuretic furosemide, demonstrated the extract's diuretic action.

Anthelmintic property

The in-vitro anthelmintic potency of the petroleum ether (60-80), chloroform, and ethanolic unripe fruit extract of *C. carandas* against Indian earthworms (Pheretima posthuma)

was assessed by Mishra *et al.* (2012). The standard medication for the workers was piperazine citrate (15 mg/ml). The study's findings led the researchers to the conclusion that the unripe fruit extract of *C. carandas* paralyses earthworms and eventually results in their death.

Anti-cancer activity

Screening was done by Sulaiman *et al.* (2008) with *C. carandas* leaves, the unripe and ripe fruits using n-hexane, chloroform and methanol as the solvent systems are extracted for their anti-cancer activity. A three step extraction on the human ovarian carcinoma cells, and lung cancer cells is done and the extracts of *C. carandas* leaves, the unripe and ripe fruits demonstrated effective anti-cancerous activity.

Cardiovascular activity

Shamim and Ahmad (2012) studied the effects of *C. carandas* extract on the cardiovascular function of normal rats in order to investigate the potential of plants as sources for safe and effective treatment for cardiovascular illnesses. This extract, administered intravenously in bolus dosages of 5-45 mg/kg, reduced arterial blood pressure in a dose-dependent manner (p 0.001). The mean arterial blood pressure significantly decreased (50.75%) after receiving a dosage of 45 mg/kg. Following CC injection at a dose of 45 mg/kg, a substantial decrease in heart rate frequency was seen (p 0.001).

4. *Coccinia grandis*

Coccinia grandis is a fast-growing perennial vine that grows several meters long. It can form dense mats on lands that readily cover shrubs and small trees. The family of *Coccinia grandis* is Cucurbitaceous, comprises 960 species. The family is predominantly distributed around the tropics. *Coccinia grandis* is used by humans mostly as a food crop in several countries in Asia, Australia, Caribbean, and the southern United States, Pacific Islands (Reddy., 2009).

Local name: Red Kovai palam

Anticancer activity

The anticancer activity of the *Coccinia grandis* is because of the antioxidant nature. The ferrocynaide is converted to ferrous due to *Coccinia grandis* antioxidant properties. *Coccinia grandis* hydrogen peroxide is reclaimed and neutralises to water (Behera *et al.*, 2012). *Coccinia grandis* dramatically decreased the number of viable cells and raised the number of non-viable cells, indicating that it has anticancer properties similar to those of the reference medication (vinblastine) (Nanasombat *et al.*, 2009; Bhattacharya *et al.*, 2011).

Antidyslipidemic activity

Singha (2007) tested the antidyslipidemic effects of a chloroform extract of *Coccinia grandis* leaves in hamsters by bringing their triglyceride and cholesterol levels down. Polyprenol-containing chloroform extract of *Coccinia grandis* leaves reduces plasma lipid profile while raising the ratio of high density lipid cholesterol to total cholesterol. At a dose of 50 mg/kg body weight, it significantly reduced blood triglycerides by 42%, total cholesterol by 25%, and glycerol by 12% in dyslipidemic hamsters fed a high-fat diet. Leaf extracts in aqueous and ethanolic forms can be utilised to treat obesity (Mishra *et al.*, 2012).

Mutagenic effect

By gradually slowing the formation of mycelia, an aqueous extract of *Coccinia grandis* inhibited growth and mutagenesis on Neurospora crassa. This finding suggests that the plant *Coccinia grandis* has mutagenesis effects on Neurospora crassa Bhuiyan *et al.*, (2009).

Hepatoprotective activity

Against CCl4-induced hepatotoxicity in experimental rats, Vadivu (2008) assessed the alcoholic extract of the fruit of *Coccinia grandis* for hepatoprotective potential. The SGPT, SGOT, and bilirubin levels were dramatically decreased after treatment with a 250 mg/kg ethanolic fruit extract. *Coccinia grandis* included antioxidants such as flavonoids, triterpenes, and tannin, which may prevent the generation of free radicals and have been linked to hepatoprotective effects. (Vinothkumar *et al.*, 2009; Anil Kumar *et al.*, 2012; DR. Krishnkumari *et al.*, 2011; Sunilson., *et al.*, 2009).

Antiulcer activity

In pylorus ligation and ethanol-induced ulcer models in experimental rats, the anti-ulcer efficacy of aqueous extract of leaves of *Coccinia grandis* was examined. In both models, the ulcer index was calculated. At doses of 250 and 500 mg/kg, aqueous extract of *Coccinia grandis* significantly inhibited the stomach lesions brought on by pylorus ligation-induced ulcer and ethanol-induced gastric ulcer. According to Girish *et al.* (2011), the extractsignificantly reduced stomach ulcer index, free acidity, and ulcer index.

5. *Physalis minima*

Physalis minima is an annual plant species belonging to the Solanaceae family, a yearly pantropical herb 20-50 cm high. The leaves are soft and smooth (not hairy), with intact or serrated edges, 2.5-12 cm long. Flowers are cream to yellowish. This fruit has a cherry tomato-like flavor, which is delicious when ripe or ripe. *Physalis minima*is a plant from America that are widespread to other tropical regions especially in India. (Fatmawati, 2019).
Local name: Sodakku thakkali

Anti-inflammatory activity

Carrageenan was injected into the right leg of the rat to evaluate the methanol extract of the *Physalis minima* plant for its ability to reduce inflammation. Oral administration of the methanol extract, chloroform fraction, and aspirin was done one hour prior to the injection of carrageenan as a control. Following carrageenan injection, the feet were dipped to obtain plethysmometric measurements. The third hour of the experiment saw the strongest suppression of rat foot oedema at a dose of 400 mg crude extract (66.67%), chloroform fraction (68.25%). The chloroform fraction inhibited rat leg oedema in the third hour (61.90%) and crude extract at the fourth hour (57.81%) following a 200 mg dosage (Murad *et al.*, 2009).

Anti-oxidant activity

Researchers tested the ethanol extract of the *Physalis minima* fruit for antioxidant activity to demonstrate its value in treating diseases caused by free radicals, such as diabetes, cardiovascular disease, cancer, and others. The ethanol extract was tested for antioxidant activity *in-vitro* using varied amounts of metal chelation, nitric oxide radical scavenging,

DPPH elimination, total antioxidant test, and iron-reducing activity. Leaf extracts demonstrated considerable antioxidant activity throughout the investigation (Karpagasundari *et al.,* 2014).

Antimicrobial activity

Based on fruit development stage, testing the bacterial inhibition of *Physalis minima* fruit is done using a variety of solvents. On Micrococcus luteus 4 MIC and Bacillus subtilis 4MIC, ripe fruit with ethyl acetate solvent has inhibitory power. On Escherichia coli 4 MIC and Bacillus cereus 4 MIC, acetone solvent has inhibitory power. Pre-ripe fruit treated with di-ethyl acetate has inhibitory effects on the microorganisms Bacillus cereus 4 MIC, Micrococcus luteus 8 MIC, while Bacillus subtilis 4 MIC is inhibited by acetone. Using *Physalis minima* fruit extracts at mature and ripe phases, this study demonstrated a strong inhibitory effect (Parkash *et al.,* 2012).

Anti-diuretic activity

The methanol extract of *Physalis minima* fruit underwent an oral method antidiuretic test. Rats were denied food and water for a period of 18 hours. 100 mg/kg and 200 mg/kg dosages of the *Physalis minima* methanol extract were administered. While the dose of 200mg/kg bodyweight shows the amount of urine (9.82) and the electrolytes Na+ (108.18) and K+, the dose of 100mg/kg bodyweight shows the volume of urine (7.46) and the electrolytes Na+ (86.23), and K + (540.7). (635.2). It has been demonstrated that *Physalis minima* leaf extract increases Na+ and K+ excretion as well as urine excretion. Jyothibasu T *et al.* (2012).

Anti-diabetic activity

Daud D *et al.* (2016) investigations have been done into how *Physalis minima* Linn (PML) methanol extract affects blood sugar levels. 24 male ICR rats were randomly assigned to one of four groups and given a maintenance diet (commercial rat chow, 5 g/head/day, and water as needed). Group A (n = 6) served as the control and got 2 ml/kg of distilled water extra. Groups B, C, and D received supplements containing 50, 100, and 200 mg/kg bodyweight of PML, respectively. When compared to the control group, the PML treatment group's blood glucose level was reduced significantly (p 0.05) (dose-dependent technique).

6. *Averrhoa carambola*

The Star-fruit plant (family: Oxalidaceae; species: *Averrhoa carambola* L.) is widely distributed around the world, especially in tropical countries such as India, Malaysia, Indonesia, and Philippines. *Averrhoa carambola* is a slow growing species of woody plants. This Star-fruit plant belongs to the genus, Averrhoa, which contains 5 species, namely A. bilimbi, A. dolichocarpa, A. leucopetala, A. microphylla and A. carambola. However, A. carambola is widely cultivated on a commercial scale (Hock Eng Khoo *et al.,* 2016).

Local name: Vilimbi palam

Anti-tumour activity

Averrhoa carambola extract was investigated in 2014 by Singh *et al.* against chemically induced hepatocellular cancer in Swiss albino mice. When compared to a control group, they discovered that administering *Averrhoa carambola* extract reduced tumour

incidence, tumour yield, and tumour burden in the hepatocellular carcinoma mouse model (Singh *et al.,* 2014).

Anti-infective effects

In 2007, Mia *et al.* identified two substances from the bark of *A. carambola* that significantly reduced the development of Escherichia coli and had weak inhibitory effect against fungi. These substances were p-anisaldehyde and -sitosterol (Mia).

Anti-ulcer activity

Goncalves *et al.* (2006) evaluated in rats the gastroprotective efficacy of an *A. carambola* fruit water-alcohol extract. In a model of ulceration caused by acidified ethanol, there showed considerable anti-ulcer efficacy. *A. carambola* demonstrated minimal anti-ulcer activity, according to their overall findings (Goncalves *et al.*, 2006).

Anti-inflammatory effects

The possible topical anti-inflammatory effects of star fruit leaves on male Swiss mice were examined by Cabrini *et al.* (2011). In the croton oil-induced ear oedema model of inflammation, ethanolic extract of star fruit leaves applied topically decreased oedema in a dose-dependent fashion. Myeloperoxidase activity was decreased by the ethanolic extract or its fractions, indicating that these substances may have an impact on how cells migrate during an inflammatory response (Cabrini *et al.,* 2011).

Hypoglycemic and antidiabetic effects

The substantial fibre content of each star fruit contributes to its advantageous effects on glucose regulation. The insoluble fibres prevent -amylase from working and postpone the release of glucose from starch (Chau *et al.,* 2004). A significant hypoglycemic effect has been shown *in vitro*. In 2007, researchers gave male Wister rats hydroalcoholic extract of *Averrhoa carambola* leaves, and they discovered a drop in blood sugar levels (Ferreira *et al.*,2008).

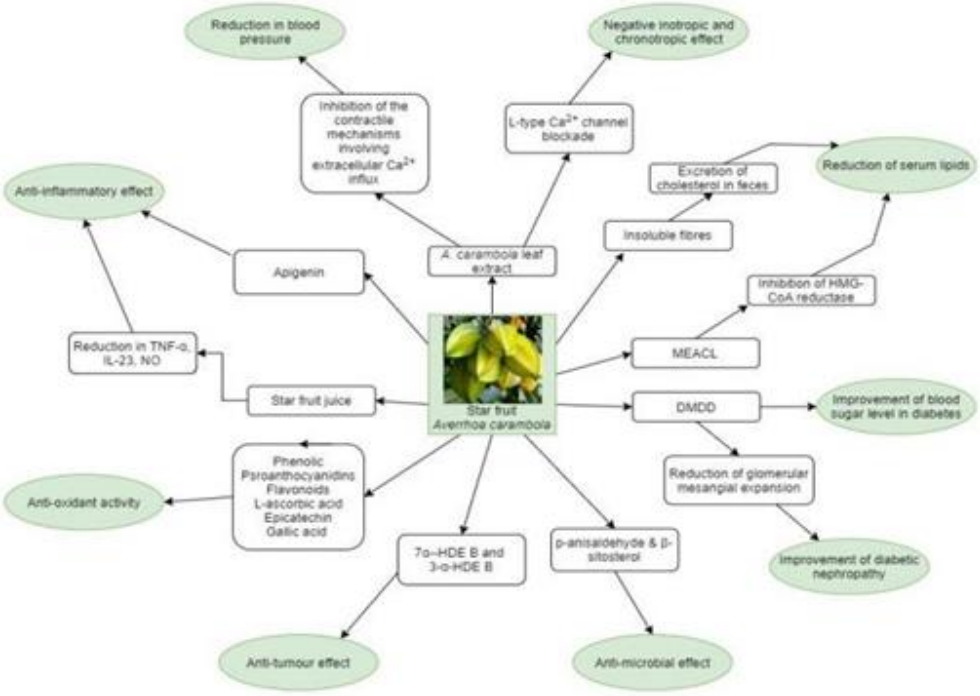


Plate 2: Beneficial effects of *Averrhoa carambola*

Conclusion:

Rare Fruits have distinctive and plentiful components with health benefits because of the special genotype and formative environment. The biological processes may become less active when a species is domesticated. Additionally, it is important to avoid over-harvesting of the rare Indian fruits as this could cause damage to the ecology. Numerous bioactivities, including antioxidant, antibacterial, anti-inflammatory, anti-cancer, and anti-diabetic activities, have been demonstrated for a variety of fruits. Some fruits have several bioactivities more than one. Rare Indian fruits have been consumed and used less frequently, yet have been developed into functional foods. Bioactivities of rare fruits should be assessed, and bioactive components should be isolated and consumption should be promoted in order to fully utilise fruit resources. The mechanisms of action should be explored further. For safe human consumption, it is also required to evaluate some fruits toxicologically.

References:

1. Ashaolu TJ, Ashaolu JO., 2020. Perspectives on the trends, challenges and benefits of green, smartand organic (GSO) foods. International Journal Gastron Food Sci, 22:100-273.
2. Ashaolu TJ, Reale A., 2020. A holistic review on Euro-Asian lactic acid bacteria fermented cerealsand vegetables. Microorganisms, 8(8):1176.
3. Baliga M.S., Pai R.J., Bhat H.P., Palatty P.L., Boloor R., 2011. Chemistry and medicinal properties of the Bakul (*Mimusops elengi* Linn): A review: Food Research International, 44, 1823–1829.
4. Behera S K and Dash V., 2012. Some Indian vegetable used as an anticancer agent. International Journal of advanced pharmaceutical and biological sciences. 2: 250-264.
5. Bhattacharya B., 2011. In-vivo and In-vitro anticancer activity of *Coccinia grandis* (L.) Voigt. (Family: Cucurbitaceae) on Swiss albino mice. Journal of Pharmacy Research. 4(3): 567-569.
6. Bhuiyan M N *et al.,* 2009. Mutagenic effect of coccinia cordifolia leaf extract on *N. crassa* fungus. Bangladesh journal of science and research. 44:215-220.
7. Brieger K, Schiavone S, Miller FJ., 2012. Reactive oxygen species: from health to disease. Swiss Medical Weekly,142:13659.
8. Cabrini D. A., Moresco H. H., Imazu P.,Silva DA, Fernandes Pietrovski CD, Augusto Gasparin Bueno Mendes E, Silveira Prudente A., Geraldo Pizzolatti M., Maria Costa Brighente, I & Fleith Otuki M., 2011. Analysis of the potential topical anti-inflammatory Activity of *Averrhoa carambola* L. in Mice. Evidence-Based Complementary and Alternative Medicine, 908059.
9. Cai M., 2019. Fruit-based functional food. In: Galanakis CM (Ed.), The Role of Alternative and Innovative Food Ingredients and Products in Consumer Wellness. Academic Press, New York.35- 72.
10. Chau, C. F., Chen C. H., & Lee M. H., 2004. Characterization and physicochemical properties of some potential fibres derived from *Averrhoa carambola*. Nahrung/Food, 48, 43–46.
11. Chaudhury A, Duvoor C, Reddy Dendi VS, Kraleti S, Chada A, Ravilla R, Marco A, Shekhawat NS, Montales MT, Kuriakose K, Sasapu A, Beebe A, Patil N, Musham CK,

Lohani GP, Mirza W., 2017. Clinical review of antidiabetic drugs: implications for Type 2 diabetes mellitus management. Frontiers in Endocrinology, 8:6.

12. Chen JP, Chan PH, Lam CTW., 2015. Fruit of *Ziziphus jujuba* (jujube) at two stages of maturity: Distinction by metabolic profiling and biological assessment. Journal of Agricultural and Food Chemistry, 63(2):739-744.
13. Chen W, Xu Y, Zhang LX, *et al.*, 2016. Blackberry subjected to *in-vitro* gastrointestinal digestion affords protection against Ethyl Carbamate-induced cytotoxicity. Food Chemistry, 212:620-627.
14. Das A, Raychaudhuri U, Chakraborty R., 2012. Cereal based functional food of Indian subcontinent: a review. Journal of Food Science and Technology, 49(6):665-672.
15. Daud D, Siti Fatimah Elias, Fatimah Sarah Mohamad Hassan, Mohammad Noor Jalil, Alene Tawang. 2016. *Physalis minima Linn* Methanolic Reduces Blood Glucose Level without Compromising Sperm Quality in Normoglycaemic Mice. Journal of Applied Pharmaceutical Science, 6(6): 8-11.
16. Deng G.F, Lin X, Xu X.R, Gao L, Xie J.F, Li H.B., 2013. Antioxidant capacities and total phenolic contents of 56 vegetables. Journal of Functional Foods, 5: 260–266.
17. Diebold L, Chandel NS., 2016. Mitochondrial ROS regulation of proliferating cells. Free Radical Biology and Medicine, 100:86-93.
18. Edzard Ernst MD., 1998. Harmless herbs? A review of the recent literature. American Journal of Medicine, 170–8.
19. Fatmawati, S., 2019. Bioaktivitas dan Konstituen Kimia Tanaman Obat Indonesia. Yogyakarta: CV Budi Utama.
20. Ferreira E. B., Fernandes L. C., Galende S. B., Cortez D. A. G., & Bazotte R. B., 2008. Hypoglycemic effect of the hydroalcoholic extract of leaves of *Averrhoa carambola* L. (Oxalidaceae). Revista Brasileira De Farmacognosia, 18:339–343. https://doi.org/10.1590/S0102- 695X2 008000300005.
21. Forbes-Hernandez T.Y, Giampieri F, Gasparrini M, Mazzoni L, Quiles J.L, Alvarez-Suarez, J.M, Battino, M., 2014. The effects of bioactive compounds from plant foods on mitochondrial function: A focus on apoptotic mechanisms. Food and Chemical Toxicology., 68:154–182.
22. Forrester SJ, Kikuchi DS., Hernandes MS, 2018. Reactive oxygen species in metabolic and inflammatory signaling. Circulation Research, 122(6):877-902.
23. Fu L, Xu B.T, Xu X.R, Qin X.S, Gan R.Y, Li H.B., 2010. Antioxidant capacities and total phenolic contents of 56 wild fruits from South China. Molecules, 15:8602–8617.
24. Fu Z, Gilbert ER, Liu D., 2013. Regulation of insulin synthesis and secretion and pancreatic Beta- cell dysfunction in diabetes. Current Diabetes Reviews, 9:25–53.
25. Gaurav S, Navneet N, Sandeep R, Singh P, Amit P and Manisha N., 2010. Effect of aqueous leaves extract of *Carissa carandas linn.* on blood glucose levels of normoglycemic & alloxan induced diabetic Wister rats. International Journal of Current Pharmaceutical Research, 2(3):65-7.
26. Gescher A, Pastorino U, Plummer S.M, Manson M.M., 1998. Suppression of tumour development by substances derived from the diet-mechanisms and clinical implications. British Journal of Clinical Pharmacology., 45:1–12.

27. Giampieri F., Alvarez-Suarez J.M.; Battino M., 2014. Strawberry and human health: Effects beyond antioxidant activity. Journal of Agricultural and Food Chemistry., 62: 3867–3876.
28. Girish C., 2011. Evaluation of Antiulcer Activity of *Coccinia grandis* Leaves. Research Journal of Pharmacology and Pharmacodynamics. 3: 2011.
29. Goncalves S. T. B. S., Bersani-Amado F. A., Melo G. A. N., Cortez D. A. G., Bersani-Amado C. A., & Cuman R. K. N., 2006. Preliminary studies on gastric anti-ulcerogenic effects of *Averrhoa carambola* in Rats. Acta Farmac Bonaerense. Latin American Journal of Pharmacy, 25:245–247.
30. Gowd V, Bao T and Chen W., 2019. Antioxidant potential and phenolic profile of blackberry anthocyanin extract followed by human gut microbiota fermentation. Food Research International, 120:523-533.
31. Halliwell B., Gutteridge J.M.C., 1999. Free Radicals in Biology and Medicine, 3rd ed. Oxford University Press: New York, NY, USA. 331–332.
32. Hock Eng Khoo, Azrina Azlan, Kin Weng Kong, and Amin Ismail, 2016. Evidence-Based Complementary and Alternative Medicine. 2016:7591951 [PMID: 27340420]
33. Hoffmann G., Schwingshackl L., 2016. Mediterranean diet supplemented with extra virgin olive oil reduces the incidence of invasive breast cancer in a randomised controlled trial. Evidence Based Medicine., 21:72.
34. Huang W.J., Zhang, X.; Chen, W.W., 2016. Role of oxidative stress in Alzheimer's disease (Review). Biomedical Reports., 4:519–522.
35. Jeong O, Kim HS., 2019. Dietary chokeberry and dried jujube fruit attenuates high-fat and high- fructose diet-induced dyslipidemia and insulin resistance via activation of the IRS-1/PI3K/Akt pathway in C57BL/6 J mice. Nutrition Metabolism, 16:38.
36. Jyothibasu T, Venkata Ramana K, Sreenu Thalla, Narasimha Raju B H. 2012. Diuretic Activity of Methanolic Extract of *Physalis minima* Leaves. Scholars Research Library, 4(6): 1832-1834.
37. Karpagasundari. C, Kulothungan S., 2014. Free Radikal Scavenging Activity of *Physalis minima Linn.* Leaf Extract (PMLE). Journal of Medicinal Plants and Studies, 2(4):59-64.
38. Krishnkumari S., Bhuvaneshwari P., Rajeswari P., 2011.The ameliorative potential of *Coccinia grandis* of serum and liver marker enzymes and lipid profile in streptozotocin induced diabetic rat. Ancient science of life. 31: 26-30.
39. Kumar Anil, 2012. A review of hepatoprotective herbal drugs. International journal of research inpharmacy and chemistry. 2: 92-102.
40. Kuprash DV, Nedospasov SA., 2016. Molecular and cellular mechanisms of inflammation. Biochemistry (Moscow), 81(11):1237-1239.
41. Li AN., Li S., Zhang YJ., Xu XR., Chen YM., Li H.B., 2014. Resources and biological activitiesof natural polyphenols. Nutrients, 6:6020–6047.
42. Lobo V., Patil A, Phatak A, Chandra N., 2010. Free radicals, antioxidants and functional foods: Impact on human health. Pharmacognosy Reviews., 4:118–126.
43. Lock K, Pamerleau J, Causer L, Altmann D.R, McKee M., 2005. The global burden of disease attributable to low consumption of fruit and vegetables: Implications for the global strategy on diet. Bull. World Health Organisation. 83:100–108.

44. Mantovani A, Allavena P, Sica A., 2008. Cancer-related inflammation. Nature, 454(7203):436- 444.
45. Medzhitov R., 2008. Origin and physiological roles of inflammation. Nature, 454(7203):428-435. 46.Medzhitov R., 2010. Inflammation 2010: new adventures of an old flame. Cell, 140(6):771-776. 47.Megala J, Geetha A., 2009. Free radical- scavenging and H+, K+-ATPase inhibition activities of *Pithecellobium dulce*. Food Chemistry, 121:1120–8.
46. Mia M, Rahman M, Begum K, Begum B, & Rashid M., 2007. Phytochemical and Biological Studies of *Averrhoa carambola*. Dhaka University Journal of Pharmaceutical Sciences 6, 125–128. 49.Mishra CK, Sasmal D, Shrivastava B., 2012. An *in-vitro* evaluation of the anthelmintic activity of unripe fruits extract of *Carissa carandas* Linn. International Journal of Drug Development and Research., 4(4):393-7.
47. Mishra Rakhi., Mishra Prem S and Ahmad Shamim., 2012. A Review on Herbal Treatment of Obesity. International Journal of pharmaceutical and chemical science. 1: 523-525.
48. Murad A.K, Haroon Khan, Sarwar Khan, Tahira Mahmood, Pir Mohammad Khan and Abdul Jabar, 2009. Anti Inflammatory, Analgesic and Antipyretic activities of *Physalis minima* Linn. Journal of Enzyme Inhibition and Medicinal Chemistry, 24(3): 632-637.
49. Nagmoti DM, Kothavade PS, Bulani VD, Gawali NB and Juvekar AR., 2015. Antidiabetic and antihyperlipidemic activity of *Pithecellobium dulce* (Roxb.) Benth seeds extract in streptozotocin- induced diabetic rats. European Journal of Integrative Medicine, 7:263–73.
50. Nanasombat S and Teckchuen N., 2009. Antimicrobial, antioxidant and anticancer activities of Thai local vegetables. Journal of Medicinal Plants Research. 3950: 443-449.
51. Osefo N, Ito T and Jensen RT., 2009. Gastric acid hypersecretory states: recent insights and advances. Current Gastroenterology Report, 11:433–41.
52. Periasamy S, Liu CT and Wu WH., 2015. Dietary *Ziziphus jujuba* fruit influence on aberrant crypt formation and blood cells in colitis-associated colorectal cancer mice. Asian Pacific Journal of Cancer Prevention, 16(17):7561-7566.
53. Pithayanukul P, Ruenraroengsak P, Bavovada R, Pakmanee N, Suttisri R and Saen-oon S., 2005. Inhibition of *Naja kaouthia* venom activities by plant polyphenols. Journal of Ethnopharmacology, 97:527–33.
54. Prakash R. Patel and Ramana Rao T V., 2012. Influence of Growth and Ripening of *Physalis minima* L. Fruit on its antibacterial Potential. Research Journal of Medicinal Plants, 6(4): 326-333.
55. Qing-Han Gao, Chun-Sen Wu, and Min Wang, 2013. The Jujube (*Ziziphus jujuba* Mill.) Fruit: AReview of Current Knowledge of Fruit Composition and Health Benefits. Journal of Agricultural and Food Chemistry 61, 14, 3351–3363.
56. Rao GN, Nagender A, Satyanarayana A, Rao DG, 2010. Preparation, chemical composition and storage studies of quamachil (*Pithecellobium dulce* L.) aril powder. The Journal of Food Science and Technology; 48(1):90–5.
57. Rashid MH, Biswas SU, Abdullah-AL-Mamun MO, Huque A, Bhuiyan JR., 2015. Phytochemical screening and analgesic, anti-bacterial and cytotoxic activity evaluation of ethanol extract of *Pithcellobium dulce* (Roxb.) benth leaf. Asian Journal of Pharmaceutical and Clinical Research. 8:451–6.

58. Reddy Uma B, 2009. Cladistic analyses of a few members of Cucurbitaceae using rbcL nucleotide and amino acid sequences. International Journal of Bioinformatics Research;1: 58-64.
59. Saha R, Hossain L, Bose U, Rahman AA., 2010. Europharmacological and diuretic activities of *Carissa carandas* linn. Leaf. Pharmacologyonline, 2:320-7.
60. Shamim S, Ahmad SI., 2012. Pharmacodynamic study on acute hypotensive activities of *Carissa carandas* extract in normal rats. Pakistan Journal of Pharmaceutical Sciences., 25(3):577-82.
61. Singh, R., Sharma, J., & Goyal, P. K., 2014. Prophylactic role of *Averrhoa carambola* (Star Fruit) extract against chemically induced hepatocellular carcinoma in Swiss albino mice. Advances in Pharmacological Sciences, 158936.
62. Singha Geetu, 2007. Antidyslipidemic activity of polyprenol from *Coccinia grandis* in high-fat diet-fed hamster model. Phytomedicine, 14:792-798.
63. Sulaiman SF, Wong ST, Ooi KL, Yusof SR, Muhammad T. and Sifzizul T., 2008. Anticancer study of *Carissa carandas* extracts. Anticancer study of *Carissa carandas* extracts. Project Report, Monograph University Sains Malaysia.
64. Sunilson J Anbu jeba., 2009. Hepatoprotective activity of *Coccinia grandis* against tetrachloride induced hepatic injury in rat. International Journal of pharmacology, 5: 222-227.
65. Suzuki H, Nishizawa T, Tsugawa H, Mogami S, Hibi T., 2012. Roles of oxidative stress in stomach disorders. Journal of Clinical Biochemistry and Nutrition, 50:35–9.
66. Tanideh N, Jamshidzadeh A, Ghanbari Saghesloo A, 2016. Effects of hydroalcoholic extract of *Ziziphus jujuba* on acetic acid induced ulcerative colitis in male rat (*Rattus norvegicus*). Journal of Coloproctology, 36(4):189-195.
67. Vadivu R., 2008. Evaluation of Hepatoprotective Activity of the Fruits of *Coccinia grandis* Linn. International Journal of Health Research. 1(3): 163-168.
68. Vergeer M, Holleboom AG, Kastelein JJ, Kuivenhoven JA., 2010. The HDL hypothesis: Does high-density lipoprotein protect from atherosclerosis? Journal of Lipid Research, 51:2058–73.
69. Vinothkumar P., Sivaraj A., Elumalai E K and Sentil Kumar B., 2009. Carbon tetrachloride induced Hepatotoxicity in rats-protective role of aqueous leaf extracts of coccinia. International Journal of PharmTech Research, 1:1612-1615.
70. Wang YG, Xu Y, Ma XQ., 2018. Extraction, purification, characterization and antioxidant activities of polysaccharides from *Zizyphus jujuba cv*. *Linzexiaozao*. International Journal of Biological Macromolecules, 118:2138-2148.
71. Wani RA, Prasad VM, Hakeem SA, Sheema S, Angchuk S, Dixit A, 2013. Shelf life of Karonda jams (*Carissa carandas* L.) under ambient temperature. African Journal of. Agricultural Research; 8(21):2447-9.
72. Xu H, Yuan ZZ, Ma X., 2018. Triterpenoids with antioxidant activities from *Myricaria squamosa*. Journal of Asian Natural Products Research, 20(3):292-298.

REVIEW ON ROLE OF MILLETS IN LIFESTYLE DISEASES

K. Bhavadharani* and R. Sughanya
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore, Tamil Nadu
*Corresponding author E-mail: skbhavadharani18@gmail.com

Abstract:

Worldwide, Cereal grain production has reached new heights. As the main source of energy, these Cereals play a vital part in the diet of humans. Millet grains are a staple meal and source of traditional remedies that are extensively consumed. Millets have a superior fatty acid profile than Cereals and are an excellent source of amino acids, methionine and cysteine, which are essential for building protein. Considering their potential as a source of vital nutrients, millets are significant in the modern diet. Millets have functional and health- promoting properties, notably being anti-diabetic, anti-obese, anti-hypertension, anti- cardiovascular disease, and anti-cancer due to the actions of the phytochemicals, which also play a part in the immune system of the body. Millets benefit those with diabetes because of their low Glycemic Index, which promotes more gradual digestion and glucose containment than other diets. Millets are a fantastic source of vitamins, phytonutrients, and dietary fibre, all of which are essential for controlling and avoiding lifestyle illnesses. Millets have great source of dietary fibre, phytonutrients and micronutrients which plays a vital role in managing and preventing life style diseases.so the present review focus on the importance and role of millets in lifestyle diseases like Diabetes, Cardiovascular diseases, Obesity, Cancer and Hypertension.

Keywords: Millets, Functional and health-promoting properties

Introduction:

Cereal foods, a rich collection of essential macro and micro elements and with non-nutrient bioactives/secondary metabolites/ phytochemicals are important in the food system. Millets, which are rich in minerals and vitamins with low fat, dietary energy, and glycemic index values, have been observed to provide numerous documented health benefits. (Gong *et al.,* 2018). Production of Cereal grains has achieved new heights worldwide. These Cereals have a significant role in the human diet as the primary source of energy. Overall Cereal production, in 2019, stands at a record of 2715 million tonnes (FAO, 2020).

Therefore, millets play an important role in the modern diet as a potential source of essential nutrients, especially in underdeveloped and developing countries. The present review summarizes the nutritional composition of millets and role of millets in lifestyle diseases like Diabetes , Cardiovascular diseases, Obesity, Hypertension and Cancer.

Major types of millets

The major types of millets are Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*), Proso millet or white millet (*Panicum miliaceum*), and Finger Millet (*Eleusine coracana*). Minor millets include Barnyard millet (*Echinochloa* spp.), Kodo millet (*Paspalum scrobiculatum*), Little millet (*Panicum sumatrense*), Guinea millet *(Brachiaria deflexa/Urochloa deflexa*), and Browntop millet (*Urochloa ramose/Brachiaria ramose/Panicum ramosum*) (Chinchole *et al.,* 2017; ICRISAT, 2017; Yang *et al.,* 2012).

Table 1: Major types of millets (Source: ICAR, 2017 (IIMR)

Sr. No.	Crop	Botanical Name	Picture	Local name	Language
1.	Pearl millet	*Pennisetum glaucum*		Bajra	English
				Kambu	Tamil
				Bajri	Gujarati
				Sajje	Kannada
2.	Foxtail millet	*Setaria italic*		Kangni/Rala/Kakum	Hindi
				Navane	Kannada
				Malayalam	Thina
				Thinai	Tamil
				Korra	Telugu
3.	Proso millet	*Panicum miliaceum*		Chenna/Barri	Hindi
				Baragu	Kannada
				Variga	Telugu
				Pani Varagu	Tamil
4.	Little millet	*Panicum sumatrense*		Kutki/Shavan	Hindi
				Chama	Malayalam
				Samai	Tamil
5.	Finger millet	*Eleusine coracana*		Samalu/Sama	Telugu
				Ragi	Kannada/ Hindi
				Kepai/Kezhvaragu	Tamil
				Ragi chodi/Ragula Manduva/Mangal	Telugu
					Hindi
6.	Barnyard millet	*Echinochloa spp.*		Sanwa/ Jangora	Hindi
				Oodalu	Kannada
				Udalu	Telugu
				Kuthiraivolly	Tamil
7.	Kodo millet	*Paspalum scrobiculatu m*		Kodra/Kode	Hindi
				Malayalam	Koovaragu
				Harka	Kannada
				Varagu	Tamil
				Arika	Telugu

Nutritional profile of millets

Millets are considered as high energy yielding nourishing foods which help in addressing malnutrition. India is the largest producer of pearl millet (Bhattacharjee *et al.,* 2007). They are consumed as flour, rolled into balls, parboiled, and served as porridge with milk (FAO, 2009). Epidemiological evidences showed a close association of millets with a decrease in the incidence/risk factors of cardiovascular disease, diabetes and certain cancers, etc. (Gong *et al.,* 2018; Radhika *et al.,* 2011; Singh & Raghuvanshi, 2012).

According to the FAO, the traditional food processing methods, such as decortications, milling, germination, fermentation, malting, and roasting of millets are recommended in order to prevent their antinutritional properties and improve their edible qualities. Functional properties, such as water and oil holding capacity, viscosity, foaming activity, bulk density, and swelling power of millets are the fundamental physicochemical properties that reveal the intricate relations between the structure, molecular components and composition and physicochemical properties of food components (Ramashia *et al.,* 2017). Probably the only Cereal crop that can grow in hot and drier conditions, i.e., 64◦C temperature and 350–400 mm annual rainfall is millets (Chivenge *et al.,* 2015).

A food's nutritional value plays a crucial role in maintaining the health and wellness of humans. Millets are nutritionally comparable to other Cereal grains (FAO, 1995). 60–70% of the nutrients are in the form of carbs, followed by 7–11% of proteins, 1.5–5% of fat, 2–7% of crude fibre, minerals, and vitamins. When compared to other Cereal grains, millets are an excellent provider of energy.

Millets are a good source of energy, dietary fiber, slowly digestible starch, and resistant starch, and thus provide sustained release of glucose and thereby satiety (Nithiyanantham *et al.,* 2019) Compared to Cereals, millets are a good source of protein- and sulphur-containing amino acids (methionine and cysteine) and have a better fatty acid profile (Anitha *et al.,* 2020) However, millets contain a limited amount of lysine and tryptophan, which varies with the cultivar. Millets are rich in vitamin E and vitamin B and minerals such as calcium, phosphorus, magnesium, manganese, potassium, and iron (Rao *et al.,* 2017; Birania *et al.,* 2020).

Table 2: Nutritional profile of millets (per 100g)

Grains	Energy (kcal)	Protein (g)	Fat (g)	CHO (g)	Dietary fibre (g)	Minerals (mg)	Ca (mg)	P (mg)
Pearl millet	363	11.6	5	61.7	11.4	2.3	27	296
Foxtail millet	331	12.3	4.3	60.0	-	3.3	14	290
Finger millet	320	7.3	1.3	66.8	11.1	2.7	364	283
Proso millet	341	12.5	1.1	70.0	-	1.9	14	206
Kodo millet	353	8.3	1.4	66.1	6.3	2.6	15	188
Barnyard millet	307	11.6	5.8	65.5	-	4.7	14	121
Little millet	329	8.7	5.3	65.5	6.3	1.7	17	220

Source – Indian food composition table and Nutritive value of Indian foods (IFCT, ICMR, 2017)

Compared to other Cereals, barnyard millet and other millet varieties have more fat, ranging from 3.5% to 5.2%. Iron and phosphorus are abundant in millets. A high calcium level of

364 mg/100 g is another benefit of finger millet (FAO, 1995; IIMR,2017) Table 2 provides information on the millets' dietary composition.

Pearl millet breaks down fats more quickly than most other Cereals. It also contains a lot of omega-3 unsaturated fatty acids, which are loaded with nutrients. Pearl millet is significantly higher in resistant starch, soluble dietary fibre, and insoluble dietary fibre than other millets and has the highest concentration of macronutrients (Ragaee *et al.,* 2006). Pearl millet has a much larger root system than other Cereal crops like wheat, rice, maize, and sorghum which enables it to absorb more nutrients from the soil. Iron, zinc, magnesium, copper, manganese, potassium and phosphorus are all present in the mineral in significant amounts. This is a potent energy source because it contains lot of fibre (11.4 g/100 g), has a calorific value of 3613 Kcal/100 g, and is high in fibre and vitamin B, vitamin A, folic acid, calcium, and magnesium are all found in moderate amount (Pattanshetti *et al.,* 2016).

With starch as its main ingredient and non-starchy polysaccharides making up 15- 20% of the seed matter as an inaccessible carbohydrate, finger millet has a carbohydrate level that is significantly higher than that of other Cereals (72%), which adds to the millet's health benefits (Devi *et al.,* 2011). Millets have a higher level of dietary fibre (22%), compared to other Cereals like wheat (12.6%), rice (4.6%), and maize (13.4%). (Chethan *et al.,* 2007). Finger millet grain contains 1.4% soluble and 15.7% insoluble dietary fibre. Finger millet contains 22.0% of the daily recommended allowance of dietary fibre (Shobana *et al.,* 2007). Compared to major Cereals like rice and wheat, jowar has a high proportion of calcium. It is also packed with iron, protein and fibre (Reddy, 2017).

Millets and health

Millet grains are widely consumed as a source of traditional medicines and are important food to preserve health. The phytonutrients and vitamins may be responsible for the antioxidant, anticancer and anti-inflammatory, antifungal, and blood clot inhibition properties of millet crops (Dykes & Rooney, 2007; Chaudhary *et al.,* 2013).

Role of millets in diabetes

Millions of individuals worldwide suffer from the disease known as diabetes. Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood glucose. Due to their high magnesium content, millets aid in the prevention of Type II Diabetes. Magnesium is a crucial mineral that produces numerous carbohydrate-digesting enzymes, which regulates insulin activity, and thus aids in improving the efficacy of insulin and glucose receptors (Reddy, 2017).

Millets reduces the α-glucosidase and pancreatic amylase thereby reducing the postprandial Hyperglycemia by reducing the enzymatic hydrolysis of complex carbohydrates. The enzymes like aldose reductase which helps in prevention of accumulation of sorbitol and reduces the risk of diabetes induced cataract diseases. Thus millets helps in controlling the blood glucose level and also helps in dermal wound healing process with the help of antioxidants (Rajasekaran *et al.,* 2004).

In comparison to other Cereals like maize, milled rice, and refined wheat flour, millets have a lower GI (Glycemic Index). When foxtail millet-based food was consumed, the GI value

was significantly lower by 30% on an average than maize-based food. Foxtail millet has median Glycemic Index and a gentle stimulation to pancreatic β-cell, which helps diabetics to avoid dangerous spike in blood glucose and improvement of postprandial blood glucose in diabetics (Ren *et al.,* 2017).

In diabetic people, pearl millet aids in long-term blood sugar stability. Due to its relatively low Glycemic Index, which aids in more gradual digestion and containment of glucose than other foods, it is also beneficial for people with diabetes. This will help healthy blood sugar levels for long stretches. (Saini *et al.,* 2021). In 2010, as part of the National Agricultural Innovation Project, the National Institute of Nutrition (ICMR) and the Indian Institute of Millets Research, Hyderabad, evaluated the Glycemic Index (GI) of foods based on sorghum (NAIP). The findings demonstrated that foods made from sorghum had a low GI and lower postprandial blood sugar levels (NIN, ICMR, 2010).

Finger millet diets showed low glycemic response due to high fibre content. They also help in dermal wound healing process (Reddy, 2017). Hypoglycaemic effect of barnyard millet is due to the presence of higher proportion of complex carbohydrates, slow rising sugars and resistant starch. Similarly, glycosylated haemoglobin value also showed significant decrease from 8.44% to 7.56 % (Itagi *et al.,* 2013).Total dietary fibre content of barnyard millet slows down the release of glucose in the blood and hence prevented the blood glucose spike as opposed high spike caused by consumption of high glycemic index food like rice.(Shweta Joshi et al.,2021).

Role of millets in cardiovascular diseases

Cardiovascular disease (CVD) is a general term for conditions affecting the heart or blood vessels. It's usually associated with a build-up of fatty deposits inside the arteries (atherosclerosis) and an increased risk of blood clots. Millet is gluten-free, therefore an excellent option for people suffering from atherosclerosis and diabetic heart disease (FAO.,1995). Dietary fibre plays an important role in imparting hypolipidemic effect by their ability to retard food digestion and nutrient absorption and thus influencing lipid metabolism. (Bisoi *et al.,* 2012).

Researchers have found that a typical sorghum wax is rich in policosanols which helps in reducing the levels of cholesterol. Foxtail millet is known as healthy heart food due to its good source of magnesium (Reddy, 2017). Finger millet Prevents cardiovascular disease by reducing plasma triglycerides in Hyperlipidemic rats (E.S. Sarita. & E. Singh, 2016). The studies on millets revealed that by consuming the porso-millet protein concentrate, it has the effect on plasma lipid levels and clearly showed that the plasma high- density lipoprotein cholesterol and adiponectin levels are elevated (Kyung *et al.,* 2008).

Millets are also a good source of magnesium which is known for reducing heart attack. Millets which are known to be rich in phytochemicals which contains phytic acid helping in lowering cholesterol and preventing cardiovascular disease by reducing plasma triglycerides (Lee *et al.,* 2010). Studies suggested that regular consumption of whole millet grains reduces the risk of CVD. Millets are one of the best possible grains to add to our diet to protect our heart. Millet is a rich source of magnesium, which is an important mineral for reducing blood pressure and the risk of heart attacks or strokes, particularly in the case of atherosclerosis. Millets are also a great source of potassium, which further keeps blood pressure low by acting as a vasodilator thus,

maintains cardiovascular health. The plant lignans of millets are prebiotic fibre which are fermented in our intestinal gut by bacteria can be converted to animal lignans by the micro flora in our digestive system and those animal lignans have been shown to protect against certain chronic diseases. Upon fermentation, they yield enterolactone, a product which is known to protect against heart disease and also some forms of breast cancers (Reddy, 2017).

Role of millets in obesity

Nowadays it is seen that Obesity has become an emerging problem which is associated with several other diseases like Diabetes, Blood pressure and Cardiac problems. Studies suggested that consuming high fibre food helps in improving the bowel function and reduce the prevalence of Obesity by improving the digestion and absorption in the body thereby reducing the risk of chronic diseases. Millets helps in satiating hunger satisfaction and helps in weight management reducing obesity.

Sorghum is rich in dietary fibre, chemical characteristics and has unique physical characteristics which help in adding bulk to the diet, viscosity, water holding and absorption capacity, which determine the subsequent physiological behaviour. It also helps in the hunger satisfaction and helps in satiety and thereby reducing the risk of development of obesity. Its Gluten free properties help in Celiac Disease. (Dayakar Rao *et al.,* 2013). Finger millet helps in losing weight, Ragi is having an amino acid called Tryptophan which helps in lowering of appetite and helps in weight control. Finger millet is digested at a slower rate which helps in keeping away the intake of excessive calories. And, fibres of finger millet gives fullness feeling thus controlling the excessive food consumption (ICAR - Indian Institute of Millets Research., 2017).

Pearl millet aids in weight loss by reducing the satiety level. Pearl millet with its high fibre content and longer grains helps in slow movement of food from stomach to the intestine. Thus helps in longer duration of food intervals and helps in weight reduction. Millets have great potential in helping to fight Obesity. Consuming millets helps in fighting Obesity and therefore helps in fighting metabolic disorders. Millets are indeed the miracle grains, which are available at a lower cost but giving higher nutritional benefits (Kimeera *et al.,* 2019).

Role of millets in hypertension

High blood pressure, also known as hypertension, is a public health problem suffered by around 1.3 million adults worldwide. This condition occurs when an elevation in the systolic and diastolic pressure occurs above 140/90 mm of Hg. (WHO, 2021). Reduction of serum ACE(Angiotensin-converting-enzyme) activity brought on by millet diets has an anti-hypertensive impact. Many studies discovered that millet inhibited ACE activity with mild hypertension, resulting in a decrease in ACE, Angiotensin II, and aldosterone levels in serum (Chen *et al.,* 2016).

Angiotensin-converting enzyme (ACE) activity can be inhibited by foxtail millet protein hydrolysates, which reduce angiotensin II and directly lower blood pressure in hypertensive rats. (Chen *et al.,* 2016).In spontaneously hypertensive rats, finger millet ethanol extracts reduce blood pressure by lowering angiotensin-converting enzyme levels and increasing antioxidant capacity (Park *et al.,* 2021).Consuming whole grains can lower blood pressure. After 12 weeks, there was a significant decrease in both SBP (4.13 mmHg) and DBP (3.49 mmHg) in healthy men and

women (40-65 years old) with moderate hypertension (130 mmHg SBP 139 mmHg, 80 mmHg DBP 89 mmHg). Fasting blood glucose levels of the participants increased while fat mass, body fat percentage, and body mass index dropped (Hou *et al.,* 2018).

In 45 middle-aged hypertension patients, ingestion of 50 g of whole grains of pulverised foxtail millet extruded as bread or millet pancakes for 12 weeks resulted in a substantial decrease in SBP of 133.61 and 129.48 mmHg as well as a decrease in the mass index and body fat. (Hou et al ., 2018).Therefore, foxtail millet protein consumption more precisely, hydrolyzed, raw, and extruded millet protein—improves hypertension because of the antioxidant and anti-inflammatory qualities that allow vascular conditions to be gradually controlled (Chen *et al.,* 2016).

Role of millets in cancer

Phytochemicals and antioxidants are two specific nutraceutical ingredients that function as terminators of free radical and singlet oxygen species and have strong anti- carcinogenic capabilities. As finger millet has a variety of such compounds they may suppress excessive cellular oxidation providing protection from different types of cancers prevalent in human population (Shahidi *et al.,* 1992). According to research, millets are high in phenolic acids, phytates, and tannins, which are antinutrients that lower the incidence of colon and breast cancer. Millets' phenolic content has been demonstrated to be beneficial in stopping the development and spread of cancer in test tubes (Chandrasekara *et al.,* 2011).

This key component of finger millet's bonded phenolic acids may function as a natural, bioactive chemotherapeutic agent against cancer, according to the studies done on breast cancer cells. Furthermore, finger millet grains can be a successful treatment for a variety of cancers without causing any negative side effects since they are high in nitriloside, a vitamin B17 compound that is specifically poisonous to cancer cells only (Choi and Park, 2015). The cyto-toxicity test on HepG2 hepatic cancer cell lines and in silico research were used to determine the anti-cancer properties of finger and pearl millet phenolics (Singh *et al.,* 2015). Since millets include both fibre and phytonutrients, they help lower the risk of colon cancer. The lignans found in millets, which are transformed into mammalian lignans, protect against breast cancer. Linoleic acid, which is present in millet, has anti-tumor properties. (Ambati *et al.,* 2019).

Sorghum's anti-carcinogenic qualities have a long history. Sorghum contains polyphenols and tannins that can inhibit the growth of cancerous and mutagenic cells in humans as well as promote the production of melanin. Oesophageal cancer incidence was low with sorghum consumption in China and other parts of the world, according to the studies of Van Rensburg (1981).

In contrast to wheat and corn, sorghum consumption revealed decreased oesophageal cancer death rates. Many of the antioxidants present in millets have the added benefit of removing additional toxins from your body, including those located in your kidney and liver, in addition to their positive effects on scavenging free radicals, which can result in cancer. By fostering appropriate excretion and reducing enzymatic activity in those organs, quercetin, curcumin, ellagic acid, and a number of other advantageous catechins can assist in detoxifying the body from any foreign substances and poisons (Reddy, 2017). Since millets include both fibre and phytonutrients, they help lower the risk of colon cancer. The lignans

found in millets, which are transformed into mammalian lignans, protect against breast cancer (Abita *et al.*, 2019).

Conclusion:

The systemic review focused on the role of millets in lifestyle diseases, according to the findings of various studies, millet grains are comparable to major grains in terms of their amount of phytochemicals, minerals, vitamins, and dietary fibre, and they also have a number of natural antioxidants to protect the body against various oxidative stresses. Among different families of antioxidants, phenolics, and flavonoids are most recurring followed by different minerals sources and vitamin. The prevalent chronic diseases linked to nutrition and lifestyle choices, such as hypertension, cardiovascular disease, diabetes, obesity and cancer impose significant social and economic burdens on a nation. Since Millets have great source of dietary fibre, phytonutrients and micronutrients they can be used in managing and preventing life style diseases.

Bibiliography:

1. Anitha S., Govindaraj M., Kane-Potaka J., 2020. Balanced amino acid and higher micronutrients in millets complements legumes for improved human dietary nutrition. *Cereal Chem.*, 97:74–84.
2. Ambati K, Sucharitha KV., 2019. Millets-review on nutritional profiles and health benefits. International Journal of Recent Scientific Research.,10(7):33943-8.
3. Bhattacharjee, R., Khairwal, I. S., Bramel, P. J., & Reddy, K. N., 2007. Establishment of a pearl millet [*Pennisetum glaucum* (L.) R. Br.] core collection based on geographical distribution and quantitative traits. Euphytica, 155, 35–45.
4. Birania S., Rohilla P., Kumar R., Kumar N., 2020.Post harvest processing of millets: A review on value added products. *Int. J. Chem. Stud.,* 8:1824–1829.
5. Bisoi P.C., Sahoo, G., Mishra, S.K., Das, C. and Das, K.L., 2012. Hypoglycemic effects of insoluble fiber rich fraction of different Cereals and millets. Journal of Food Processing and Technology. 3(7):1-11
6. Chaudhary Kanchan, Y. N., 2013. Evaluation of hypoglycemic properties of kodo millet based food products in healthy subjects. IOSR Journal of Pharmacy (IOSRPHR), 3(2), 14–20
7. Chen, J.; Duan, W.; Ren, X.; Wang, C.; Pan, Z.; Diao, X.; Shen, Q., 2016. Effect of foxtail millet protein hydrolysates on lowering blood pressure in spontaneously hypertensive rats. Eur. J. Nutr., *56*, 2129–2138.
8. Chethan S and Malleshi NG., 2007. Finger millet polyphenols: optimization of extraction and the effect of pH on their stability. Food Chemistry 105: 862-870.
9. Chinchole, M., Pathak, R. K., Singh, U. M., & Kumar, A., 2017. Molecular characterization of EcCIPK24 gene of finger millet (*Eleusine coracana*) for investigating its regulatory role in calciumtransport. 3 Biotech, 7, 267.
10. Choi, Y. E., and Park, E., 2015. Ferulic acid in combination with PARP inhibitor sensitizes breast cancer cells as chemotherapeutic strategy. Biochem. Biophys. Res. Community.
11. Devi, P. B., Vijayabharathi, R., Sathyabama, S., Malleshi, N. G., & Priyadarisini, V. B., 2011. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fibre: A review. Journal of Food Science and Technology, 51(6), 1021–1040.

12. Dykes, L., & Rooney, L. W., 2007. Phenolic compounds in Cereal grains and their health benefits. Cereal Foods World, 52(3), 105–111.
13. FAO (food and agriculture organization). World food situation; 2017. http://www.fao.org/worldfoodsituation/csdb/en/. Accessed 25 Feb 2020
14. Food Agriculture Organization (FAO), 1995. Corporate document repository. Sorghum and milletsin human nutrition. http://www.fao.org/docrep/ t0818e/T0818E0e.htm
15. FAO, 2009. FAOSTAT. Food and Agriculture Organisation of the United Nations. FAOSTAT. Retrieved from http://faostat.fao.org/site/339/ default.aspx
16. Gong, L., Cao, W., Chi, H., Wang, J., Zhang, H., Liu, J., & Sun, B., 2018. Whole Cereal grains and potential health effects: Involvement of the gut microbiota. Food Research International, 103, 84–102.
17. Hou D, Chen J, Ren X, Wang C, Diao X, Hu X, Zhang Y and Shen Q., 2018. A whole foxtail millet diet reduces blood pressure in subjects with mild hypertension J. Cereal Sci. 84 13-19
18. ICAR - Indian Institute of Millets Research, 2017 (ICMR) Jana kalinova, Nutritionally important components of Proso millets (*panicum miliceum L.*) Global science books food, 1(1), 91-100
19. ICRISAT. (2017). Small millets. Retrieved from http://www.icrisat.org/ homepage
20. Itagi, S., Naik, R. and Yenagi, N., 2013.Versatile little millet therapeutic mix for diabetic and non diabetics. Asian Journal of Science and Technology. 4 (10): 033-035.
21. Kimeera Ambati and Sucharitha K.V., 2019. Millets review on Nutritional profile and health benefits. International Journal of Recent Scientific Research, July,.Vol. 10, Issue, 07(I), pp. 33943-33948 .
22. Kyung-Ok PARK, Yoshiaki ITO, Takashi NAGASAWA, Myeong-Rak CHOI & Naoyuki NISHIZAWA. 2008. Effects of Dietary Korean Proso-Millet Protein on Plasma Adiponectin, HDL Cholesterol, Insulin Levels, and Gene Expression in Obese Type 2 Diabetic Mice, Bioscience, Biotechnology, and Biochemistry, 72:11, 2918-2925
23. Lee, S. H., Chung, I. M., Cha, Y. S., & Park, Y., 2010. Millet consump- tion decreased serum concentration of triglyceride and C-re- active protein but not oxidative status in hyperlipidemic rats. Nutrition Research, 30(4), 290–296.
24. NIN, 2017. Indian Food Compostion Tables. IIMR (Ministry of Health and Family Welfare, GoI); Hyderabad, India: 2017.
25. Nithiyanantham S., Kalaiselvi P., Mahomoodally M. F., Zengin G., Abirami A., Srinivasan G. 2019. Nutritional and functional roles of millets—A review. *Journal of food biochemistry*, 43(7):01-10.
26. Reddy O.S.K., 2017. Smart Millet and Human Health, Green Universe Environmental Services Society.
27. Pattanashetti S.K., Upadhyaya H.D., Dwivedi S.L., Vetriventhan M., 2016. Reddy K.N. Genetic and Genomic Resources for Grain Cereals Improvement. Elsevier; Amsterdam, The Netherlands: Pearl Millet; 253–289.
28. Park SY, Jeong EW, Yang YS, Kim HJ, Go GW, Lee HG., 2021. Finger millet ethanol extracts prevent hypertension by inhibiting the angiotensin-converting enzyme level and

enhancing the antioxidant capacity in spontaneously hypertensive rats. Antioxidants (Basel). Nov 4;10(11):1766

29. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P & Sudha A. 2011. Dietary Profile of Urban Adult Population in South India in the Context of Chronic Disease Epidemiology (CURES-68). J. Public Health Nut., 14(4): 591–598.
30. ao A, Prabhu D, Krishnamurthy V., 2019. Millets in metabolic syndrometime to tap the potential.J Evid Based Med Healthc. 6:1284–7
31. Rao D.B., Malleshi N.G., Annor G.A., Patil J.V., 2017. Millets Value Chain for Nutritional Security: A Replicable Success Model from India. Nutritional and health benefits of millets; IndianInstitute of Millets Research (IIMR); Hyderabad, India, p. 112
32. Ragaee, S., Abdel-Aal, E. S. M., & Noaman, M., 2006. Antioxidant activity andnutrient composition of selected Cereals for food use. Food Chemistry, 98(1), 32-38.
33. Rajasekaran NS, Nithya M, Rose C & Chandra TS., 2004. The effect of finger millet feeding on the early responses during the process of wound healing in diabetic rats. Biochim. Biophys. Acta.; 1689: 190–201.
34. Saini S., Saxena S., Samtiya M., Puniya M., Dhewa T., 2021. Potential of Underutilized Millets as Nutri-Cereal: An Overview. *J. Food Sci. Technol.*;58:4465–4477
35. Sarita, E. S., & Singh, E., 2016. Potential of millets: Nutrients composition and health benefits. Journal of Scientific and Innovative Research, 5(2), 46–50.
36. Shahidi, F., Janitha, P. K., and Wanasundara, P. D., 1992. Phenolic antioxidants. *Crit. Rev. Food Sci. Nutr.* 32, 67–103.
37. Shobana S, Usha Kumari SR, Malleshi NG, Ali SZ., 2007. Glycemic response of rice, wheat and fnger millet based diabetic food formulations in normoglycemic subjects. Int J Food Sci Nutr 58: 363-372.
38. Shweta Joshi and Sarita Srivastava, 2021. Hypoglycemic and Hypolipidemic Effect of Barnyard Millet Consumption in Type 2 Diabetic Subjects. Int.J.Curr. Microbiol.App.Sci. 10(03): 467-477.
39. Singh P & Raghuvanshi RS., 2012. Finger Millet for Food and Nutrition Security. African Journal of Food Science. 2012; 6(4): 77-84.
40. Singh, N., Meenu, G., Sekhar, A., and Abraham, J., 2015. Evaluation of anti-microbial and anti- cancer properties of finger millet (*Eleusine coracana*) and Pearl millet (*Pennisetum glaucum*) extracts. *Pharma. Innov. J.* 3, 82–86.
41. Van Rensburg SJ., 1981. Epidemiological and dietary evidence for a specific nutritional predisposition to esophageal cancer. J Natl Cancer Inst 67(2):243–51
42. Yang, X., Wan, Z., Perry, L., Lu, H., Wang, Q., Zhao, C., Ge, Q., 2012. Early millet use in northern China. Proceedings of the National Academy of Sciences of the United States of America, 109(10), 3726– 3730.

REVIEW ON EFFECT OF CONSUMING EXCESSIVE SUGARS ON HUMAN HEALTH

R. Dhamini* and J. Sridevi
Department of Nutrition & Dietetics
PSG College of Arts & Science, Coimbatore- 641014
*Corresponding author E-mail: dhaminir2001@gmail.com

Abstract:

Consumption of added sugars is linked to an increased risk of various chronic diseases such as obesity, cardiovascular disease, diabetes, non-alcoholic fatty liver disease (NAFLD), cognitive decline, and even some malignancies. Through systematic reviews, meta-analyses, and randomised controlled trials (RCTs), this review article provides a summary of current research on added sugars and health implications. Although it is acceptable to take added sugars in moderation, removing them from the diet without reducing other caloric sources appears unlikely to have a major beneficial effect.

Keywords: Added sugars, health considerations

Introduction:

At the beginning of the 20th century sucrose commonly known as refined sugar replaced the other natural sweeteners and became the most popular sweetening agent used especially by the consumers and food industry; but most of them results in ill health or worsen the health. Sugar is one of the oldest traded commodities. From the 15th Century onwards sugar has had a large influence on many economies worldwide (Griggs, 2011; Gudoshnikov *et al.,* 2004) and nowadays represents an important commodity for the economies of different countries and one of the most regulated products in international markets (Benešová *et al.*, 2015).

Where does added sugar come from

Food group	Proportion of average intake
Soda/energy/sports drinks	42.2%
Grain-based desserts	11.9%
Fruit drinks	8.5%
Dairy desserts	5.5%
Candy	5.0%
Ready-to-eat cereals	2.9%
Sugars/honey	4.1%
Tea	3.8%
Yeast breads	2.3%
Syrups/toppings	1.4%

Source: CDC, National Health and Nutrition Examination Survey, 2005–06.

Sucrose, commonly known as sugar, is a disaccharide carbohydrate, extractable in nature from various plant sources. However, given the modest content in most vegetables, it is economically advantageous to extract it from sugar cane (which contains 10–15% sucrose on the

total weight) and sugar beet (containing 13–18% sucrose of its weight) (FAO, 2010; Gudoshnikov *et al.,* 2004).Sugar production relies on two different crops that are produced in very distant geographical areas from each other, resulting in a strong competition and inter-relationship between the markets of the two crops namely Sugar cane and Beet crops. Whether during the 1960s beet sugar accounted for almost half of the world production tonnage, today only 20% of global sugar is produced from beet while 80% of the global production of sucrose comes from sugar cane (FAO, 2010).

Sugar consumption and Risk factors of Chronic disease

Added sugars are among the most controversial and hotly debated topics in all the nutrition field [5 - 22]. Consumption of added sugars has beenassociated with increased risk of obesity [23,24,25] as well as increased risk factors forcardiovascular disease (CVD) [26], including dyslipidaemia [27,28], elevated blood pressure [20,29,30], diabetes [21,31,32], non-alcoholic fatty liver disease [33,34], and even cognitive decline [35] and cancer [36,37]. Data to support these assertions, however, have been challenged consistently. Often these assertions have been based on research trials which provide added sugars in dosages well above those typically found in human consumption (Supra physiological) [12]. Studies comparing pure fructose to pure glucose, neither of which is consumed to any appreciable degree in the human diet, have also been extrapolated to human nutrition [38,39]. Although, some trials have compared sucrose to glucose or starch in isocaloric exchange and demonstrated harm with regard to sucrose in insulin/glucose markers and prediabetes/diabetes.Speculation about chronic conditions based on acute data has frequently been employed [40].

Metabolic controversies in Sugars containing Fructose

Many of the controversies related to fructose are based on the well-known differences between metabolism of fructose and glucose in the liver. Over 90% of fructose ingested is absorbed through the small intestine and metabolized in the liver on first pass. In contrast, glucose is metabolized by a variety of organs. It is important to note, however, that the pathways are interactive. Numerous studies including isotope studies have shown that roughly 50% of fructose is converted to glucose within the liver. An additional 15%–20% is converted to glycogen, 20%–25% to lactate, and a few percent to carbon dioxide [62,63]. Multiple studies have shown that only 1%–5% of consumed fructose may follow the pathway of de novo lipogenesis and be converted into free fatty acids which are then packaged as triglycerides and either stored in the liver or released in the bloodstream [62,64,65]. Some short-term data with very large doses of pure fructose have suggested that increases in liver fat can be achieved over a short period of time; Faeh *et al.* [66] gave seven healthy men six days of a high fructose diet comprising an extra 25% of total calories and demonstrated suppression of adipose tissue lipolysis. Schwarz *et al.* [67] demonstrated that utilisation of a diet with 25% pure fructose increased fractional hepatic DNL and liver fat. The researchers studied 25 Latino children and 15 African American children and demonstrated over a ten-day period that replacing high fructose products with vegetables, bread, or pasta decreased liver fat in the study population [68]. In certain animals, de novo lipogenesis can be a major pathway [69]. In humans, it is minimal. Some investigators have misinterpreted the effect of this pathway in humans to contend that fructose consumption can result in increased risk of Non-Alcoholic Fatty Liver Disease

(NAFLD) and Insulin resistance [15]. The notion that high fructose corn syrup (HFCS) consumption has contributed to the obesity epidemic gained traction after the publication of an opinion piece in the American Journal of Clinical Nutrition in 2004 by Bray, Nielson, and Popkin (1). The authors noted that there is a temporal relation between the increase in HFCS consumption and the rise in obesity rates, but cautioned that this association does not prove cause and effect. Unfortunately, this caveat was ignored by many, leading to the erroneous belief that HFCS was uniquely responsible for obesity. However, subsequent research has shown that HFCS and sucrose have identical metabolic effects and health outcomes in humans (70-72).

It is worth noting that sugar consumption has actually declined in the United States, Britain, canada, and Australia, even as obesity rates continue to rise. This phenomenon, dubbed the"Australian Paradox," was first observed in Australia (73). Additionally, Mozaffarian *et al.* combined data from the Nurses' Health Study and Health Professionals Follow-up Study to investigate the impact of increased servings of various foods on weight change over four years (74). After adjusting for age, BMI, sleep, physical activity, alcohol consumption, television watching, smoking, and all other dietary factors, the researchers found that French fries, potato chips, processed meat, and red meat were associated with more weight gain than sugar-sweetened beverages (SSBs). However, it's important to note that these findings come from cohort studies and are not the same as a randomized controlled trial. It may be that these food items are simply markers for an overall diet that is high in energy density and thus more likely to result in weight gain (74).

The impact of sugars on body weight and composition

Here has been debate regarding the relationship between sugar consumption and weight gain. Randomized controlled trials (RCTs) have been conducted to explore this link, and four recent meta-analyses have reported different conclusions due to variations in inclusion and exclusion criteria, as well as endpoint estimates [46,75,76,77] (See Table 1). Two meta-analyses by Sievenpiper *et al.* [76] and Te Morenga *et al.* [46] examined the effect of body weight in adults by assessing the isocaloric exchange of sugar or fructose with other macronutrients. Meanwhile, all four research groups conducted meta-analyses on studies involving an increased intake of sugar calories among adults consuming ad libitum diets, with all four concluding that significant weight gain occurred, although individual studies often did not support this. Recent meta-analyses by Dolan *et al.* [78, 79] using interventional studies did not find a link between fructose consumption and obesity in normal weight or obese individuals. A report by the Scientific Advisory Committee on Nutrition (SACN) in the UK, based on systematic reviews, found that high levels of free sugar consumption were associated with excess calorie intake [47]. Therefore, weight gain in these studies could not be solely attributed to free sugar consumption. Fructose-containing sugars have been reported to potentially predispose individuals to abdominal weight gain [80, 81]. However, a 10-week study showed that the difference in abdominal weight gain between fructose and glucose disappeared when appropriate comparisons were made [80]. Similarly, a six-month study showed that those who consumed sugar-sweetened beverages increased visceral abdominal fat, but also gained weight, which represents a confounding variable [80].

Three randomized controlled trials (RCTs) have been conducted recently to investigate the relationship between sugar consumption and weight change. These studies employed slightly different strategies. One trial involved consuming average amounts of fructose-containing sugars (high fructose corn syrup (HFCS) or sucrose) for adults and did not result in an increase in body weight over a ten-week, free living trial [51]. Another trial utilized mean amounts of these sugars as part of an overall hypocaloric diet and did not inhibit weight loss [52]. It is worth noting that there were no differences observed between 10% and 20% of either HFCS or sucrose. In a larger trial involving 355 men and women who consumed either 8%, 18%, or 30% of kcals/day of either sucrose or HFCS as part of a mixed nutrient diet, individuals gained an average of slightly over two pounds over a ten-week period. However, most of this was driven by the 30% kcals per day (above the 95% population consumption for fructose) [53]. At the end of the study, individuals consumed an average of more than 200 kcals/day compared to baseline. Hence, this should be viewed as a hypercaloric trial.

In subtraction trials, fructose-containing sugars led to the expected weight loss (with some exceptions in children). This suggests that fructose-containing sugars do not behave differently from other macronutrients, mainly starch when comparisons are matched for calories. Another approach to this issue was obtained from an ad libitum trial design where fructose-containing sugars were freely replaced with other sources of energy in the diet, and no strict control of the amount of sugars in the background diet occurred. The Carbohydrate Ratio Management in European National Diets (CARMEN) trial [84] is the largest and longest trial that used such a design. This diet compared ad libitum high complex carbohydrate diet to an ad libitum higher fat control trial in 398 obese individuals studied for over six months. Both ad libitum diets resulted in weight loss. There was no significant difference between the ad libitum high sugars diet and the ad libitum high complex carbohydrate diet. There was a non-significant tendency toward greater weight loss in the latter. This trial also showed that under free living conditions, it is possible to lose weight following an ad libitum high sugars diet employing a strategy to freely replace energy from high fructose-containing sugars with other sources of energy in the diet. It also demonstrates that there is no clear advantage for reducing sugars as compared to fat in the diet [46,75,76,77]. Given the complexity of weight gain and energy regulation, it is unlikely that one component of the diet significantly impacts this problem. In fact, the consensus statement from the American Society of Nutrition on energy regulation specifically warns against isolating one component of the diet and blaming it for obesity [85].

Furthermore, numerous studies have linked increased caloric intake from all sources and decreased physical activity to weight gain [86][87]. In fact, the average American consumed 454 more calories in 2010 than in 1970, with 93% of these additional calories coming from increased consumption of flour and cereal products or fats, while only 7% (39 additional calories) came from all sugars combined. Interestingly, the percentage of calories from sugar in the American diet actually declined from 19% to 17% during this period [88]. However, it is important to note that sugars may provide excess energy due to their hedonic properties, and increased sugar intake in some individuals may be indicative of an overall less healthy, energy-dense diet. The recent literature on the impact of added sugars on obesity, weight gain, or weight loss is still a subject of debate. Most randomized controlled trials suggest that weight gain only occurs in hypercaloric

trials, which suggests that overall caloric consumption is likely to be a larger contributor to weight gain than any unique property of sugars [74][75].

Considerable confusion exists surrounding the potential impact of added sugars on risk factors for diabetes. Two ecological studies that suggested a correlation between the availability of sugars and increased risk of diabetes received a great deal of media attention [31,32]. However, caution must be exercised when interpreting such studies as they are considered to be one of the lowest forms of evidence and have been criticized on various technical grounds. For instance, in one ecological study, Goran *et al.* [32] reported a 20% higher prevalence of diabetes in European Union (EU) countries with higher availability of high fructose corn syrup (HFCS) compared to those with lower availability. However, it was later pointed out by Van Buul *et al.* [5] that the HFCS consumption data in EU countries reported in the study were actually production data and cannot be assumed to be equivalent to consumption data, as HFCS freely crosses EU borders. In another ecological study, Basu *et al.* [31] used food supply data from the UNFAO to determine market availability of different food items worldwide and concluded that sugar availability was associated with higher diabetes prevalence. However, market availability of food is a highly unreliable indicator of sugar consumption [6].

On the other hand, prospective cohort studies have not found a direct relationship between fructose and diabetes [89]. While pooled analyses of these studies did reveal an increased risk of diabetes associated with SSBs as a source of free sugar, this relationship was only seen when comparing the highest and lowest levels of exposure [22,90]. Interestingly, pooled analyses of these studies for total sugars, total sucrose, and total fructose did not yield the same relationship [91]. Furthermore, systematic reviews and meta-analyses have reported a decrease in the risk factor glycosylated proteins with sugar consumption [82]. Finally, a large European cohort study did not find an increase in diabetes risk associated with added sugars [92].

Risk drivers for diabetes:

Considerable confusion exists with regard to the potential impact of added sugars on risk factors for diabetes. A great deal of attention was paid to this issue in the media following two ecological studies which suggested that availability of sugars was correlated with increased risk of diabetes [31,32]. These types of ecological studies, however, must be treated with great caution. Ecological studies are considered as one of the lowest forms of evidence. Furthermore, these studies have been criticized on a variety of technical grounds. In one ecological study, Goran *et al.* [32] reported that diabetes prevalence was 20% higher in European Union (EU) countries with higher availability of HFCS compared to countries with low availability. As noted by Van Buul et al (5) . However, HFCS consumption data in EU countries reported in this study were, in fact, not ‘consumption data’ at all but ‘production data’ [5]. Since HFCS travels freely across EU borders, production data cannot be assumed to be equivalent to consumption data. In another ecological study, Basu et al (31) used food supply data from the UNFAO to determine market availability of different food items worldwide and concluded that sugar availability was associated with higher diabetes prevalence. Market availability of food, however, is a highly unreliable indicator of sugar consumption [6].

Prospective cohort studies have not documented a direct relationship between fructose and diabetes [89]. Pooled analysis of these cohorts did reveal that SSBs (Sugar-Sweetened

Beverages) as a source of free sugar are associated with an increased risk of diabetes only when comparing highest and lowest levels of exposure [22,90]. Pooled analyses of these cohorts, however, for total sugars, total sucrose, and total fructose have not yielded the same relationship [91]. In addition, systematic reviews and meta-analyses of sugar and diabetes risk factors have actually reported a decrease in the risk factor namely glycosylated proteins [82]. A large cohort study in Europe also did not show an increase in diabetes risk with added sugars [92].

The question of whether or not sugar is a unique cause of diabetes has not been addressed in any RCT. Most of the data related to the question of a potential relationship between sugar consumption and diabetes comes from RCTs looking at the risk factors for diabetes or cohort studies. Prospective cohort studies provide mixed evidence concerning sugar consumption and diabetes. Malik et al (24). Reported meta-analyses of eight cohort studies, four of which did not find a significant effect of SSB with the incidence of diabetes and five did not adjust findings for energy intake and body weight [22]. A study published by the same group did not show a relation between sugar consumption and the risk of diabetes [93].

Other cohort studies have also failed to find significant associations between sugar intake and diabetes [94,95,96] and one study found a significant negative association [95]. With regard to systematic reviews and meta-analyses, few data are available to support an association between sugar intake and diabetes [94,95,96]. Cozma et al(84) reported a systematic review and meta-analysis of 18 feeding studies on fructose and diabetes risk and found no adverse impact on glycemic control including insulin, glucose, glycosylated blood proteins (including HbA1c) [82]. The SACN report published in 2015 [47] did not show an association between free sugars consumption and risk factors for diabetes.

Most randomized controlled trials of non-diabetic patients substituting sucrose for fructose in a controlled diet did not report adverse effects on multiple risk factors for diabetes [70,78,97,98,99]. Two recent RCTs have also not demonstrated increased risk factors for diabetes over a 10-week time period. In one study of 123 individuals who consumed average levels of fructose containing sugars (9% of calories from fructose itself or 18% of calories from either sucrose or HFCS) did not yield increase in fasting glucose, insulin, or insulin resistance via the Homeostatic Model of Assessment (HOMA) [100]. Another RCT evaluated 267 individuals who consumed either HFCS or sucrose at dosage ranges between 8% and 30% of calories (25^{th} through 95^{th} percentile of calories) and did not find any increase in risk factors for diabetes [53].

This literature taken together provides little direct evidence that sugar consumption increases risk factors of diabetes. Moreover, since the relationship between diabetes and obesity is well established and, as already indicated, scant evidence is available relating isocaloric substitution of sugars for other carbohydrates, it appears prudent to focus on other risk factors for diabetes such as obesity rather than singling out sugars. Since diabetes takes 20–30 years to develop short-term RCTs focusing on risk factors for diabetes should be taken with caution recognizing this limitation.

Risk Factors for Cardiovascular Disease:

The American Heart Association (AHA) has set a recommendation that adult males should not consume more than 150 kcals per day from added sugars, while females should limit their intake to no more than 100 kcals per day [101]. This suggests that consuming higher levels

of added sugars may increase the risk of heart disease. Moreover, the 2015 DGAC concluded that there is "moderate" evidence for the association between added sugars and heart disease [48]. However, the SACN report published in 2015 did not find any link between sugar consumption and risk factors for heart disease [47]. The available evidence in this area is mixed and inconclusive [13].

It is worth noting that no RCTs have evaluated the relationship between added sugars and cardiovascular disease. Therefore, the available data comes from either cohort studies or RCTs examining risk factors for CVD [137]. Dietary sugars may have varying effects on blood lipids. Several studies have demonstrated that diets containing more than 20% of kcals from simple sugars may result in elevated fasting triglycerides, which is a well-known risk factor for CVD (refer to Table 3) [32,54-61,99].

The American Heart Association's Scientific Statement on triglycerides suggests avoiding excessive fructose as one of the mechanisms to reduce the risk of hypertriglyceridemia [102]. However, recent systematic reviews and meta-analyses have reported that when fructose is isocalorically substituted for other carbohydrates, it does not lead to increased fasting or post-prandial triglycerides [103,104].

To put the issue of SSB consumption into perspective, it should be noted that the primary risk factors for heart disease, such as avoiding cigarette smoking, maintaining a healthy weight, controlling or avoiding diabetes, and leading an active lifestyle, are well-established. Therefore, it would be more prudent to focus on these established risk factors rather than solely targeting sugar intake. Longer-duration RCTs would be beneficial in examining the potential links between sugar consumption and risk factors for CVD [137].

Research on the effects of sugar on the brain, specifically on reward pathways and downstream portions, has been a controversial topic. Early studies were primarily conducted on animals, but recent advances in functional MRI have allowed more human studies to be conducted. However, caution must be taken when interpreting animal studies as there are significant differences between animal and human brains. Furthermore, studies comparing fructose versus glucose have led to speculation that they interact differently in the brain, potentially leading to overconsumption of calories. Studies comparing the normally consumed sugars of sucrose or HFCS have found no differences in blood flow to the hypothalamus and brain connectively. Claims of sugar addiction have been made, supported by animal data, but the translation of animal data to humans is complex and speculative. Several reviews have questioned the fundamental premise of food or sugar addiction, and more research is needed in this area. Despite popular belief, the concept of sugar addiction appears to be an exaggeration of scientific data. (James M. Rippe, Theodore J. Angelopoulos, 137)

Impact of sugars on the brain:

The impact of sugar on the brain, particularly on reward pathways and downstream regions, has been extensively studied and debated. Early research in this area primarily involved animal studies [43,112,113,114]. However, advancements in functional MRI (fMRI) technology have allowed for more studies to be conducted on human subjects [115]. While animal studies are informative, caution must be exercised due to significant differences between animal and human brains, particularly in rodents, which are commonly used as models [116,117].

Compounding the confusion, some studies have compared the effects of fructose versus glucose on blood flow to the hypothalamus and reward pathways, despite these monosaccharides rarely being consumed in isolation in human diets [118,119]. Such studies have led to speculation that fructose and glucose may interact differently in the brain, potentially leading to overconsumption of calories [137].

However, trials comparing the commonly consumed sugars of sucrose or HFCS on blood flow to the hypothalamus and brain connectivity have not shown any differences between sweetened beverages consumed with a mixed nutrient meal versus an unsweetened control [120]. Stephan *et al.* [35] used epidemiological data to suggest that increased consumption of fructose-containing sugars may contribute to dementia. Nevertheless, studies conducted over durations ranging from 10 to 24 weeks and using average consumption levels of fructose-containing sugars have not found any evidence of cognitive changes [123,124].

Regrettably, there has been speculation among researchers that the sweetness derived from added sugars may cause a type of sugar "addiction" [15,125]. This assertion has been reinforced by animal data [126,127], although the translation of such data to humans in this field is complicated and speculative. A number of recent reviews have conducted extensive analyses challenging the fundamental premise of either food or sugar "addiction" [128,129,130]. Unfortunately, the public and the popular press have adopted the notion of sugar "addiction," which appears to be a considerable exaggeration of the scientific evidence. Clearly, further research is required in this area (Rippe & Angelopoulos, 137).

Conclusion:

It is clear that there are many important links between Nutrition and Health. The present emphasis on added sugars, however, has created an environment that is “Sugar-Centered” as general opinion. There are well established risk factors for obesity, diabetes, and cardiovascular disease and considerable overlap amongst these entities when it comes to nutritional practices. Certainly, added sugars can be viewed as components of overall diet and therefore as reduction targets, as well as other high-energy components of that nutritional model. Identified added sugars as primary or single culprits for metabolic diseases are obesity, diabetes and cardiovascular disease appear to be incompatible with modern, high-quality evidence and are unlikely to result in health benefits. The reduction of these dietary components without further reductions seems unlikely to achieve significant results.

References:

1. Gidding S.S., Lichtenstein A.H., Faith M.S., Karpyn A., Mennella J.A., Popkin B., Rowe J., Van Horn L., Whitsel L. Implementing american heart association pediatric and adult nutrition guidelines, Circulation. 2009;119:1161–1175.
2. Thomas M.C., Moran J., Forsblom C., Harjutsalo V., Thorn L., Ahola A., Waden J., Tolonen N., Saraheimo M., Gordin D., *et al.* The association between dietary sodium intake, esrd, and all-cause mortality in patients with type 1 diabetes. Diabetes Care. 2011;34:861–866. Doi: 10.2337/dc10-1722.
3. O’Donnell M., Mente A., Rangarajan S., McQueen M.J., Wang X., Liu L., Yan H., Lee S.F., Mony P., Devanath A., *et al.* Urinary sodium and potassium excretion, mortality, and

cardiovascular events. N. Engl. J. Med. 2014;371:612–623. Doi: 10.1056/NEJMoa1311889.

4. Nakamura Y., Okamura T., Tamaki S., Kadowaki T., Hayakawa T., Kita Y., Okayama A., Ueshima H., Group N.D.R. Egg consumption, serum cholesterol, and cause-specific and all-cause mortality: The national integrated project for prospective observation of non-communicable disease and its trends in the aged, 1980 (nippon data80) Am. J. Clin. Nutr. 2004;80:58–63.
5. Van Buul V.J., Tappy L., Brouns F.J. Misconceptions about fructose-containing sugars and their role in the obesity epidemic. Nutr. Res. Rev. 2014;27:119–130. Doi: 10.1017/S0954422414000067.
6. Tappy L., Lê K.-A. Health effects of fructose and fructose-containing caloric sweeteners: Where do we stand 10 years after the initial whistle blowings? Curr. Diab. Rep. 2015;15:1–12. doi: 10.1007/s11892-015-0627-0.
7. Kahn R., Sievenpiper J.L. Dietary sugar and body weight: Have we reached a crisis in the epidemic of obesity and diabetes?: We have, but the pox on sugar is overwrought and overworked. Diabetes Care. 2014;37:957–962. doi: 10.2337/dc13-2506.
8. Rippe J. Fructose, High Fructose Corn Syrup, Sucrose and Health. Humana Press; New York, NY, USA: 2014.
9. Rippe J. The metabolic and endocrine response and health implications of consuming sweetened beverages: Findings from recent, randomized, controlled trials. Adv. Nutr. 2013;4:677–686. doi: 10.3945/an.113.004580.
10. Rippe J.M., Angelopoulos T.J. Sucrose, high-fructose corn syrup, and fructose, their metabolism and potential health effects: What do we really know? Adv. Nutr. 2013;4:236–245. doi: 10.3945/an.112.002824.
11. White J. Straight talk about high-fructose corn syrup: What it is and what it ain't. Am. J. Clin. Nutr. 2008;88:1716S–1721S. doi: 10.3945/ajcn.2008.25825B.
12. White J.S. Challenging the fructose hypothesis: New perspectives on fructose consumption and metabolism. Adv. Nutr. 2013;4:246–256. doi: 10.3945/an.112.003137.
13. Rippe J.M., Angelopoulos T.J. Fructose-containing sugars and cardiovascular disease. Adv. Nutr. 2015;6:430–439. doi: 10.3945/an.114.008177.
14. Bray G.A., Popkin B.M. Dietary sugar and body weight: Have we reached a crisis in the epidemic of obesity and diabetes?: Health be damned! Pour on the sugar. Diabetes Care. 2014;37:950–956. doi: 10.2337/dc13-2085.
15. Lustig R.H. Fructose: Metabolic, hedonic, and societal parallels with ethanol. J. Am. Diet. Assoc. 2010;110:1307–1321. doi: 10.1016/j.jada.2010.06.008.
16. Rippe J.M., Angelopoulos T.J. Sugars and health controversies: What does the science say? Adv. Nutr. 2015;6:493S–503S. doi: 10.3945/an.114.007195.
17. Klurfeld D.M., Foreyt J., Angelopoulos T.J., Rippe J.M. Lack of evidence for high fructose corn syrup as the cause of the obesity epidemic. Int. J. Obes. (Lond.) 2012;27:771–773. doi: 10.1038/ijo.2012.157.
18. American Dietetic Association Position of the American dietetic association: Use of nutritive and nonnutritive sweeteners. J. Am. Diet. Assoc. 2004;104:255–275.

19. Popkin B.M. The World Is Fat: The Fads, Trends, Policies, and Products That Are Fattening the Human Race. Penguin Group; New York, NY, USA: 2008.
20. DiNicolantonio J.J., Lucan S.C. The wrong white crystals: Not salt but sugar as aetiological in hypertension and cardiometabolic disease. Open Heart. 2014;1:e000167. doi: 10.1136/openhrt-2014-000167.
21. DiNicolantonio J.J., O'Keefe J.H., Lucan S.C. Added fructose: A principal driver of type 2 diabetes mellitus and its consequences. Mayo Clin. Proc. 2015;90:372–381. doi: 10.1016/j.mayocp.2014.12.019.
22. Lucan S.C., DiNicolantonio J.J. How calorie-focused thinking about obesity and related diseases may mislead and harm public health. An alternative. Public Health Nutr. 2015;18:571–581. doi: 10.1017/S1368980014002559.
23. Olsen N.J., Heitmann B.L. Intake of calorically sweetened beverages and obesity. Obes. Rev. 2009;10:68–75. doi: 10.1111/j.1467-789X.2008.00523.x.
24. Malik V.S., Schulze M.B., Hu F.B. Intake of sugar-sweetened beverages and weight gain: A systematic review. Am. J. Clin. Nutr. 2006;84:274–288.
25. Malik V.S., Popkin B.M., Bray G.A., Després J.-P., Hu F.B. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. Circulation. 2010;121:1356–1364. doi: 10.1161/CIRCULATIONAHA.109.876185.
26. Bray G.A. Fructose and risk of cardiometabolic disease. Curr. Atheroscler. Rep. 2012;14:570–578. doi: 10.1007/s11883-012-0276-6.
27. Marckmann P. Dietary treatment of thrombogenic disorders related to the metabolic syndrome. Br. J. Nutr. 2000;83(Suppl. 1):S121–S126. doi: 10.1017/S0007114500001057.
28. Bray G.A., Popkin B.M. Calorie-sweetened beverages and fructose: What have we learned 10 years later. Pediatr. Obes. 2013;8:242–248. doi: 10.1111/j.2047-6310.2013.00171.x.
29. Feig D., Soletsky B., Johnson R. Effect of allopurinol on blood pressure of adolescents with newly diagnosed essential hypertension. J. Am. Med. Assoc. 2008;300:924–932. doi: 10.1001/jama.300.8.924.
30. Nguyen S., Choi H.K., Lustig R.H., Hsu C.Y. Sugar-sweetened beverages, serum uric acid, and blood pressure in adolescents. J. Pediatr. 2009;154:807–813. doi: 10.1016/j.jpeds.2009.01.015.
31. Basu S., Yoffe P., Hills N., Lustig R.H. The relationship of sugar to population-level diabetes prevalence: An econometric analysis of repeated cross-sectional data. PLoS ONE. 2013;8:e57873. Doi: 10.1371/journal.pone.0057873.
32. Goran M.I., Ulijaszek S.J., Ventura E.E. High fructose corn syrup and diabetes prevalence: A global perspective. Glob. Public Health. 2013;8:55–64. Doi: 10.1080/17441692.2012.736257.
33. Clark J.M. The epidemiology of nonalcoholic fatty liver disease in adults. J. Clin. Gastroenterol. 2006;40:S5–S10. Doi: 10.1097/1001.mcg.0000168638.0000184840.ff.
34. McCullough A. Update on nonalcoholic fatty liver disease. J. Clin. Gastroenterol. 2002;34:255–262. Doi: 10.1097/00004836-200203000-00013.
35. Stephan B.C., Wells J.C., Brayne C., Albanese E., Siervo M. Increased fructose intake as a risk factor for dementia. J. Gerontol. A. Biol. Sci. Med. Sci. 2010;65:809–814. Doi: 10.1093/gerona/glq079.

36. Cantley L.C. Cancer, metabolism, fructose, artificial sweeteners, and going cold turkey on sugar. BMC Biol. 2014;12:8. Doi: 10.1186/1741-7007-12-8.
37. Bartrina J.A., Rodrigo C.P. Aassociation between sucrose intake and cancer: A review of the evidence. Nutr. Hosp. 2013;4:95–105.
38. Stanhope K., Griffen S., Bair B., Swarbrick M., Kelm N., Havel P. Twenty four hour endocrine and metabolic profiles following consumption of high-fructose corn syrup-, sucrose-, fructose-, and glucose-sweetened beverages with meals. Am. J. Clin. Nutr. 2008;87:1194–1203.
39. Cox C.L., Stanhope K.L., Schwarz J.M., Graham J.L., Hatcher B., Griffen S.C., Bremer A.A., Berglund L., McGahan J.P., Havel P.J., *et al.* Consumption of fructose-sweetened beverages for 10 weeks reduces net fat oxidation and energy expenditure in overweight/obese men and women. Eur. J. Clin. Nutr. 2012;66:201–208. Doi: 10.1038/ejcn.2011.159.
40. Stice E., Burger K.S., Yokum S. Relative ability of fat and sugar tastes to activate reward, gustatory, and somatosensory regions. Am. J. Clin. Nutr. 2013;98:1377–1384. Doi: 10.3945/ajcn.113.069443.
41. Lindqvist A., Mohapel P., Bouter B., Frielingsdorf H., Pizzo D., Brundin P., Erlanson-Albertsson C. High-fat diet impairs hippocampal neurogenesis in male rats. Eur. J. Neurol. 2006;13:1385–1388. Doi: 10.1111/j.1468-1331.2006.01500.x.
42. Funari V.A., Herrera V.L., Freeman D., Tolan D.R. Genes required for fructose metabolism are expressed in purkinje cells in the cerebellum. Brain Res. Mol. Brain Res. 2005;142:115–122. Doi: 10.1016/j.molbrainres.2005.09.019.
43. Miller C.C., Martin R.J., Whitney M.L., Edwards G.L. Intracerebroventricular injection of fructose stimulates feeding in rats. Nutr. Neurosci. 2002;5:359–362. Doi: 10.1080/1028415021000033839.
44. Shu H.J., Isenberg K., Cormier R.J., Benz A., Zorumski C.F. Expression of fructose sensitive glucose transporter in the brains of fructose-fed rats. Neuroscience. 2006;140:889–895. Doi: 10.1016/j.neuroscience.2006.02.071.
45. Bray G. Energy and fructose from beverages sweetened with sugar or high-fructose corn syrup pose a health risk for some people. Adv. Nutr. 2013;4:220–225. Doi: 10.3945/an.112.002816.
46. Te Morenga L., Mallard S., Mann J. Dietary sugars and body weight: Systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ. 2013;346:e7492. Doi: 10.1136/bmj.e7492.
47. Scientific Advisory Committee on Nutrition (SACN) Carbohydrates and Health Report. The Stationery Office; London, UK: Sep 1, 2014.
48. Scientific Report of the 2015 Dietary Guidelines Advisory Committee. USDA; Washington, DC, USA: 2015. Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture.
49. Johnson R., Appel L., Brands M., Howard B., Lefevre M., Lustig R., Sacks F., Steffen L., Wylie-Rosett J., American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and

Prevention Dietary sugars intake and cardiovascular health: A scientific statement from the american heart association. Circulation. 2009;120:1011–1020.

50. Scottish Intercollegiate Guidelines Network (SIGN) [(accessed on 17 August 2016)]. Available online: http://www.Sign.Ac.Uk/guidelines/fulltext/50/
51. Lowndes J., Sinnett S., Pardo S., Nguyen V.T., Melanson K.J., Yu Z., Lowther B.E., Rippe J.M. The effect of normally consumed amounts of sucrose or high fructose corn syrup on lipid profiles, body composition and related parameters in overweight/obese subjects. Nutrients. 2014;6:1128–1144. Doi: 10.3390/nu6031128.
52. Lowndes J., Kawiecki D., Pardo S., Nguyen V., Melanson K.J., Yu Z., Rippe J.M. The effects of four hypocaloric diets containing different levels of sucrose or high fructose corn syrup on weight loss and related parameters. Nutr. J. 2012;11:55–65. Doi: 10.1186/1475-2891-11-55.
53. Lowndes J., Sinnett S., Yu Z., Rippe J. The effects of fructose-containing sugars on weight, body composition and cardiometabolic risk factors when consumed at up to the 90th percentile
53. Lowndes J., Sinnett S., Yu Z., Rippe J. The effects of fructose-containing sugars on weight, body composition and cardiometabolic risk factors when consumed at up to the 90th percentile population consumption level for fructose. Nutrients. 2014;6:3153–3168. Doi: 10.3390/nu6083153.
54. Antar M.A., Little J.A., Lucas C., Buckley G.C., Csima A. Interrelationship between the kinds of dietary carbohydrate and fat in hyperlipoproteinemic patients. 3. Synergistic effect of sucrose and animal fat on serum lipids. Atherosclerosis. 1970;11:191–201. Doi: 10.1016/0021-9150(70)90057-2.
55. Bantle J.P., Swanson J.E., Thomas W., Laine D.C. Metabolic effects of dietary sucrose in type ii diabetic subjects. Diabetes Care. 1993;16:1301–1305. Doi: 10.2337/diacare.16.9.1301.
56. Black R.N., Spence M., McMahon R.O., Cuskelly G.J., Ennis C.N., McCance D.R., Young I.S., Bell P.M., Hunter S.J. Effect of eucaloric high- and low-sucrose diets with identical macronutrient profile on insulin resistance and vascular risk: A randomized controlled trial. Diabetes. 2006;55:3566–3572. Doi: 10.2337/db06-0220.
57. Cooper P.L., Wahlqvist M.L., Simpson R.W. Sucrose versus saccharin as an added sweetener in non-insulin-dependent diabetes: Short- and medium-term metabolic effects. Diabet. Med. 1988;5:676–680. Doi: 10.1111/j.1464-5491.1988.tb01079.x.
58. Groen J.J., Balogh M., Yaron E., Cohen A.M. Effect of interchanging bread and sucrose as main source of carbohydrate in a low fat diet on the serum cholesterol levels of healthy volunteer subjects. Am. J. Clin. Nutr. 1966;19:46–58.
59. Marckmann P., Raben A., Astrup A. Ad libitum intake of low-fat diets rich in either starchy foods or sucrose: Effects on blood lipids, factor vii coagulant activity, and fibrinogen. Metab. Clin. Exp. 2000;49:731–735. Doi: 10.1053/meta.2000.6237.
60. Sorensen L.B., Raben A., Stender S., Astrup A. Effect of sucrose on inflammatory markers in overweight humans. Am. J. Clin. Nutr. 2005;82:421–427.
61. Stanhope K.L., Bremer A.A., Medici V., Nakajima K., Ito Y., Nakano T., Chen G., Fong T.H., Lee V., Menorca R.I., *et al.* Consumption of fructose and high fructose corn syrup

increase postprandial triglycerides, LDL-cholesterol, and apolipoprotein-b in young men and women. J. Clin. Endocrinol. Metab. 2011;96:E1596–E1605. Doi: 10.1210/jc.2011-1251.

62. Tappy L., Le K. Metabolic effects of fructose and the worldwide increase in obesity. Physiol. Rev. 2010;90:23–46. Doi: 10.1152/physrev.00019.2009.
63. Sun S.Z., Empie M.W. Fructose metabolism in humans—What isotopic tracer studies tell us. Nutr. Metab. (Lond.) 2012;9:89. Doi: 10.1186/1743-7075-9-89.
64. Hellerstein M.K., Schwarz J.M., Neese R.A. Regulation of hepatic de novo lipogenesis in humans. Annu. Rev. Nutr. 1996;16:523–557. doi: 10.1146/annurev.nu.16.070196.002515.
65. Hellerstein M.K. No common energy currency: De novo lipogenesis as the road less traveled. Am. J. Clin. Nutr. 2001;74:707–708.
66. Faeh D., Minehira K., Schwarz J.M., Periasamy R., Park S., Tappy L. Effect of fructose overfeeding and fish oil administration on hepatic de novo lipogenesis and insulin sensitivity in healthy men. Diabetes. 2005;54:1907–1913. doi: 10.2337/diabetes.54.7.1907.
67. Schwarz J.M., Noworolski S.M., Wen M.J., Dyachenko A., Prior J.L., Weinberg M.E., Herraiz L.A., Tai V.W., Bergeron N., Bersot T.P., *et al.* Effect of a high-fructose weight-maintaining diet on lipogenesis and liver fat. J. Clin. Endocrinol. Metab. 2015;100:2434–2442. doi: 10.1210/jc.2014-3678.
68. Schwarz J.-M., Noworolski S.M., Wen M.J., Jones G.M., Sinclair E., Dyachenco A., Tai V., Alin M.V., Erkin-Cakmak A., Gugliucci A., *et al.* Isocaloric fructose restriction for 10 days reduces hepatic de novo lipogenesis and liver fat in obese Latino and African American children; Proceedings of the Endocrine Society's 97th Annual Meeting and Expo; San Diego, CA, USA. 5–8 March 2015.
69. Sievenpiper J.L., de Souza R.J., Kendall C.W., Jenkins D.J. Is fructose a story of mice but not men? J. Am. Diet. Assoc. 2011;111:219–220; author reply 220–212. doi: 10.1016/j.jada.2010.12.001.
70. Melanson K.J., Summers A., Nguyen V., Brosnahan J., Lowndes J., Angelopoulos T.J., Rippe J.M. Body composition, dietary composition, and components of metabolic syndrome in overweight and obese adults after a 12-week trial on dietary treatments focused on portion control, energy density, or glycemic index. Nutr. J. 2012;11:57. doi: 10.1186/1475-2891-11-57.
71. Stanhope K., Havel P. Endocrine and metabolic effects of consuming beverages sweetened with fructose, glucose, sucrose or high-fructose corn syrup. Am. J. Clin. Nutr. 2008;88:1733S–1737S. doi: 10.3945/ajcn.2008.25825D.
72. Soenen S., Westerterp-Plantenga M.S. No differences in satiety or energy intake after high fructose corn syrup, sucrose, or milk preloads. Am. J. Clin. Nutr. 2007;86:1586–1594.
73. Barclay A., Brand-Miller J. The Australian paradox: A substantial decline in sugars intake over the same timeframe that overweight and obesity have increased. Nutrients. 2014;6:663–664. doi: 10.3390/nu6020663.
74. Mozaffarian D., Hao T., Rimm E.B., Willett W.C., Hu F.B. Changes in diet and lifestyle and long-term weight gain in women and men. N. Engl. J. Med. 2011;364:2392–2404. doi: 10.1056/NEJMoa1014296.

75. Kaiser K.A., Shikany J.M., Keating K.D., Allison D.B. Will reducing sugar-sweetened beverage consumption reduce obesity? Evidence supporting conjecture is strong, but evidence when testing effect is weak. Obes. Rev. 2013;14:620–633. Doi: 10.1111/obr.12048.
76. Sievenpiper J.L., de Souza R.J., Mirrahimi A., Yu M.E., Carleton A.J., Beyene J., Chiavaroli L., Di Buono M., Jenkins A.L., Leiter L.A., *et al.* Effect of fructose on body weight in controlled feeding trials: A systematic review and meta-analysis. Ann. Intern. Med. 2012;156:291–304. Doi: 10.7326/0003-4819-156-4-201202210-00007.
77. Malik V.S., Pan A., Willett W.C., Hu F.B. Sugar-sweetened beverages and weight gain in children and adults: A systematic review and meta-analysis. Am. J. Clin. Nutr. 2013;98:1084–1102. Doi: 10.3945/ajcn.113.058362.
78. Dolan L.C., Potter S.M., Burdock G.A. Evidence-based review on the effect of normal dietary consumption of fructose on development of hyperlipidemia and obesity in healthy, normal weight individuals. Crit. Rev. Food Sci. Nutr. 2010;50:53–84. Doi: 10.1080/10408390903461426.
79. Dolan L.C., Potter S.M., Burdock G.A. Evidence-based review on the effect of normal dietary consumption of fructose on blood lipids and body weight of overweight and obese individuals. Crit. Rev. Food Sci. Nutr. 2010;50:889–918. Doi: 10.1080/10408398.2010.512990.
80. Maersk M., Belza A., Stødkilde-Jørgensen H., Ringgaard S., Chabanova E., Thomsen H., Pedersen S.B., Astrup A., Richelsen B. Sucrose-sweetened beverages increase fat storage in the liver, muscle, and visceral fat depot: A 6-mo randomized intervention study. Am. J. Clin. Nutr. 2012;95:283–289. Doi: 10.3945/ajcn.111.022533.
81. Stanhope K., Schwarz J., Keim N., Griffen S., Bremer A., Graham J., Hatcher B., Cox C., Dyachenko A., Zhang W., *et al.* Consuming fructose-sweetened, not glucose-sweetened, beverages increases visceral adiposity and lipids and decreases insulin sensitivity in overweight/obese humans. J. Clin. Investig. 2009;119:1322–1334. Doi: 10.1172/JCI37385.
82. Cozma A.I., Sievenpiper J.L., de Souza R.J., Chiavaroli L., Ha V., Wang D.D., Mirrahimi A., Yu M.E., Carleton A.J., Di Buono M., *et al.* Effect of fructose on glycemic control in diabetes: A systematic review and meta-analysis of controlled feeding trials. Diabetes Care. 2012;35:1611–1620. Doi: 10.2337/dc12-0073.
83. Ha V., Sievenpiper J.L., de Souza R.J., Chiavaroli L., Wang D.D., Cozma A.I., Mirrahimi A., Matthew E.Y., Carleton A.J., Dibuono M. Effect of fructose on blood pressure a systematic review and meta-analysis of controlled feeding trials. Hypertension. 2012;59:787–795. Doi: 10.1161/HYPERTENSIONAHA.111.182311.
84. Saris W.H., Astrup A., Prentice A.M., Zunft H.J., Formiguera X., Verboeket-van de Venne W.P., Raben A., Poppitt S.D.,Seppelt B., Johnston S., *et al.* Randomized controlled trial of changes in dietary carbohydrate/fat ratio and simple vs complex carbohydrates on body weight and blood lipids: The carmen study. The carbohydrate ratio management in european national diets. Int. J. Obes. Relat. Metab. Disord. 2000;24:1310–1318. doi: 10.1038/sj.ijo.0801451.

85. Hall K.D., Heymsfield S.B., Kemnitz J.W., Klein S., Schoeller D.A., Speakman J.R. Energy balance and its components: Implications for body weight regulation. Am. J. Clin. Nutr. 2012;95:989–994. doi: 10.3945/ajcn.112.036350.
86. Swinburn B., Sacks G., Ravussin E. Increased food energy supply is more than sufficient to explain the us epidemic of obesity. Am. J. Clin. Nutr. 2009;90:1453–1456. doi: 10.3945/ajcn.2009.28595.
87. Rippe J.M., Dysinger W.S., Rust R., Frank A., Blair S.N., Parkinson M. American college of lifestyle medicine expert panel discussion: The treat the cause movement. Am. J. Lifestyle Med. 2014;8:291–300. doi: 10.1177/1559827614521987.
88. United States Department of Agriculture-Economic Research Service . Loss-Adjusted Food Availability Data Series. USDA; Washington, DC, USA: 2013. Calories average daily per capita calories from the US food supply, adjusted for spoilage and other waste.
89. Sievenpiper J.L., Tappy L., Brouns F. Fructose as a driver of diabetes: An incomplete view of the evidence. Mayo Clin. Proc. 2015;90:984–988. doi: 10.1016/j.mayocp.2015.04.017.
90. Xi B., Li S., Liu Z., Tian H., Yin X., Huai P., Tang W., Zhou D., Steffen L.M. Intake of fruit juice and incidence of type 2 diabetes: A systematic review and meta-analysis. PLoS ONE. 2014;9:e93471. doi: 10.1371/journal.pone.0093471.
91. Tsilas C.S., de Souza R.J., Tawfik R., Blanco-Mejia S., Cozma A.I., Mirrahimi A., Jayalath V., Ha V., Beyene J., Kendall C.W.C., *et al*. No relation between total sugars intake and incident diabetes: A systematic review and meta-anaylsis of cohorts; Proceedings of the 32nd International Symposium on Diabetes and Nutrition; Reykjavik, Iceland. 25–27 June 2014.
92. The Interact Consortium, Consumption of sweet beverages and type 2 diabetes incidence in European adults: Results from epic-interact. Diabetologia. 2013;56:1520–1530.
93. Janket S.-J., Manson J.E., Sesso H., Buring J.E., Liu S. A prospective study of sugar intake and risk of type 2 diabetes in women. Diabetes Care. 2003;26:1008–1015. doi: 10.2337/diacare.26.4.1008.
94. Hodge A.M., English D.R., O'Dea K., Giles G.G. Glycemic index and dietary fiber and the risk of type 2 diabetes. Diabetes Care. 2004;27:2701–2706. doi: 10.2337/diacare.27.11.2701.
95. Meyer K.A., Kushi L.H., Jacobs D.R., Jr., Slavin J., Sellers T.A., Folsom A.R. Carbohydrates, dietary fiber, and incident type 2 diabetes in older women. Am. J. Clin. Nutr. 2000;71:921–930.
96. Colditz G.A., Manson J.E., Stampfer M.J., Rosner B., Willett W.C., Speizer F.E. Diet and risk of clinical diabetes in women. Am. J. Clin. Nutr. 1992;55:1018–1023.
97. Aeberli I., Gerber P.A., Hochuli M., Kohler S., Haile S.R., Gouni-Berthold I., Berthold H.K., Spinas G.A., Berneis K. Low to moderate sugar-sweetened beverage consumption impairs glucose and lipid metabolism and promotes inflammation in healthy young men: A randomized controlled trial. Am. J. Clin. Nutr. 2011;94:479–485. Doi: 10.3945/ajcn.111.013540.
98. Aeberli I., Hochuli M., Gerber P.A., Sze L., Murer S.B., Tappy L., Spinas G.A., Berneis K. Moderate amounts of fructose consumption impair insulin sensitivity in healthy young

men: A randomized controlled trial. Diabetes Care. 2013;36:150–156. Doi: 10.2337/dc12-0540.

99. Moore M.C., Davis S.N., Mann S.L., Cherrington A.D. Acute fructose administration improves oral glucose tolerance in adults with type 2 diabetes. Diabetes Care. 2001;24:1882–1887. Doi: 10.2337/diacare.24.11.1882.
100. Lowndes J., Sinnett S., Rippe J. No change in oral glucose tolerance tests as a result of ten weeks of consumption of various fructose containing sugars or glucose; Proceedings of the Endocrine Society's 96th Annual Meeting and Expo; Chicago, IL, USA. 21–24 June 2014.
101. Johnson R.K., Appel L.J., Brands M., Howard B.V., Lefevre M., Lustig R.H., Sacks F., Steffen L.M., Wylie-Rosett J. Dietary sugars intake and cardiovascular health: A scientific statement from the American heart association. Circulation. 2009;120:1011–1020. Doi: 10.1161/CIRCULATIONAHA.109.192627.
102. Miller M., Stone N., Ballantye C., Bttiner V., Criqui M., Ginsberg H., Goldberg H., Howard W., Jacobson M., Kris Etherton P., *et al.* Triglycerides and cardiovascular disease: A scientific statement from the American heart association. Circulation. 2011;123:2292–2333. Doi: 10.1161/CIR.0b013e3182160726.
103. Livesey G., Taylor R. Fructose consumption and consequences for glycation, plasma triacylglycerol, and body weight: Meta-analyses and meta-regression models of intervention studies. Am. J. Clin. Nutr. 2008;88:1419–1437.
104. Wang D.D., Sievenpiper J.L., de Souza R.J., Cozma A.I., Chiavaroli L., Ha V., Mirrahimi A., Carleton A.J., Di Buono M., Jenkins A.L., *et al.* Effect of fructose on postprandial triglycerides: A systematic review and meta-analysis of controlled feeding trials. Atherosclerosis. 2014;232:125–133. Doi: 10.1016/j.atherosclerosis.2013.10.019.
105. Archer E., Pavela G., Lavie C.J. The inadmissibility of what we eat in America and nhanes dietary data in nutrition and obesity research and the scientific formulation of national dietary guidelines. Mayo Clin. Proc. 2015;90:911–926. Doi: 10.1016/j.mayocp.2015.04.009.
106. Yang Q., Zhang Z., Gregg E.W., Flanders W.D., Merritt R., Hu F.B. Added sugar intake and cardiovascular diseases mortality among us adults. JAMA Intern. Med. 2014;174:516–524. Doi: 10.1001/jamainternmed.2013.13563.
107. Stanhope K.L., Medici V., Bremer A.A., Lee V., Lam H.D., Nunez M.V., Chen G.X., Keim N.L., Havel P.J. A dose-response study of consuming high-fructose corn syrup–sweetened beverages on lipid/lipoprotein risk factors for cardiovascular disease in young adults. Am. J. Clin. Nutr. 2015 doi: 10.3945/ajcn.114.100461.
108. Stanhope K.L., Havel P.J. Fructose consumption: Potential mechanisms for its effects to increase visceral adiposity and induce dyslipidemia and insulin resistance. Curr. Opin. Lipidol. 2008;19:16–24. Doi: 10.1097/MOL.0b013e3282f2b24a.
109. Te Morenga L.A., Howatson A.J., Jones R.M., Mann J. Dietary sugars and cardiometabolic risk: Systematic review and meta-analyses of randomized controlled trials of the effects on blood pressure and lipids. Am. J. Clin. Nutr. 2014;100:65–79. Doi: 10.3945/ajcn.113.081521.
110. Bremer A.A., Auinger P., Byrd R.S. Relationship between insulin resistance-associated metabolic parameters and anthropometric measurements with sugar-sweetened beverage

intake and physical activity levels in us adolescents: Findings from the 1999–2004 national health and nutrition examination survey. Arch. Pediatr. Adolesc. Med. 2009;163:328–335.

111. Dhingra R., Sullivan L., Jacques P.F., Wang T.J., Fox C.S., Meigs J.B., D'Agostino R.B., Gaziano J.M., Vasan R.S. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. Circulation. 2007;116:480–488. Doi: 10.1161/CIRCULATIONAHA.107.689935.
112. Lenoir M., Serre F., Cantin L., Ahmed S.H. Intense sweetness surpasses cocaine reward. PLoS ONE. 2007;2:e698. Doi: 10.1371/journal.pone.0000698.
113. Ross A.P., Bartness T.J., Mielke J.G., Parent M.B. A high fructose diet impairs spatial memory in male rats. Neurobiol. Learn. Mem. 2009;92:410–416. Doi: 10.1016/j.nlm.2009.05.007.
114. Messier C., Whately K., Liang J., Du L., Puissant D. The effects of a high-fat, high-fructose, and combination diet on learning, weight, and glucose regulation in c57bl/6 mice. Behav. Brain Res. 2007;178:139–145. Doi: 10.1016/j.bbr.2006.12.011.
115. De Silva A., Salem V., Matthews P.M., Dhillo W.S. The use of functional MRI to study appetite control in the CNS. Exp. Diabetes Res. 2012;2012:764017. Doi: 10.1155/2012/764017.
116. Premack D. Human and animal cognition: Continuity and discontinuity. Proc. Natl. Acad. Sci. USA. 2007;104:13861–13867. Doi: 10.1073/pnas.0706147104.
117. Sarter M. Animal cognition: Defining the issues. Neurosci. Biobehav. Rev. 2004;28:645–650. doi: 10.1016/j.neubiorev.2004.09.005. [PubMed] [CrossRef] [Google Scholar]
118. Page K.A., Luo S., Romero A., Adam T.C., Hu H., Monterosso J. Fructose compared to glucose ingestion preferentially activates brain reward regions in response to high-calorie food cues in young, obese hispanic females. Endocrinol. Rev. 2012;33:1666. [Google Scholar]
119. Purnell J.Q., Klopfenstein B.A., Stevens A.A., Havel P.J., Adams S.H., Dunn T.N., Krisky C., Rooney W.D. Brain functional magnetic resonance imaging response to glucose and fructose infusions in humans. Diabetes Obes. Metab. 2011;13:229–234. doi: 10.1111/j.1463-1326.2010.01340.x.
120. Pena-Gomez C., Alonso-Alonso M., Bravo S., Magerowski G., Sinnett S., Blackburn G., Rippe J. Hypothalamic fmri responses to different sugars under normal intake conditions: A pilot study; Proceedings of the Obesity Society 32nd Annual Scientific Meeting (NAASO); Atlanta, GA, USA. 11–17 November 2013.
121. Wang G.J., Volkow N.D., Fowler J.S. The role of dopamine in motivation for food in humans: Implications for obesity. Expert Opin. Ther. Targets. 2002;6:601–609. doi: 10.1517/14728222.6.5.601.
122. Blum K., Braverman E.R., Holder J.M., Lubar J.F., Monastra V.J., Miller D., Lubar J.O., Chen T.J., Comings D.E. Reward deficiency syndrome: A biogenetic model for the diagnosis and treatment of impulsive, addictive, and compulsive behaviors. J. Psychoact. Drugs. 2000;32(Suppl. i–iv):1–112. doi: 10.1080/02791072.2000.10736099.
123. Lowndes J., Rippe J.M. No effect of sugar sweetened milk on performance of a battery of cognitive assessment tests. FASEB J. 2016;30:1160–1163.

124. Lowndes J., Angelopoulos T.J., Rippe J.M. No effect of sugar sweetened or diet beverages on performance of a battery of cognitive assessment tests. FASEB J. 2016;30:1160–1164.
125. Lustig R.H., Schmidt L.A., Brindis C.D. Public health: The toxic truth about sugar. Nature. 2012;482:27–29. doi: 10.1038/482027a.
126. Bocarsly M.E., Powell E.S., Avena N.M., Hoebel B.G. High-fructose corn syrup causes characteristics of obesity in rats: Increased body weight, body fat and triglyceride levels. Pharmacol. Biochem. Behav. 2010;97:101–106. doi: 10.1016/j.pbb.2010.02.012.
127. Avena N.M., Hoebel B.G. Bingeing, withdrawal and craving: An animal model of sugar addiction. In: Gold M., Brownell K., editors. Food and Addiction: A Comprehension Handbook. Oxford University Press; New York, NY, USA: 2012.
128. Ziauddeen H., Farooqi I., Fletcher P. Obesity and the brain: How convincing is the addiction model? Nat. Rev. 2012;13:279–286. doi: 10.1038/nrn3212.
128. Ziauddeen H., Farooqi I., Fletcher P. Obesity and the brain: How convincing is the addiction model? Nat. Rev. 2012;13:279–286. doi: 10.1038/nrn3212.
129. Benton D. The plausibility of sugar addiction and its role in obesity and eating disorders. Clin. Nutr. 2010;29:288–303. doi: 10.1016/j.clnu.2009.12.001.
130. Corwin R.L.W., Hayes J.E. Are sugars addictive? Perspectives for practitioners. In: Rippe J., editor. Fructose, High Fructose Corn Syrup, Sucrose and Health. Springer; New York, NY, USA: 2014. pp. 199–215.
131. Slavin J. Two more pieces to the 1000-piece carbohydrate puzzle. Am. J. Clin. Nutr. 2014;100:4–5. doi: 10.3945/ajcn.114.090423.
132. Siri-Tarino P.W., Sun Q., Hu F.B., Krauss R.M. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. Am. J. Clin. Nutr. 2010;91:535–546. doi: 10.3945/ajcn.2009.27725.
133. De Oliveira Otto M.C., Mozaffarian D., Kromhout D., Bertoni A.G., Sibley C.T., Jacobs D.R., Jr., Nettleton J.A. Dietary intake of saturated fat by food source and incident cardiovascular disease: The multi-ethnic study of atherosclerosis. Am. J. Clin. Nutr. 2012;96:397–404. doi: 10.3945/ajcn.112.037770.
134. Astrup A. A changing view on saturated fatty acids and dairy: From enemy to friend. Am. J. Clin. Nutr. 2014;100:1407–1408. doi: 10.3945/ajcn.114.099986.
135. Andon B., Anderson J. The oatmeal-cholesterol connection: 10 years later. Am. J. Lifestyle Med. 2008;2:51–57. doi: 10.1177/1559827607309130.
136. U.S. Department of Agriculture. U.S. Department of Health and Human Services . Report of the Advisory Committee on the Dietary Guidelines for Americans 2010. 7th ed. U.S. Government Printing Office; Washington, DC, USA: 2010.
137.James M. Rippe , Theodore J. AngelopoulosNutrients. 2016 Nov; 8(11): 697.published online 2016 Nov 4. Doi: 10.3390/nu8110697 PMCID: PMC5133084 PMID: 27827899

DIABETIC KNOWLEDGE AND NUTRITIONAL INTERVENTION FOR DIABETIC PATIENTS

P. A. Fathimath Labeeba* and M. Sivasakthi
Department of Nutrition & Dietetics
PSG College of Arts & Science, Coimbatore- 641014
*Corresponding author E-mail: labyraihana1213@gmail.com

Abstract:

Diabetes is a metabolic condition caused by a combination of genetics, environmental factors, ethnicity and diet. Diabetes is becoming more prevalent as a result of changing lifestyles and unhealthy diet. Type 1 diabetes is an autoimmune disorder characterized by the destruction of insulin-producing beta cells in the pancreas. It typically presents in childhood or adolescence, and patients require insulin therapy for survival. Type 1 diabetes accounts for approximately 5 - 10% of all cases of diabetes. Type 2 diabetes is a metabolic disorder characterized by insulin resistance and impaired insulin secretion. It typically presents in adulthood, but the incidence is increasing in children and adolescents due to the obesity epidemic. Type 2 diabetes accounts for approximately 90-95% of all cases of diabetes. Gestational diabetes mellitus (GDM) is a form of glucose intolerance that develops during pregnancy. GDM typically resolves after delivery, but affected women are at increased risk of developing Type 2 diabetes in later life. Monogenic diabetes is a rare form of diabetes caused by a single gene mutation that affects insulin secretion or action. Monogenic diabetes can present in childhood or adulthood and can be misdiagnosed as Type 1 or Type 2 diabetes. Majority of the studies found that diabetes patients' knowledge was lacking Diabetes knowledge and awareness of complications will aid in disease prevention. Nutritional and educational interventions such as animated videos, posters, pamphlets and charts will aid in increasing people's knowledge.

Keywords: Diabetes, diet, lifestyle, knowledge, educational intervention

Introduction:

Diabetes mellitus (DM) was first honoured as a complaint around 3000 years ago by the ancient Egyptians and Indians, illustrating some clinical features veritably analogous to what we now known as diabetes (Frank, 1957). DM is a combination of two words, diabetes Greek wordoutgrowth, means siphon- to pass through and the Latin word mellitus means honeyed or sweet. In 1776, redundant sugar in blood and urine was first verified in Great Britain (Ahmed, 2002) (Reece and Homko, 1998). With the passage of time, a wide knowledge of diabetes along with detailed aetiology and pathogenesis has been achieved. DM is defined as a "metabolic complaint characterized by hyperglycaemia brought out either by insufficiency of insulin secretion or the action of insulin". The inadequately controlled DM can lead to damage of different organs, especially eyes, nerves, kidneys and cardiovascular system (Gavin *et al.,* 1997). Diabetic Mellitus (DM) is a set of metabolic sicknesses marked through high blood glucose level attributable to troubles in insulin production, usage, or both. In several regions of the world, the WHO has reported an increase in the prevalence of DM in recent decades. The International Diabetes Federation's most recent data showed that, with the prevalence rising from 8.8 to 10.4%,

an estimated 415 million adults aged 20 to 79 had DM across the world in 2015. By 2040, that figure is projected to rise to 642 million. Even though there are many people diagnosed with DM, up to 193 million people roughly half of all those with DM are not aware that they have the condition. Geographically, the age-adjusted prevalence of DM is 3.8% in Africa, 7.3% in Europe, 10.7% in the Middle East and North Africa, 11.5% in North America and the Caribbean, 9.6% in South and Central America, 9.1% in Southeast Asia, and 8.8% in the Western Pacific. The top three nations with the highest prevalence of DM continue to be China, India, and USA (WHO, 2016).

Asian Indian people, which we extensively outline as people originating from the Indian subcontinent (the international locations of India, Pakistan, Bangladesh, Sri Lanka, Afghanistan, Nepal, Bhutan and the Maldives) (UNGRC, 2016) constitute >17% of the world`s populace and still have a particular phenotype, characterized with the aid of using excessive degrees of intra-stomach fats and insulin resistance not withstanding a low BMI, which predisposes them to T2DM and untimely coronary heart sickness. It is crucial to understand the patterns and behaviours of diabetes mellitus in this ethnic group. Fortunately, research on the condition and its complications has expanded at the same time that diabetes mellitus has become more common in India. The epidemiology, distinctive characteristics, and complications of diabetes mellitus in India are covered in this review. Furthermore, we will describe the main obstacles in providing patients with diabetes mellitus with the best treatment possible and offer potential alternatives (Unnikrishnan *et al.,* 2014).

Classification

Diabetes Mellitus is extensively labelled into three main kinds based on aetiology and clinical manifestations namely Type 1 diabetes, Type 2 diabetes and Gestational diabetes (GDM). A few more-less prevalent types of diabetes are Monogenic diabetes and Prediabetes (Choi and Chung, 2016), (Picke *et al.,* 2019), (Carrillo-Larco *et al.,* 2019).

Type 1 Diabetes mellitus

The loss of beta cells in the pancreatic islets causes Type 1 diabetes mellitus (T1DM), an autoimmune condition. T1DM can manifest at any age, however it usually first becomes apparent in adolescents, peaking around puberty. Both sexes have an equal chance of developing T1DM during childhood, although males are more likely to develop the condition in the early stages of adulthood (Karvonen *et al.,* 1997). Although it used to be more common among Europeans, other ethnic groups are starting to experience it more frequently. 415 million people worldwide are projected to have diabetes according to the International Diabetes Federation (IDF) 2015 Atlas. By 2040, 642 million people are expected to be living in this country (Ogurtsova *et al.,* 2017). One of the most common autoimmune illnesses of childhood is T1DM, which accounts for 5–10% of all diabetes causes. In all populations, the prevalence of T1DM is rising. In Europe, the incidence of T1DM in children under the age of five is expected to double in less than 20 years (Patterson *et al.,* 2009).

It is obvious that both hereditary and environmental factors contribute to T1DM, even though the exact causes are yet unknown. The human leukocyte antigen (HLA) locus is the genetic area most closely related to T1DM. Since genes linked to insulin synthesis or beta-cell function have also been discovered, diabetes-related genetic variables are not all immune system-

related. Due to exposure to various environmental circumstances, monozygotic (identical) twins with identical genes may experience varying health outcomes when they have T1DM (Steck and Rewers, 2011). There is a lot of knowledge about the significance of genetic variables in the pathogenesis of T1DM, but much less is known about the influence of environmental factors. Environmental characteristics are complicated, and their mechanisms of effect are mostly unknown (Knip and Simell, 2012).

Type 2 Diabetes mellitus

According to the World Health Organization (WHO) diabetes mellitus is a chronic, metabolic disorder marked by high blood glucose levels that, over time, cause damage to the heart, vasculature, eyes, kidneys and nerves. T2DM, which accounts for over 90% of cases of diabetes mellitus characterized by tissue insulin resistance (IR), inadequate compensatory insulin secretory response, and insufficient insulin secretion by pancreatic islet cells, is the most common type of the disease. Progression of the disorder makes insulin secretion now no longer capable of keeping glucose homeostasis, causing hyperglycaemia (Stumvoll *et al.,* 2005; Weyer *et al.,* 1999).

Obesity or having a higher body fat percentage that is primarily distributed in the abdominal area is the main characteristics of patients with T2DM. Adipokine dysregulation and increased release of free fatty acids (FFA) are only two examples of the numerous inflammatory pathways that adipose tissue uses to induce IR in this state. The prevalence and incidence of Type 2 diabetes have increased by four times due to population ageing, sedentary lifestyles, high-calorie diets and the global rise in obesity (Chatterjee *et al.,* 2017; Zhou *et al.,* 2016).

The organs concerned with T2DM development encompass pancreas (β-cells and α-cells), liver, skeletal muscle, kidneys, brain, small intestine, and adipose tissue (DeFronzo, 2009). According to the evolving research, adipokine dysregulation, inflammation and abnormalities in intestine microbiota, have emerged as significant pathophysiological contributors (Schwartz *et al.,* 2016).

Epidemiological data exhibit disturbing trends that indicate a concerning outlook for T2DM. According to the International Diabetes Federation (IDF), diabetes claimed 4.2 million lives in 2019 and affected 463 million adults between the ages of 20 and 79, with that number expected to reach 700 million by 2045. At least 720 billion USD in healthcare costs were attributable to diabetes in 2019. Furthermore, as 1 in 3 diabetics, or 232 million people, went undiagnosed, the true disease burden of T2DM is likely underrepresented. The age range between 40 and 59 years, when the majority of diabetics, are diagnosed, more than 80% of T2DM patients residing in low- to middle-income nations, T2DM incidence and prevalence vary by geographic region. Cardiovascular disease (CVD) is the leading cause of morbidity and mortality associated with T2DM, and patients with T2DM have a 15% greater risk of all-cause mortality compared to persons without diabetes (Gaede *et al.,* 2003).

Gestational diabetes

Diabetic discovered during pregnancy that is not obviously diabetes is known as gestational diabetes mellitus (GDM) (ADA, 2013). According to O'SULLIVAN et al. (1966), this syndrome is linked to complications during pregnancy, such as macrosomia of the foetus, stillbirth, metabolic changes in the new born and other issues. According to Pettitt *et al.* (1991),

the children of mothers with GDM are more likely to develop diabetes and obesity (Dabalkea, 2007). According to Damm (2009) and O'Sullivan (1984), women with GDM are more likely to develop diabetes in the years after giving birth. The degree of risk connected to GDM, the best diagnostic standards, the potential for early detection and treatment to enhance pregnancy outcomes, and the cost-benefit analysis of such initiatives are all still up for debate.

Prediabetes

Prediabetics are at a significant risk of developing Type 2 diabetes in the future even though they do not now fit the criteria for diabetes. Individuals are considered to have prediabetes., as per the ADA Expert Committee, if their 2-hour plasma glucose levels during the oral glucose tolerance test (OGTT) range from 140 to 199 mg/dL (7.8 to 11.0 mmol/L), or if they have impaired fasting plasma glucose (IFG) levels between 100 and 125 mg/dL (5.6 and 6.9 mmol/L). The IFG range, which the World Health Organization (WHO) continues to use, is between 110 and 125 mg/dL (6.1-6.9 mmol/L). According to the research by Sherwin *et al.* (2012), and Huang *et al.* (2014), prediabetes has been linked to an increased risk of dying from cancer and cardiovascular disease. According to a continuous glycaemic risk viewpoint, lower glucose levels in the normal range are still associated with cardiovascular disease. Hence the classification of prediabetes with the provided cut off values is false (Buysschaert and Bergman, 2011).

American Diabetes Association (ADA), 2009 has proposed to use haemoglobin A1C (HbA1c) to diagnose diabetes. ADA (2010) also suggested using HbA1c (5.7%–6.4%) to diagnose prediabetes. IDF estimates that 316 million persons worldwide had IGT in 2013 (a global prevalence of 6.9%), and that figure will increase to 471 million by 2030. The Centre for Disease Control and Prevention reported that in 2014, 1 in 3 Americans, or 86 million people, have prediabetes (Centre for Disease control and prevention, 2014). In the Middle East Arab States of the Gulf, Kuwait, Qatar, the United Arab Emirates and Bahrin are four of the top ten nations with the greatest prevalence of prediabetes, with prevalence rates of 17.9%, 17.1%, 16.6%, and 16.3%, respectively (IDF, 2013). The number of patients with prediabetes varies depending on the approach and criteria used to make the diagnosis. According to Inoue et al. (2009), the number of patients diagnosed with prediabetes using the IFG criterion of 100-125 mg/dL is 4-5 times higher than those using the WHO definition of 110-125 mg/dL. When diabetes and prediabetes are diagnosed using HbA1c criteria, the results differ from those obtained using FPG or OGTT. HbA1c was used to diagnose more cases of prediabetes than FPG was (Bernal- Lopez *et al.*, 2011; Lipska *et al.*, 2010). Prediabetes is linked to metabolic syndrome, obesity (particularly visceral or abdominal obesity), dyslipidemia with high triglycerides and/or low HDL cholesterol, and hypertension (Grundy, 2012).

Not all people with prediabetes go on to develop diabetes; nevertheless, exercise combined with a 5% to 10% weight loss reduces the chance of getting diabetes (40 -70%) significantly (Tabak et al., 2012). In comparison to people with HbA1c of 5.5%-6.0%, those with HbA1c of 6.0%-6.5% have a twice as high chance of getting diabetes (25-50%) in five years. (Zhang *et al.*, 2010).

Monogenic

Monogenic diabetes is thought to affect 2-5% of all diabetic patients (Ledemann, 1995). Cammidge first identified families with autosomal dominant diabetes in 1928, marking the beginning of the identification of a genetic type (Cammidge, 1928). In 1975, the term "Maturity Onset Diabetes of the Young" (MODY) was coined to describe diabetes that develops before the age of 25 and is inherited via the autosomal dominant gene due to an intrinsic -cell abnormality (Tattersall and Fajans, 1975). The glucokinase (GCK) gene was the first one to be causally linked (Vonnet *et al.,* 1992). A few years later, mutations in the transcription factor genes hepatocyte nuclear factor 4 and 1 alpha (HNF4A, HNF1A), which are responsible for two other monogenic types of diabetes, MODY1 and MODY3, were discovered (Yamagata *et al.,* 1996).

In the past, a classification criterion included the age at which diabetes first manifested. In contrast to MODY forms of diabetes, which usually appear before the age of 25, neonatal diabetes is identified within 6 months of delivery. The same family of particular gene mutations, according to current investigations, can manifest clinically in neonates as well as in adults with "type 2-like" or "type 1-like" forms.

Many monogenic forms of diabetes are now overlooked or misdiagnosed as type 2 or type 1 diabetes. It will be possible to pinpoint the precise cause of diabetes with improved access to genetic testing. I examine developmental and cellular problems, glucose uptake at the cell surface, and the intracellular fate of glucose molecules that trigger insulin secretion in the current review. I do this by delineating the many gene flaws using a functional approach (Schwitzgebel, 2014).

Factors influencing the growing diabetes

Numerous genetic-environmental combinations may lead to diabetes, the expanding rates of urbanisation, migration from rural to urban regions, adoption of sedentary lifestyle and poor dietary practices are the key causative factors raising the incidence of diabetes (Ramachandran *et al.,* 2009 and 2013).

Obesity

Epidemiological studies have shown a significant association between obesity and the risk of acquiring type 2 diabetes, which has been attributed to the rise in the incidence and prevalence of obesity (Alberti, 2001). The chance of acquiring Type 2 diabetes is thought to rise by 9% for every kilogram of the body weight, according to Mokdad *et al.* (1999).

According to research reports, Type 2 diabetes mellitus can occur in people who have obesity as a primary cause of insulin resistance, metabolic dysregulation, hypertension, and aberrant lipid metabolism (Shoelson *et al.,* 2006; Badawi *et al.,* 2010). According to research by Shoelson *et al.* (2006), higher release of adipocyte-derived bioactive metabolites such as lipids, free fatty acids, monocyte chemo-attractant protein-1, and pro-inflammatory cytokines is associated with insulin resistance in obese people. Further research exposed that fatty acid exposure to muscle cells reduces insulin's ability to mediate glucose uptake, which in turn leads to insulin resistance and promotes the onset of Type 2 diabetes (Dimopoulos *et al.,* 2006; Bilan *et al.,* 2009).

A study comparing young, insulin-resistant lean children of type 2 diabetic individuals with insulin-sensitive controls of similar body mass index revealed that systemic inflammation

may not play a significant role in the development of insulin resistance in lean people (King, 2008). This finding helps to support the hypothesis that obesity may contribute to the development of insulin resistance, which in turn contributes to the development of type 2 diabetes. TNF-alpha gene expression is up-regulated in adipose tissues, nevertheless, as demonstrated by human and animal models, which links this to pro-inflammatory cytokines secreted from adipose tissues to insulin resistance in Type 2 diabetes mellitus (Wellen & Hotamisligil, 2005; Krogh-Madsen *et al.,* 2006).

Physical activity and lifestyle

Numerous cross-sectional, prospective, and retrospective investigations have discovered a strong link between T2DM and physical inactivity (Weinstein *et al.,* 2001). Over a thousand non-diabetics from the high-risk Pima Indian population participated in a prospective study. It was discovered that the incidence rate of diabetes remained higher among less active men and women across all BMI groups during an average follow-up period of six years. The available data point to a variety of potential molecular pathways that could account for the preventive impact of physical activity on the onset of T2DM. First, there is evidence to support the idea that exercise improves insulin sensitivity (Davies *et al.,* 2003).

According to a thorough research released by the US Department of Health and Human Services in 2015, exercise greatly improved abnormal glucose tolerance when it was predominantly caused by insulin resistance rather than by low levels of circulating insulin (Charokopou *et al.,* 2015). Secondly, before insulin medication is necessary, the first phases of T2DM are probably the ones when physical activity will be most helpful in avoiding the disease's progression. Physical exercise's protective mechanism and insulin seem to work together in a beneficial way. Contracting skeletal muscle increases the absorption of glucose into cells during a single extended physical activity session. This impact improves the muscle's ability to transfer glucose and increases blood flow within the muscle (Tucker and Palmer, 2011). Third, it has been discovered that physical activity also helps to lower intra-abdominal fat, which is a known risk factor for insulin resistance. Exercise can lower body fat reserves and has been shown, in several other research studies, to be inversely related to the distribution of intra- abdominal fat (Cole, *et al.,* 1998). Extreme increases in the incidence of T2DM are reportedly caused by lifestyle and environmental variables (Danaei *et al.,* 2011).

Diet

The quantity and nature of dietary fat alters insulin sensitivity and glucose tolerance (Storlien *et al.,* 1996; Lichtenstein and Schwab, 2000). According to Pan *et al.* (1997), a high fat diet may worsen glucose tolerance through a number of mechanisms, including a reduction in the ability of insulin to bind to its receptors, impaired glucose transport, a reduction in glycogen synthase and accumulation of triglycerides in skeletal muscles. By changing membrane fluidity and insulin signaling, the fatty acid composition of the food influences insulin action as well as the composition of tissue phospholipids.

Stress

Stress is described as "a stimulation event of sufficient severity to induce disequilibrium in the homeostasis of physiological systems" and can arise from a range of stressors. Stress- related neuroendocrine changes might cause pathophysiological abnormalities (Sridhar and Madhu,

2002). As a result of the production of cortisol and catechol amines, the hypothalamic- pituitary-adrenal (HPA) axis and sympathetic nervous system (SNS) are activated in response to a stressor, which causes a cascade of physiological, behavioural and psychological repercussions (epinephrine and norepinephrine). The HPA axis and SNS on repeated firing causes the system to become dysregulated, which causes diseases such autoimmune disorders, obesity, diabetes, substance misuse, depression, and cardiovascular disease. Diabetes development is also influenced by stress. By raising the levels of hormones such as glucagon, cortisol, growth hormone, catecholamines, Corticotrophin Releasing Hormone (CRH), prolactin, leptin, and neuropeptide, stress-related changes cause hyperglycaemia (Sterling, 2004 and McEwen, 2000).

According to Bjorn top's theory, the sympathetic nervous system's activation after stress might result in a series of hormonal changes that eventually cause obesity and, in turn, diabetes. The onset of metabolic syndrome and visceral obesity may be influenced by psychosocial stress. Both men and women with central obesity who are premenopausal have been demonstrated to have higher levels of HPA activity. Both central and peripheral gynecoid and android obesity target metabolically significant tissues namely the liver and visceral fat and are correlated with variable HPA regulation. The prevalence of Type 2 diabetes mellitus and visceral obesity were both linked to chronic psychological stress. According to Sridhar and Madhu (2002), there was a correlation between the frequency of stressful events and the prevalence of newly diagnosed diabetes.

Adoption of educational intervention strategies

Disseminating patient education can be done in at least four different ways. During routine care, the straightforward dissemination of information regarding dietary (lifestyle) adjustments and the key elements of illness management is frequently carried out. The information is typically extremely generic and not individualized. The second kind of education is individual counselling or education, which actually enables you to fully personalize your intervention and build strong rapport and trust between patient and educator. When opposed to individual education, group education may be more advantageous due to peer pressure and cost effectiveness. The fourth strategy is structured education, which has certain features and can be given as either group or individual instruction (Ouyang, 2017)

Group vs. Individual Interventions

The effects of individual diabetes education on metabolic control, diabetes knowledge, and psychosocial outcome were assessed by a systematic review and meta-analysis among 1359 patients by 9 trials. There were no differences between the groups in the improvement of metabolic control at 12 and 18 months in six studies comparing individual instruction to conventional care. Individual but not group diabetes knowledge gave some additional advantages in psychosocial and behavioral consequences such as physical component rating and encouraged food rating (Sperl-Hillen *et al.*, 2011). The results of individual or group diabetes education were evaluated in several randomized studies. A systematic review and meta-analysis of 11 trials including 1532 individuals confirmed that group-based education might dramatically lower systolic blood pressure, increase glucose levels, lower HbA1c, and increase understanding of the condition. Similarly, a reduced need for medication was noticed. Improvement in HbA1c was

documented not only in the short-term period (11.4% at 4-6 months) however was also sustained for two years (-1.0%) (Deakin *et al.,* 2005).

Glycated hemoglobin increased in the control group but not in the patient group, according to a 4-year randomized controlled clinical trial for Type 2 diabetes patients employing a group care paradigm (p 0.001). The group care model seems to be cost-effective and successful in improving diabetes managements which includes knowledge of diabetes, quality of life and health behaviors (p<0.001) (Trento *et al.,* 2002). A direct and self-assured relationship with patients can make individual sessions generally more beneficial than group sessions. They can also be employed on an as-needed basis. The use of particular instruments to modify teaching is crucial for group learning. An educational program for groups that was culturally appropriate was able to lower HbA1c over a 24-month period, according to a recent meta-analysis that included 28 studies (Creamer *et al.,* 2015).

Group attention intervention vs. Structured group

The Patients Empower Program (PEP) recently demonstrated in a sizable Chinese cohort of 795 type 2 diabetic patients that a structured education program (including individual and group sessions) may not only improve metabolic outcomes and risk factors, but also reduce all-cause mortality and cardiovascular disease (Wong *et al.,* 2015). In another study, participants in a 5-session manual-based, educator-led structured group intervention utilizing cognitive behavioral methods were evaluated for their effectiveness in improving their poorly managed diabetes. It was discovered that this arm was more successful in lowering blood sugar levels in persons with long-term diabetes than the other two control arms (individual control and group attention control). Furthermore, during particular and scheduled sessions, qualified and experienced teachers should give structured education. All facets of education should be covered in educator preparation programs (Weinger *et al.,* 2011).

When physicians offered the intervention, a meta-analysis among nurses and dietitians revealed that the effect on HbA1c was not significant; in contrast, nurses and dietitians had effect sizes of -0.71% and -0.88%, respectively (Gary *et al.,* 2003). The data demonstrated the necessity for evaluating structured and reproducible group techniques with long-term educational interdisciplinary assistance, based on exact theoretical foundations and tailored to varied people and cultures (Deakin *et al.,* 2005) (Dinneen, 2008). To adapt to individual needs and help patients in terms of behavior, practice, attitudes, knowledge and self-management abilities, quality programs should be evidence-based and carried out by qualified, dynamic and flexible experts (Carrey *et al.,* 2012).

Intensive lifestyle intervention

Intensive lifestyle intervention can also be effective in figuring out a partial remission of type 2 diabetes. It not only causes decrease in body weight and HbA1c but also leads to amelioration of concomitant cardiovascular risk factors consisting of blood pressure and lipids (Chen *et al.,* 2015). The appropriate global contact time between patients and educators, as well as the quantity and frequency of teaching sessions. Trails have not definitively clarified number and frequency of education classes and the ideal worldwide contact time between patients and educators and are still up for debate. It's far probably that periods must be shorter at the

beginning of the educational programs. A meta-analysis documented that every additional hour of contact time is capable of reducing HbA1c by 0.04% (Norris *et al.*, 2002).

Conclusion:

Diabetic patients have very little knowledge of diabetic diet. The perceived needed for the patient to adhere to a healthy diabetic diet is to enhance the knowledge. To educate the diabetic population about diabetic diet through animated videos, posters, pamphlets and. Planned educational intervention must be strengthened by emphasizing the diet planning. The knowledge level can be improved by improving existing educational interventions so that a diabetic patient have good control over the blood sugar level and minimize the complications associated with it. Health professionals should take up the opportunities to educate diabetic patients.

References:

1. Ahmed AM. (2002) History of diabetes mellitus. Saudi medical journal. 1;23(4):373-8.
2. Alberti KG. (2001). Treating type 2 diabetes–today's targets, tomorrow's goals. Diabetes, Obesity and Metabolism, 3:3-10.
3. American Diabetes Association, (2013), Standards of Medical Care in Diabetes. *Diabetes Care*; 36 (Supplement_1): S11–S66
4. American Diabetes Association. (2010) Diagnosis and classification of diabetes mellitus. Diabetes care, 33(Supplement_1):S62-9.
5. Badawi A, Klip A, Haddad P, Cole DE, Bailo BG, El-Sohemy A, Karmali M. (2010). Type 2 diabetes mellitus and inflammation: Prospects for biomarkers of risk and nutritional intervention. Diabetes, metabolic syndrome and obesity: targets and therapy, 173-86.
6. Bernal-Lopez.MR,Santamaría-Fernandez S, Lopez-Carmona D, Tinahones FJ, Mancera-Romero J, Peña-Jimenez D, Jansen-Chaparro S, Baca-Osorio AJ, Cuesta-Muñoz AL, Serrano-Rios M, Gomez-Huelgas R. (2011). HbA1c in adults without known diabetes from southern Europe. Impact of the new diagnostic criteria in clinical practice. Diabetic medicine, 28(11):1319-22.
7. Bilan PJ, Samokhvalov V, Koshkina A, Schertzer JD, Samaan MC, Klip A. (2009). Direct and macrophage-mediated actions of fatty acids causing insulin resistance in muscle cells. Archives of physiology and biochemistry, 115(4):176-90.
8. Buysschaert M, Bergman M. (2011) Definition of prediabetes. Medical Clinics, 95(2):289-97.
9. Cammidge PJ. (1928). Diabetes mellitus and heredity. British medical journal, 2(3538):738.
10. Carrey M, Davies M, Khunti K. (2012). Supplying the missing link in diabetes care: evidence- based structured education for people with type 2 diabetes. In: Vora J, Buse J, eds. Evidence- based Management of Diabetes. Shrewsbury, UK: TFM Publishing Limited, 67–80.
11. Carrillo-Larco, R. M., Barengo, N. C., Albitres-Flores, L., & Bernabe-Ortiz, A. (2019). The risk of mortality among people with type 2 diabetes in Latin America: A systematic review and meta-analysis of population-based cohort studies. *Diabetes/metabolism research and reviews*, *35*(4), e3139.
12. Centers for Disease Control and Prevention. (2014). National diabetes statistics report: estimates of diabetes and its burden in the United States, 2014. Atlanta, GA: US

Department of Health and Human Services.

13. Charokopou M, Sabater FJ, Townsend R, Roudaut M, McEwan P, Verheggen BG. (2016). Methods applied in cost-effectiveness models for treatment strategies in type 2 diabetes mellitus and their use in Health Technology Assessments: a systematic review of the literature from 2008 to 2013. Current medical research and opinion, 32(2):207-18.
14. Chatterjee, S., Khunti, K., & Davies, M. J. (2017). Type 2 diabetes. *The lancet*, *389*(10085), 2239-2251.
15. Chen, L., Pei, J. H., Kuang, J., Chen, H. M., Chen, Z., Li, Z. W., & Yang, H. Z. (2015). Effect of lifestyle intervention in patients with type 2 diabetes: a meta analysis. *Metabolism*, *64*(2), 338- 347.
16. Choi, Y. J., & Chung, Y. S. (2016). Type 2 diabetes mellitus and bone fragility: Special focus on bone imaging. *Osteoporosis and Sarcopenia*, *2*(1), 20-24.
17. Cole G, Hammond S, Leonard B, Fridinger F. (1998). Using "stages of behavioral change" constructs to measure the short-term effects of a worksite-based intervention to increase moderatephysical activity. Psychological Reports, 82(2):615-8.
18. Creamer J, Attridge M, Ramsden M, Cannings-John R, Hawthorne K. (2016). Culturally appropriate health education for Type 2 diabetes in ethnic minority groups: an updated Cochrane Review of randomized controlled trials. Diabetic Medicine, 33(2):169-83.
19. Dabelea D. (2007) The predisposition to obesity and diabetes in offspring of diabetic mothers. Diabetes care. 30(Supplement_2):S169-74.
20. Damm P. (2009) Future risk of diabetes in mother and child after gestational diabetes mellitus. International Journal of Gynecology & Obstetrics. 104(Supplement):S25-6.
21. Danaei G, Finucane MM, Lu Y, Singh GM, Cowan MJ, Paciorek CJ, Lin JK, Farzadfar F, Khang YH, Stevens GA, Rao M. (2011). National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2· 7 million participants. The lancet, 378(9785):31-40.
22. Davies R, Roderick P, Raftery J. (2003). The evaluation of disease prevention and treatment using simulation models. European Journal of Operational Research, 150(1):53-66.
23. Deakin TA, McShane CE, Cade JE, Williams R. (2005). Group based training for self-management strategies in people with type 2 diabetes mellitus. Cochrane database of systematic reviews.
24. Deakin TA, McShane CE, Cade JE, Williams R. (2005). Group based training for self-management strategies in people with type 2 diabetes mellitus. Cochrane database of systematic reviews.
25. DeFronzo, R. A. (2009). From the triumvirate to the ominous octet: a new paradigm for the treatment of type 2 diabetes mellitus. *Diabetes*, *58*(4), 773-795.
26. Dimopoulos N, Watson M, Sakamoto K, Hundal HS. (2006). Differential effects of palmitate andpalmitoleate on insulin action and glucose utilization in rat L6 skeletal muscle cells. Biochemical Journal, 399(3):473-81
27. Dinneen SF. (2008). Structured education for people with type 2 diabetes. BMJ,

336(7642):459- 60.

28. Frank, L. L. (1957). Diabetes mellitus in the texts of old Hindu medicine (Charaka, Susruta, Vagbhata). *The American journal of gastroenterology*, *27*(1), 76-95.
29. Gæde, P., Vedel, P., Larsen, N., Jensen, G. V., Parving, H. H., & Pedersen, O. (2003). Multifactorial intervention and cardiovascular disease in patients with type 2 diabetes. *New England Journal of Medicine*, *348*(5), 383-393.
30. Gary TL, Genkinger JM, Guallar E, Peyrot M, Brancati FL. (2003). Meta-analysis of randomized educational and behavioral interventions in type 2 diabetes. The Diabetes Educator, 29(3):488- 501.
31. Gavin III, J. R., Alberti, K. G. M. M., Davidson, M. B., & DeFronzo, R. A. (1997). Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes care*, *20*(7), 1183.
32. Grundy SM.(2012). Pre-diabetes, metabolic syndrome, and cardiovascular risk. Journal of the American College of Cardiology, 59(7):635-43.
33. Huang Y, Cai X, Chen P, Mai W, Tang H, Huang Y, Hu Y. (2014). Associations of prediabetes with all-cause and cardiovascular mortality: a meta-analysis. Annals of medicine, 46(8):684-92.
34. Huang Y, Cai X, Qiu M, Chen P, Tang H, Hu Y, Huang Y. (2014). Prediabetes and the risk of cancer: a meta-analysis. Diabetologia, 57:2261-9.
35. Inoue K, Matsumoto M, Akimoto K. (2009). The threshold for definition of impaired fasting glucose in a Japanese population. Diabetic medicine, 26(11):1175-8.
36. Karvonen, M., Pitkäniemi, M., Pitkäniemi, J., Kohtamäki, K., Tajima, N., & Tuomilehto, J. (1997). Sex difference in the incidence of insulin-dependent diabetes mellitus: an analysis of the recent epidemiological data. *Diabetes/metabolism reviews*, *13*(4), 275-291.
37. King GL. (2008). The role of inflammatory cytokines in diabetes and its complications. Journalof periodontology, 79:1527-34.
38. Knip, M., & Simell, O. (2012). Environmental triggers of type 1 diabetes. *Cold Spring Harbor perspectives in medicine*, *2*(7), a007690.
39. Krogh-Madsen R, Plomgaard P, Møller K, Mittendorfer B, Pedersen BK. (2006). Influence of TNF-α and IL-6 infusions on insulin sensitivity and expression of IL-18 in humans. American Journal of Physiology-Endocrinology and Metabolism, 291(1):E108-14.
40. Ledermann H. (1995). Is maturity onset diabetes at young age (MODY) more common in Europe than previously assumed?. Lancet (London, England), 345(8950):648.
41. Lichtenstein AH, Schwab US. (2000). Relationship of dietary fat to glucose metabolism. Atherosclerosis, 150(2):227-43. doi: 10.1016/s0021-9150(99)00504-3. PMID: 10856515.
42. Lipska KJ, De Rekeneire N, Van Ness PH, Johnson KC, Kanaya A, Koster A, Strotmeyer ES, Goodpaster BH, Harris T, Gill TM, Inzucchi SE. (2010). Identifying dysglycemic states in older adults: implications of the emerging use of hemoglobin A1c. The Journal of Clinical Endocrinology & Metabolism, 95(12):5289-95.
43. Malek, R., Hannat, S., Nechadi, A., Mekideche, F. Z., & Kaabeche, M. (2019). Diabetes and Ramadan: A multicenter study in Algerian population. *Diabetes research and clinical practice*, *150*, 322-330.

44. McEwen BS (2000) Allostasis and allostatic load: implications for neuropsychopharmacology. Neuropsychopharmacology 22: 108-124.
45. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. (1999). The spread of the obesity epidemic in the United States, 1991-1998. Jama. 282(16):1519-22.
46. Norris SL, Lau J, Smith SJ, Schmid CH, Engelgau MM. (2002). Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. Diabetes care, 25(7):1159-71.
47. Ogurtsova, K., da Rocha Fernandes, J. D., Huang, Y., Linnenkamp, U., Guariguata, L., Cho, N. H., ... & Makaroff, L. E. (2017). IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes research and clinical practice*, *128*, 40-50.
48. O'sullivan JB, Gellis SS, Dandrow RV, Tenney BO (1966). The potential diabetic and her treatment in pregnancy. Obstetrics & Gynecology. 1;27(5):683-9.
49. Ouyang C. (2017). Dietary education for patients with type 2 diabetes: failure or success. Diabetes Manag, 7(5):377-82.
50. Pan DA, Lillioja S, Kriketos AD, Milner MR, Baur LA, Bogardus C, Jenkins AB, Storlien LH. (1997). Skeletal muscle triglyceride levels are inversely related to insulin action. Diabetes, 46(6):983-8. doi: 10.2337/diab.46.6.983. PMID: 9166669.
51. Patterson, C. C., Dahlquist, G. G., Gyürüs, E., Green, A., & Soltész, G. (2009). Incidence trends for childhood type 1 diabetes in Europe during 1989–2003 and predicted new cases 2005–20: a multicentre prospective registration study. *The Lancet*, *373*(9680), 2027-2033.
52. Pettitt DJ, Bennett PH, Saad MF, Charles MA, Nelson RG, Knowler WC. (1991) Abnormal glucose tolerance during pregnancy in Pima Indian women: long-term effects on offspring. Diabetes, 40(Supplement_2):126-30.
53. Picke, A. K., Campbell, G., Napoli, N., Hofbauer, L. C., & Rauner, M. (2019). Update on the impact of type 2 diabetes mellitus on bone metabolism and material properties. *Endocrine connections*, *8*(3), R55.
54. Ramachandran A, Ma RC, Snehalatha C. (2009). Diabetes in Asia. Lancet. 2010 Jan 30;375(9712):408-18. doi: 10.1016/S0140-6736(09)60937-5, PMID: 19875164.
55. Ramachandran A, Snehalatha C, Samith Shetty A, Nanditha A. (2013). Primary prevention of Type 2 diabetes in South Asians--challenges and the way forward. Diabet Med. 2013 Jan;30(1):26-34. doi: 10.1111/j.1464-5491.2012.03753.x. Erratum in: Diabet Med. 2013 Mar;30(3):375. Ambady, R [corrected to Ramachandran, A]. PMID: 22827704.
56. Reece, E. A., & Homko, C. J. (1998). Diabetes mellitus in pregnancy. What are the best treatmentoptions?. *Drug safety*, *18*(3), 209-220.
57. Schwartz, S. S., Epstein, S., Corkey, B. E., Grant, S. F., Gavin III, J. R., & Aguilar, R. B. (2016). The time is right for a new classification system for diabetes: rationale and implications of the β- cell–centric classification schema. *Diabetes care*, *39*(2), 179-186.
58. Schwitzgebel VM. (2014). Many faces of monogenic diabetes. Journal of diabetes investigation, 5(2):121-33.
59. Sherwin R, Jastreboff AM. (2012). Year in diabetes 2012: the diabetes tsunami. The Journal of Clinical Endocrinology & Metabolism, 97(12):4293-301.

60. Shoelson SE, Lee J, Goldfine AB. (2006). Inflammation and insulin resistance. The Journal of clinical investigation, 116(7):1793-801.
61. Sperl-Hillen J, Beaton S, Fernandes O, Von Worley A, Vazquez-Benitez G, Parker E, Hanson A, Lavin-Tompkins J, Glasrud P, Davis H, Adams K. (2011). Comparative effectiveness of patient
education methods for type 2 diabetes: a randomized controlled trial. Archives of internal medicine, 171(22):2001-10.
62. Sridhar GR, Madhu K (2002) Psychosocial aspects of diabetes. In Ahuja MMS, Tripathy BB, Moses SGP *et al.* (eds). RSSDI Textbook of Diabetes. Research Society for the Study of Diabetesin India, Hyderabad, 737-755
63. Steck AK, Rewers MJ.(2011). Genetics of type 1 diabetes. Clinical chemistry. 1;57(2):176-85.
64. Sterling P (2004) Principles of allostasis: Optimal design, predictive regulation, pathophysiology, and rational therapeutics. In:Schulkin J, ed. Allostasis, Homeostasis, and the Costs of Physiological Adaptation. Cambridge: Cambridge University Press, 17-64.
65. Storlien LH, Baur LA, Kriketos AD, Pan DA, Cooney GJ, Jenkins AB, Calvert GD, Campbell LV. (1996). Dietary fats and insulin action. Diabetologia, 39(6):621-31. doi: 10.1007/BF00418533. PMID: 8781757.
66. Stumvoll, M., Goldstein, B. J., & Van Haeften, T. W. (2005). Type 2 diabetes: principles of pathogenesis and therapy. *The Lancet*, *365*(9467), 1333-1346.
67. Sutherland HW, Stowers JM, editors. (2012)Carbohydrate metabolism in pregnancy and the newborn 1978. Springer Science & Business Media.
68. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. (2012) Prediabetes: a high-risk state for diabetes development. The Lancet, 379(9833):2279-90.
69. Tattersall RB, Fajans SS, Arbor A. (1975). A difference between the inheritance of classical juvenile-onset and maturity-onset type diabetes of young people. Diabetes, 24(1):44-53.
70. Trento M, Passera P, Bajardi M, Tomalino M, Grassi G, Borgo E, Donnola C, Cavallo F, Bondonio P, Porta M. (2002). Lifestyle intervention by group care prevents deterioration of TypeII diabetes: a 4-year randomized controlled clinical trial. Diabetologia, 45:1231-9.
71. Tucker DM, Palmer AJ. (2011). The cost-effectiveness of interventions in diabetes: A review of published economic evaluations in the UK setting, with an eye on the future. primary care diabetes, 5(1):9-17.
72. United Nations Geographic Region Classification. (2016) List of country names. (online).
73. Unnikrishnan, R., Anjana, R. M., & Mohan, V. (2014). Diabetes in South Asians: is the phenotype different?. *Diabetes*, *63*(1), 53-55.
74. Vionnet N, Stoffel M, Takeda J, Yasuda K, Bell GI, Zouali H, Lesage S, Velho G, Iris F, Passa PH, Froguel PH. (1992) Nonsense mutation in the glucokinase gene causes early-onset non- insulin-dependent diabetes mellitus. Nature, 356(6371):721-2.
75. Weinger K, Beverly EA, Lee Y, Sitnokov L, Ganda OP, Caballero AE. (2011). The effect of a structured behavioral intervention on poorly controlled diabetes: a randomized controlled trial. Archives of internal medicine, 171(22):1990-9.

76. Weinstein MC, Toy EL, Sandberg EA, Neumann PJ, Evans JS, Kuntz KM, Graham JD, Hammitt JK. (2001). Modeling for health care and other policy decisions: uses, roles, and validity. Valuein Health, 4(5):348-61.
77. Wellen KE, Hotamisligil GS. (2005). Inflammation, stress, and diabetes. The Journal of clinical investigation, 115(5):1111-9.
78. Weyer, C., Bogardus, C., Mott, D. M., & Pratley, R. E. (1999). The natural history of insulin secretory dysfunction and insulin resistance in the pathogenesis of type 2 diabetes mellitus. *The Journal of clinical investigation*, *104*(6), 787-794.
79. Wong CK, Wong WC, Lam CL, Wan YF, Wong WH, Chung KL, Dai D, Tsui EL, Fong DY. (2014). Effects of Patient Empowerment Programme (PEP) on clinical outcomes and health service utilization in type 2 diabetes mellitus in primary care: an observational matched cohort study. PloS one, 9(5):e95328.
80. Wong CK, Wong WC, Wan YF *et al.* (2015). Empowerment Programme in primary care educed all-cause mortality and cardiovascular diseases in patients with type 2 diabetes mellitus: A population-based propensity-matched cohort study. Diabetes. Obes. Metab. 17(2), 128–135.
81. World Health Organisation (2016) Global report on diabetes. World Health Organisation.
82. Yamagata K, Oda N, Kaisaki PJ, Menzel S, Furuta H, Vaxillaire M, Southam L, Cox RD, Lathrop GM, Boriraj VV, Chen X. (1996). Mutations in the hepatocyte nuclear factor-1α gene in maturity-onset diabetes of the young (MODY3). Nature, 384(6608):455-8.
83. Zhang X, Gregg EW, Williamson DF, Barker LE, Thomas W, Bullard KM, Imperatore G, Williams DE, Albright AL. (2010). A1C level and future risk of diabetes: a systematic review. Diabetes care, 33(7):1665-73.
84. Zhou, B., Lu, Y., Hajifathalian, K., Bentham, J., Di Cesare, M., Danaei, G. & Gaciong, Z. (2016).Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4· 4 million participants. *The lancet*, *387*(10027), 1513-1530.

MILLETS - A FUNCTIONAL INGREDIENT FOR VALUE ADDED PRODUCT DEVELOPMENT

P. Gomathi* and M. Sivasakthi
Department of Nutrition & Dietetics,
PSG College of arts & science, Coimbatore-641014
*Corresponding author E-mail: gomathigomathi0887@gmail.com

Abstract:

Millets are small grain cereals mostly grown in Asian and African countries. Millets are good sources of macronutrients like carbohydrates, protein, fiber, fat, vitamins and minerals etc. Millets are found with anti cancer, anti anemic, anti diabetic, anti lipidemic properties. Millets are used to develop bakery products like noodles, pasta and convenient breakfast and baby formula foods. In the current scenario, millets are widely used for the development of functional foods with profuse therapeutic benefits.

Keywords: Millets, bakery products, noodles, pasta, cookies, bread

Introduction:

Millets are a group of small-seeded grasses that have been cultivated for thousands of years in many parts of the world, particularly in Asia and Africa. Millets are a versatile and nutritious food source, providing essential minerals, vitamins, and dietary fiber. Millets are also known for their ability to grow in harsh and arid environments, making them an important crop for food security in regions with limited water and other resources.

Millets are two types namely minor and major millets. Major Millets like Bajra or Pearl millet (*Pennisetum americanum*), Ragi or Finger millet (*Eleusine coracana*), and minor Millets like Navane or Foxtail millet (*Setaria italica*), Samai or Little millet (*Panicum miliare*), Varagu or Kodo millet (*Paspalum scrobiculatum*), Panivaragu or Proso millet (*Panicum miliaceum*), Kuthiraivali or Barnyard millet (*Echinochloa frumentacea*) are the Important millets cultivated largely in the Asian and African countries. (Ushakumari *et al.,* 2004).

Millets offer health benefits in daily diet and help in the management of disorders like obesity, hypertension, hypercholestrol, hyperglycemia, cancer, anemia, diabetes Mellitus, hyperlipidemia etc. (Veena, 2003).

Value addition of foods using millets:

1. Pearl millet

Pearl millet (*Pennisetum americanum*) is a highly nutritious and drought-tolerant cereal crop that is widely grown in Africa and Asia. It is a staple food for millions of people, especially in arid and semi-arid regions where other cereal crops such as wheat and rice cannot be grown. According to Jatet *et al.* (2021), Pearl millet is the sixth most important cereal crop in the world, with India being the largest producer and consumer of this crop. Pearl millet is an important source of nutrition for millions of people, especially in Africa and Asia, where it is consumed in various forms such as porridge, bread, and fermented beverages. According to Govindaraj *et al.* (2015) Pearl millet is an excellent source of protein, fiber, vitamins, and minerals such as iron,

calcium, and phosphorus. The study also noted that Pearl millet is gluten- free, making it a good choice for people with gluten intolerance.

Sanoussi *et al.* (2020) highlighted the importance of Pearl millet in the Sahel region of West Africa, where it is a major source of food and income for small-scale farmers. The study noted that Pearl millet has a high yield potential and can be grown in harsh environmental conditions, making it a valuable crop for food security and poverty reduction in the region.(Sanoussi *et al.,* 2020). In addition to its nutritional value and resilience, Pearl millet has also been found to have potential health benefits. Balasubramanian *et al.* (2016) showed that Pearl millet consumption can help to reduce the risk of chronic diseases such as diabetes and cardiovascular disease, due to its high fiber and antioxidant contents by consuming millet based food products.

Pearl millet based products

Pearl millet is an important cereal crop grown in many parts of the world, especially in arid and semi-arid regions. It is known for its nutritional value and is an excellent source of protein, dietary fiber, and minerals such as iron and zinc. One of the most popular Pearl millet-based products is Pearl millet flour, which is used to make various food items such as bread, porridge, cookies, beverages and pancakes.

Pearl millet based cookies

According to Purohit *et al.* (2015), Pearl millet flour can be used as a functional ingredient in the development of gluten-free cookies. The Pearl millet flour improved the

nutritional and sensory properties of the cookies, including increased protein, fiber, and mineral content, as well as improved texture and flavor.

Pearl millet based porridge

According to Kumari *et al.* (2019), Pearl millet porridge is a nutritious and palatable food that can be used to combat malnutrition in developing countries. The Pearl millet porridge had high levels of protein, fiber, and minerals, and was well-liked by both children and adults.

Pearl millet based beverages

In addition to these products, Pearl millet can also be used to make fermented beverages. Pearl millet-based traditional beverages in Nigeria had high levels of lactic acid bacteria, which have been shown to have probiotic properties. The Pearl millet-based beverages could be a potential source of probiotics for human health (Sanni *et al.,* 2008).

Pearl millet based bread

According to Gichuhi *et al.* (2019), Pearl millet flour can be used to make high-quality bread with good sensory and nutritional properties. The bread made with 100% Pearl millet flour had higher levels of protein, dietary fiber, and minerals than bread made with wheat flour. The authors concluded that Pearl millet flour has potential property as a functional ingredient for the production of bread and other baked goods.

Pearl millet based snacks

Pearl millet-based product that has gained popularity in recent years is Pearl millet-based snacks. A study published in the International Journal of Food Science and Technology revealed that extruded snacks made with Pearl millet flour had good sensory properties and high nutritional value (Chandrasekara *et al.,* 2015). The Pearl millet-based snacks had higher levels of

protein, dietary fiber, and minerals than traditional corn-based snacks. The investigator has suggested that Pearl millet-based snacks could be a nutritious and affordable alternative to traditional snacks.

2. Sorghum millet

Sorghum (*Sorghum bicolor* (L.) Moench) is a cereal crop that is widely grown for food, animal feed, and biofuel production in many regions of the world, particularly in Africa and Asia. According to the Food and Agriculture Organization of the United Nations (FAO),

Sorghum is the fifth most important cereal crop in the world after maize, wheat, rice, and barley (FAO, 2021) loaded with ample amount of potential health properties.

Sorghum can be used to make a variety of foods, including beverages, porridge, baked goods, and extruded goods. The best of these are Sorghum-ogi, SGs drinks, and SGs components (as food additives). Sorghum-ogi, which is made from wet-milled fermented Sorghum, is regarded as one of the probiotic foods. It is a thin, creamy, porridge that flows freely. In addition, foods made from Sorghum can be enjoyed all over the world as functional foods for human health. Technology-based methods for removing or lowering anti-nutritional elements, enhancing Sorghum quality, and creating foods with high nutritional value include soaking, germination, fermentation, thermal treatments, irradiation, and others. In addition, a combination of additional treatments, including soaking, and germination would result in better functional food development.

Sorghum is employed in preparations of porridge, bread, and other foods made from Sorghum, fermentation (with yeasts and lactic acid bacteria, for example) is used. Studies on fermented grain foods have revealed enhanced amino acid profiles and higher digestibility when compared to unfermented grain diets (Day & Morawicki, 2018; Nkhata *et al.*, 2018). Sorghum's *in-vitro* protein digestibility was greatly increased by traditional fermentation (TF), and enzyme inhibitory activities were significantly reduced. Trypsin inhibitory activity was lowered between 31 and 58%, whilst amylase inhibitory activity was decreased between 74 and 75%. Moreover, following fermentation, the reduction in tannin content varied from 15 to 35% (Osman, 2004). According to a different study, Sorghum's TF considerably reduced the tannin concentration by between 52.7 and 56.9%. Almost 50% of the phytic acid content was significantly reduced, and trypsin level was increased.

Sorghum millet based products

Sorghum millet can be used to make a variety of products, including flour, bread, pasta, and snacks. Here are some examples of Sorghum and millet-based products.

Sorghum millet based bread

According to Abang *et al.* (2019), Sorghum millet-based product is “Sorghum millet-based bread.” Sorghum and millet flour were used to produce bread that had comparable sensory qualities and nutritional composition to wheat bread. The study found that the Sorghum millet-based bread had higher levels of protein, fiber, and minerals than wheat bread (Abang *et al.*, 2019).

Sorghum millet based snacks

According to Oyeyinka *et al.* (2018), Sorghum and millet flours were used to produce snacks that were high in protein, fiber, and antioxidants. The Sorghum millet-based snacks had higher nutritional value than commercially available corn and potato-based snacks.

Sorghum millet based beer

Sorghum-based product that is gaining popularity is Sorghum beer, which is a traditional alcoholic beverage in many African countries. Sorghum beer is made by fermenting Sorghum grains with water, yeast, and other ingredients. According to a study published in the journal Food Science and Nutrition, Sorghum beer is rich in phenolic compounds, which have been shown to have antioxidant and anti-inflammatory properties (Makhuvele *et al.,* 2019). The Sorghum beer is a good source of lactic acid bacteria, which can improve gut health and boost the immune system.

Sorghum based Pasta

Sorghum pasta is a gluten-free pasta made from Sorghum flour. It has a slightly nutty flavor and a chewy texture. Sorghum pasta is an excellent alternative to wheat pasta for people with celiac disease or gluten sensitivity. A study published in the Journal of Cereal Science found that Sorghum pasta had a higher protein content and lower glycemic index than wheat pasta (Ndolo et al., 2017).

3. Little millet

Little millet, scientifically known as Panicum sumatrense, is a small-grained cereal crop that is grown in many parts of the world, including India, China, and Africa. It is an important source of nutrition for millions of people, particularly in developing countries, where it is often consumed as a staple food. According to (Kamal Kant *et al.* 2020), Little millet is a rich source of nutrients such as carbohydrates, proteins, dietary fiber, and minerals. It is also low in fat and gluten-free. Saini and Yadav, (2018) investigated the usage of small millet (Panicum sumatrense) in the extrusion-based manufacturing of ready-to-eat snack products. Little millet (0–20%), maize flour (40–50%), and rice flour (40–50%) were combined to create the twin-screw extruded product. Extrusion cooking was done using the best possible extrusion conditions, Increase in moisture (4.45-5.70%), ash (0.75-1.45%%), protein (3.25-4.38%%), fat (0.82-1.17%), fibre (1.05-2.88%), bulk density, and hardness (0.11-0.24) N of the extruded products result from adding more small millet (0-20%) to the extrusion blend.

A small amount of Little millet flour was added in various amounts namely, T0 (0%), T1 (5%), T2, T3, and T4 (20%). The maximum and minimum chemical characteristics, such as moisture, ash, protein, fat, crude fibre, carbohydrate, and calorific values, of the flour fortified extrudate were also determined after extrusion and are 5.70%, 1.45%, 4.38%, 1.17%, 2.88%,89.65%, and 378.98% and 4.45%, 0.75%, 3.25%, 0.82%, 1.05%, 84.42%, and 365.73%, respectively. Expansion ratio and bulk density of the extruded product were at their highest and lowest values of 4.01 and 0.24 kg/m3 and 2.63 and 0.11 kg/m3 respectively. The created composite flour's textural characteristics revealed a maximum hardness of 27.85 N and a minimum hardness of 7.84 N. The textural properties of extruded products are generally described by the hardness and crispness. The textural parameters studied were crispness,

hardness and cutting strength and it was analyzed with help of textural analyzer (Yadav and Chandra, 2015).

Little millet based products

Little millet is a type of millet grain that is gaining popularity due to its nutritional value and versatility in cooking. In recent years, there has been a surge in the development of Little millet-based products to cater to the growing demand for healthy and sustainable food options. Here are some examples of Little millet-based products.

Little millet based Cookies

Little millet cookies are a healthy snack option made with Little millet flour, jaggery, and ghee. According to Kaur *et al.* (2020), Little millet cookies have a low glycemic index, making them suitable for people with diabetes.

Little millet Instant Noodles

Little millet instant noodles are a healthier alternative to traditional instant noodles made with refined flour. According to a study published in the Journal of Food Science and Technology by authors (Gupta *et al.,* 2018), Little millet instant noodles have a lower fat content and higher protein content than traditional instant noodles.

Little millet Porridge Mix

Little millet porridge mix is a nutritious breakfast option made with Little millet, jaggery, and spices like cardamom and cinnamon. According to Ganesan *et al.* (2017), Little millet porridge mix is a rich source of dietary fiber, antioxidants, and minerals like calcium and phosphorus.

Little millet Instant Mix

Little millet instant mixes are becoming popular as a quick and easy breakfast option. A study conducted by Sujatha *et al.* (2018) found that instant mixes made from Little millet had a higher protein, dietary fiber, and iron content than the traditional wheat-based mixes. These mixes can be easily prepared by adding hot water, and they are a great option for those with busy schedules.

Little millet based Noodles

Little millet noodles are a healthier alternative to traditional wheat-based noodles. A study conducted by Ahmed *et al.* (2019) found that Little millet noodles had higher protein, dietary fiber, and mineral content than wheat-based noodles. These noodles can be prepared with vegetables and a low-sodium sauce for a healthy and delicious meal.

Little millet Based Bread

Little millet bread is a gluten-free option that is becoming popular among health-conscious individuals. A study conducted by Hukkeri *et al.* (2021) found that bread made from Little millet flour had higher protein, dietary fiber, and mineral content than wheat-based bread. This bread can be enjoyed as a sandwich or toasted with a healthy spread.

4. Foxtail millet

Foxtail millet (*Setaria italica*) is an ancient cereal crop that has been cultivated in India for over 3000 years. It is believed to have originated in China and then spread to India, where it has become an important crop (Reddy *et al.,* 2019). Foxtail millet is also known by its scientific name Setaria italica, and is a member of the Poaceae family. Foxtail millet is a highly nutritious

crop that is rich in protein, fiber, and minerals such as iron, calcium, and phosphorus (Joshi *et al.*, 2019). It is also a good source of antioxidants and has been found to have potential health benefits in the prevention of diabetes, obesity, and cardiovascular diseases (Ganesan *et al.*, 2018). By exposing native grains (12% mc) to HTST treatment at 230+/- 5 oC, the cereal processing technologies can be successfully applied to Foxtail millet to produce ready-to-eat or RTE products in the form of flaked, extruded, roller dried, decorticated, and popped grains (Ushakumari *et al.*, 2004). Roller-dried millet had the highest level of starch gelatinization, followed by the products that were popped, flaked, and extruded. According to Fujita et al. (1996), the microstructure of puffed starch granules becomes spherical, while that of popped and extruded products has a structure resembling a honeycomb. To make dough, finger millet and Foxtail millet flour are cooked at 80 to 100 degrees Celsius with varying amounts of water (100 to 130 ml) and time (1-3 minutes).

Foxtail Millet based products

Foxtail millet is a nutritious cereal crop that has been used in various traditional dishes in India and other parts of Asia for centuries. In recent years, there has been growing interest in developing Foxtail millet-based products due to its numerous health benefits. In this response, some Foxtail millet-based products are highlighted.

Foxtail Millet Based cookies

Foxtail millet can be used as a substitute for wheat flour in making cookies, which makes them gluten-free and healthier. A study by Rani *et al.* (2019) found that Foxtail millet cookies had higher protein, fiber, and mineral content than wheat flour cookies. They also had a lower glycemic index, making them a suitable option for people with diabetes.

Foxtail Millet based Noodles

Noodles made from Foxtail millet flour are a popular food item in some parts of India. According to Muthulakshmi et al. (2019) found that Foxtail millet noodles had higher protein, fiber, and mineral content than wheat noodles. They also had a lower glycemic index, making them a healthier option.

Foxtail Millet Bread

Foxtail millet flour can be used to make bread, which is a healthier alternative to wheat bread. A study by Singh *et al.* (2016) found that Foxtail millet bread had a lower glycemic index and higher protein and mineral content than wheat bread.

Foxtail Millet Porridge

Foxtail millet can be used to make porridge, which is a popular breakfast item in some parts of Asia. A study by Shobana *et al.* (2016) found that Foxtail millet porridge had a lower glycemic index and higher fiber and mineral content than rice porridge. It also helped in reducing postprandial glucose levels in people with diabetes.

5. Finger millet

Finger millet (*Eleusine coracana*) is an important cereal crop that is widely cultivated in Africa and Asia. finger millet is an ancient crop that has been cultivated for more than 5000 years, and it is one of the few crops that can thrive in harsh environments with poor soil fertility and low rainfall. Finger millet is highly nutritious and is considered as a "superfood" due to its high protein, fiber, and mineral content (Hittalmani *et al.*, 2017). According to Sanjana *et al.*

(2015), finger millet is a rich source of calcium, iron, and zinc, which are important minerals for human health. It is also rich in antioxidants such as phenolic acids, flavonoids, and tannins, which have been shown to have anti-inflammatory and anti-cancer properties.

Processes used to prepare value added finger millet products include milling, malting, fermentation, popping, and decortication. Also developing from finger millet are noodles, vermicilli, pasta, Indian sweet (halwa) mix, papads, soups, and bakery goods. Studies conducted *in-vitro* and *in-vivo* (on animals) suggested that finger millet has qualities that can help with wound healing, blood sugar control, cholesterol reduction, and anti-ulceration. On these health effects, there aren't any randomised clinical trials or appropriate interventions, though. Studies on the glycemic index (GI) of finger millet preparations show low to high values, but the majority of the investigations used outmoded methods. In order to develop evidence-based health benefits, adequate GI testing of finger millet preparations and short- and long-term human intervention trials may be helpful (Shobana *et al.*, 2013).

Finger millet based products

Finger millet biscuit

Ragi biscuits are a healthier alternative to regular biscuits as they are made with Ragi flour, which is rich in fiber and nutrients. Ragi biscuits have a low glycemic index, which makes them suitable for diabetic patients (Thakur *et al.*, 2015).

Ragi flakes

Ragi flakes are made by steaming and flattening finger millet grains. They can be consumed as a breakfast cereal or used in baking. Ragi flakes are a rich source of dietary fiber, protein, and iron. Ragi flakes have potential health benefits in the prevention of cardiovascular diseases (Sumathi & Urooj, 2012).

6. Proso millet

Proso millet (Panicum miliaceum) is a warm-season grass crop that belongs to the family Poaceae. It is grown for its small, nutritious seeds, which can be consumed as food or used for livestock feed. Proso millet is also known as broomcorn millet, common millet, hog millet, and white millet. Uppal *et al.* (2017) found that consuming Proso millet can help to reduce the risk of chronic diseases such as diabetes and cardiovascular disease. This is because Proso millet is low in glycemic index and high in antioxidants, which can help improve blood sugar control and reduce oxidative stress.

Proso millet is a rich source of nutrients such as protein, dietary fiber, and minerals like iron, magnesium, and phosphorus (Kumar *et al.,* 2016). Its high nutritional value makes it a popular food in many parts of the world, particularly in Asia and Africa. In India, Proso millet is used to make a variety of dishes such as khichdi, dosa, and roti and analysed its functional properties that shows quite good with respect to its shelf life and long term use (Kumar *et al.*, 2016).

Proso millet based products

Proso Millet Beer

Proso millet beer is a gluten-free alternative to traditional beer that is becoming increasingly popular among health-conscious consumers. According to a study by (Kadam et al.

2021), Proso millet beer had a high nutritional value, with a protein content of 3.7% and a fiber content of 0.4%.

Proso millet-based bread

According to a study by Kurek *et al.* (2017), Proso millet flour can be used as a substitute for wheat flour in bread-making resulting in a gluten-free bread with good sensory and

nutritional properties. The investigator found that Proso millet flour had a higher protein and mineral content than wheat flour and the bread made with Proso millet flour had a softer crumb texture and a slightly nutty flavor.

Proso millet-based flakes

According to a study by Gupta *et al.* (2016), millet flakes can be made from Proso millet using a simple and cost-effective process. The investigator has revealed that millet flakes had higher fiber and mineral content than wheat flakes, and they could be used as a breakfast cereal or a snack food.

7. Kodo millet

Kodomillet, also known as Paspalum scrobiculatum is a nutritious and drought-resistant cereal grain that has been cultivated in India for thousands of years. Kodo millet is an important minor millet crop grown in India, particularly in the arid and semiarid regions of the country, where it is considered to be a hardy crop that can withstand adverse weather conditions. In addition to being a hardy crop, Kodo millet is also rich in essential nutrients such as protein, fiber, and minerals (Deeksha Singh *et al.* 2015). Kodo millet is an excellent source of dietary fiber, with a content ranging from 8.8 to 11.6%, and protein, with a content ranging from 7.3 to 12.3% (Ramu *et al.,* 2016). Gupta *et al.* (2019) found that Kodo millet has anti-diabetic, anti-inflammatory, and anti-cancer properties, and may also be beneficial in the management of cardiovascular diseases." The study also noted that Kodo millet has a low glycemic index, which means it can help regulate blood sugar levels and the food products normally developed frommillets are infant baby food formulations, snack foods and health mix developments. The effect of thermal and non-thermal processing of foods are also researched and observed with good quality characteristics.

Kodo Millet based products

Kodo Millet based Bread

According to Gujral *et al.* (2011) Kodo millet can also be used to make bread. A study bread made from Kodo millet had a higher nutritional value compared to wheat bread, containing more protein, fiber, and essential minerals. Finally analysis on sensory evaluation moisture, texture, flavour, taste and overall appearance. Bread was found to have a significant increase in fiber content, which can prove to be highly beneficial for individuals suffering from heart disease, diabetes and obesity.

Kodo Millet based Cookies

Kodo millet can also be used to make cookies. Cookies made from Kodo millet had a high antioxidant activity and a low glycemic index, making them a healthy snack option (Hariharan *et al.,* 2016). To be analyzed in Texture, flavour and taste, aroma and overall acceptability.

Kodo Millet based pasta

Kodo millet pasta is another popular product that is made from Kodo millet flour. It is a healthier alternative to traditional wheat pasta and is suitable for people with gluten intolerance. Kodo millet pasta is rich in dietary fiber and protein, making it a nutritious option for a quick and easy meal (Arunkumar *et al.*, 2014).

Conclusion:

In many cultures all over the globe, millet has been consumed for centuries. It is a versatile and healthy grain. Due to their numerous health advantages and distinctive flavor, millet-based goods have grown in popularity in recent years. The abundance of nutrients in millet-based products is one of their primary advantages. A significant provider of calcium, vital amino acids, and vitamins, they also help in preventing diabetes, tumors, obesity, and premature ageing. There is always a tremendous opportunity because small millets can produce a range of value-added products. Research in the nutritional and nutrigenomics fields constantly seeks out nutrient-rich natural sources such as small millets are cheap, simple to grow, environment friendly and great source of nutrition. Small millets are able to be used to address malnutrition issues throughout the nation.

References:

1. Abang, Z., Achikanu, C., Khandaker, M., & Islam, S. (2019). Quality evaluation of bread produced from Sorghum and millet flour blends. Journal of Food Science and Technology, 56(7), 3442-3449.
2. Anitha, P., & Urooj, A. (2010). Nutritional quality of extruded snacks formulated using Pearl millet andrice blends. Journal of Food Science and Technology, 47(4), 405-411.
3. Babu, D. R., *et al.* (2019). Therapeutic potential of millets: A review. Frontiers in nutrition, 6, 118.
4. Balasubramanian, S., Vaidyanathan, K., & Patwardhan, B. (2016). Pearl millet: a review of its potential health benefits. Journal of the Science of Food and Agriculture, 96(13), 4310-4316.
5. Chandrasekara, A., Shahidi, F., & Decker, E. A. (2015). Extruded snacks from Pearl millet and navy bean blend: Physical, sensory and nutritional quality. International Journal of Food Science & Technology, 50(4), 986-994.
6. Day, C. N., & Morawicki, R. O. (2018). Effects of fermentation by yeast and amylolytic Lactic acid bacteria on grain Sorghum protein content and digestibility. Journal of Food Quality, 1–8.
7. Doggett, H. (1988). Sorghum. Longman Scientific & Technical.
8. Dykes, L. and Rooney, L. W. (2006). Sorghum and millet phenols and antioxidants. Journal of Cereal Science, 44(3): 236-251.
9. FAO. (2021). Sorghum. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/Sorghum/en/.
10. Fujita S, Sugimoto Y, Yamashita Y and Fuwa H (1996). Physico-chemical studies of starch from Foxtail Millet. Food Chemistry, 30: 209-213.
11. Ganesan, K., Xu, B., & Weon, J. B. (2018). Foxtail Millet: Nutritional and Health Benefits. Journal of Agricultural and Food Chemistry, 66(19), 4669-4675. Doi:

10.1021/acs.jafc.8b00887

12. Gichuhi, P. N., Wanjau, R., Ngugi, H. K., & Ng'ang'a, J. K. (2019). Pearl millet flour for bread making: Effect of particle size and hydration on dough and bread quality. Journal of Cereal Science, 87, 123-128.
13. Gupta, R. K., Kumar, V., & Yadav, S. K. (2016). Development of millet flakes from Proso millet: Optimization of process parameters using response surface methodology. Journal of Food Science and Technology, 53(2), 1156-1163.
14. Hariharan, K., Alagusundaram, K., & Chandrasekaran, M. (2016). Development and nutritional evaluation of Kodo millet (*Paspalum scrobiculatum*) incorporated cookies. International Journal of Food Science and Nutrition, 1(4), 22-25.
15. Hittalmani, S., Mahadevaiah, C., Muthiah, A.R., and Parthasarathy Rao, P. (2017). Finger millet for food security: A review. Agricultural Reviews, 38(1), 55-60.
16. Joshi, V. K., Kumar, S., & Mishra, S. K. (2014). Antioxidant activity and physicochemical properties of malted Kodo millet (*Paspalum scrobiculatum*) porridge. Journal of Food Science and Technology, 51(12),4047-4052.
17. Kamal Kant, *et al.* (2020). Nutritional and therapeutic potential of Little millet (*Panicum sumatrense*): A review. Journal of food science and technology, 57(8), 2785-2794.
18. Karthikeyan, S., Elumalai, S., & Kumar, S. (2019). Nutritional quality and glycemic index of ragi cookies. International Journal of Chemical Studies, 7(2), 2716-2721. Doi: 10.22271/chemi.2019.v7.i2b.8466
19. Kothari, C. R., *et al.* (2021). Sorghum flour: a potential alternative to wheat flour. Journal of Food Science and Technology, 58(1), 1-7.
20. Kumar, A., Tomer, V. P. S., Singh, A. K., & Kumar, A. (2016). Proso millet: a new crop of nutraceutical values for the world. Journal of Agriculture and Food Chemistry, 64(39), 7271-7279.
21. Kumar, D., Bhardwaj, R. L., & Singh, R. (2020). Development and quality evaluation of extruded snack food based on barnyard millet (*Echinochloa frumentacea*) and chickpea (*Cicer arietinum*). Journal of Food Measurement and Characterization, 14(1), 334-341.
22. Kumar, G. R., & Ramalakshmi, K. (2020). Quality evaluation of barnyard millet-based idli batter. Journalof Food Science and Technology, 57(10), 3737-3746.
23. Kumar, S., Gupta, S., Thakur, S., & Sharma, A. (2016). Evaluation of Antioxidant and Anti-inflammatory Activities of Barnyard Millet (*Echinochloa frumentacea*) Extracts. Journal of Food Science and Technology, 53(2), 1264-1272.
24. Kumari, P. L., *et al.* (2021). Development and characterization of Kodo millet (*Paspalum scrobiculatum*) based cookies: An alternative for wheat based cookies. International Journal of Food Science and Nutrition, 6(1), 120-125.
25. Kumari, S., Anitha, S., & Kumar, S. (2019). Nutritional and sensory evaluation of Pearl millet (*Pennisetum glaucum*) porridge. Journal of Food Science and Technology, 56(1), 246-253.
26. Kurek, M. A., Wyrwisz, J., & Sabat, R. (2017). Bread made from Proso millet (*Panicum miliaceum* L.) flour. Journal of Food Science and Technology, 54(1), 138-145.
27. Makhuvele, R. H., *et al.* (2019). Health benefits of Sorghum beer: a review. Food Science

and Nutrition, 7(4), 1169-1180

28. Mgonja, M. A., Ogunniyi, L. T., Ndakidemi, P. A., & Fawole, O. B. (2018). Proso millet: a review of potential for food and feed security. Journal of Agricultural Science, 10(7), 1-15.
29. Muthulakshmi, M., Jyothi Lakshmi, A., & Elango, A. (2019). Development and quality evaluation of noodles prepared from Foxtail millet (*Setaria italica*). Journal of Agroalimentary Processes and Technologies, 25(2), 214-223.
30. Narayan, B., Neginhal, V., & Thimmaraju, R. (2015). Development and evaluation of ragi based health drink mix. International Journal of Science and Research, 4(12), 1899-1902.
31. Oyeyinka, S. A., Afolabi, W. A., Adegoke, G. O., Adekunte, A. O., & Ogunjobi, M. A. (2018). Quality and nutritional attributes of snacks produced from blends of Sorghum and millet flours. Food Science & Nutrition, 6(7), 2021-2027.
32. Pawar, N., Narkhede, H. P., & Singhal, R. S. (2016). Effect of extrusion cooking on the physico- chemical, nutritional and antioxidant properties of Proso millet based pasta. Journal of Food Science and Technology, 53(7), 2853-2863.
33. Prasad, S., Muthuswamy, S., Senthilkumar, B., & Rajakumar, R. (2014). Antioxidant and antidiabetic activity of finger millet (*Eleusine coracana*) polyphenols. Journal of Food Science and Technology, 51(7),1506-1512. Doi: 10.1007/s13197-012-0663-2
34. Prasanthi, A. R., Sudha, M. L., & Haridas Rao, P. (2019). Glycemic index and sensory evaluation of barnyard millet-based cookies. Journal of Food Science and Technology, 56(11), 4978-4985.
35. Purohit, P., Kumar, V., & Banerjee, R. (2015). Formulation and development of gluten-free cookies using Pearl millet flour. Journal of Food Science and Technology, 52(9), 5794-5800.
36. Rani, P., Urooj, A., & Sunita, M. (2019). Development and quality evaluation of gluten-free cookies using Foxtail millet (*Setaria italica*). Journal of Food Measurement and Characterization, 13(3), 1866- 1875.
37. Rao, K. S., Ramesh, H. P., & Srinivasa Rao, P. (2015). Development and quality evaluation of instant noodles prepared from ragi (*Eleusine coracana*) flour. International Journal of Food Science and Technology, 50(9), 2089-2095.
38. Reddy, P. S., Jogeswar, G., & Reddy, K. H. (2019). Foxtail Millet (*Setaria italica* L.): A Review on Its Potentiality as Health Food and Prospects in Processing Industries. Frontiers in Sustainable Food Systems, 3, 1-12. Doi: 10.3389/fsufs.2019.00107
39. Rooney, W. L., Blumenthal, J., Bean, B., and Mullet, J. E. (2007). Designing Sorghum as a dedicated bioenergy feedstock. Biofuels, Bioproducts, and Biorefining, 1(2): 147-157.
40. Saleh, A. S., Zhang, Q., Chen, J., & Shen, Q. (2013). Millet grains: nutritional quality, processing, and potential health benefits. Comprehensive Reviews in Food Science and Food Safety, 12(3), 281-295.
41. Sanjana, J.C., Babu, P.S., and Pushpalatha, H.G. (2015). Finger millet (*Eleusine coracana*): a review of itsnutritional properties, processing, and plausible health benefits. Advances in Food and Nutrition Research, 75, 103-130.
42. Sanni, A. I., Onilude, A. A., & Ogunbanwo, S. T. (2008). Microbiological and physicochemical changes during the natural fermentation of cereal foods. African Journal

of Biotechnology, 7(25), 4855-4866.

43. Sanoussi, A. F., Sanoussi, M. S., Adamou, S., & Saadou, M. (2020). Assessing the contribution of Pearl millet to food security and poverty reduction in the Sahel region of West Africa. Agriculture & Food Security, 9(1), 1-12.
44. Sanoussi, A. F., Sanoussi, M. S., Adamou, S., & Saadou, M. (2020). Assessing the contribution of Pearl millet to food security and poverty reduction in the Sahel region of West Africa. Agriculture & Food Security, 9(1), 1-12.
45. Sharma, S., Chandra, S., & Singh, K. (2019). Barnyard millet porridge: a nutritious and healthy breakfast.International Journal of Chemical Studies, 7(4), 3383-3385.
46. Shobana, S., Kumari, P. L., & Singh, R. P. (2016). Glycemic responses of different Indian recipes containing Foxtail millet (*Setaria italica*) as compared to those containing rice (Oryza sativa) or wheat (*Triticum aestivum*) in healthy volunteers. Food Chemistry, 203, 214-219.
47. Shobana, S., Kumari, P. L., & Singh, R. P. (2016). Glycemic responses of different Indian recipes containing Foxtail millet (Setaria italica) as compared to those containing rice (*Oryza sativa*) or wheat (*Triticum aestivum*) in healthy volunteers. Food Chemistry, 203, 214-219.
48. Singh, N., Kaur, H., Kaur, G., & Gupta, A. K. (2015). Nutritional composition, phenolic content and antioxidant activity of Kodo millet (*Paspalum scrobiculatum*) flakes. Journal of Food Science and Technology, 52(12), 7763-7769.
49. Singh, R., Sharma, P., & Gupta, R. K. (2016). Nutritional evaluation of Foxtail millet (*Setaria italica*) bread. Journal of Food Science and Technology, 53(2), 1189-1197.
50. Singh, R., Sharma, P., & Gupta, R. K. (2016). Nutritional evaluation of Foxtail millet (*Setaria italica*) bread. Journal of Food Science and Technology, 53(2), 1189-1197.
51. Sudha, M. L., *et al.* (2014). Nutritional and sensory quality of low glycemic index foods prepared using locally available Indian cereals and pulses. Journal of Food Science and Technology, 51(7), 1494-1503.
52. Sudha, V., Spiegelman, D., Hong, B., Malik, V., Jones, C., Wedick, N. M., Hu, F. B., & Willett, W. C. (2016). Consumer acceptance and preferences for types of chapatis in southern India. Journal of Hunger & Environmental Nutrition, 11(3), 328–341. https://doi.org/10.1080/19320248.2015.1067837
53. Thakur, S., *et al.* (2015). Physicochemical, nutritional and sensory evaluation of bakery products prepared from millet-based composite flours. Journal of Food Science and Technology, 52(2), 1161-1167.
54. Tian, Y., Liu, J., Xiong, Y. L., & Chen, J. (2019). Preparation and characterization of gluten-free pasta from Proso millet flour. LWT, 108, 94-101.
55. United States Department of Agriculture. (n.d.). Proso millet. https://www.ars.usda.gov/pacific-west-area/logan-ut/small-grains-and-potato-germplasm-research/docs/Proso-millet/
56. Uppal, V., Bains, K., & Singh, G. (2017). Proso millet (*Panicum miliaceum* L.): an underutilized nutraceutical grain crop. Journal of Food Science and Technology, 54(13), 3993-4008.

57. Ushakumari SR, Shrikantan L and Malleshi NG (2004). The functional properties of popped, flaked, Extruded and roller dried Foxtail millet (Setaria Italica). International Journal of Food Science and Technology, 39: 907-915.
58. Veena B (2003). Nutritional, functional and utilization Studies on barnyard millet. M. Sc. Thesis, University of Agricultural Sciences, Dharwad (Karnataka), India.
59. Vetriventhan, M., *et al.* (2020). Little millet for food and nutritional security. Plant Genetic Resources, 18(4), 330-335.
60. Yadav KC, Chandra R. Influence of green leafy vegetable incorporation and process variable on textural characteristics of extrudaten. Bioved. 2012; 26:95-105.
61. Yadav, S., Sharma, S., & Singh, K. (2021). Nutritional composition and glycemic index of barnyardmillet flour. Journal of Food Science and Technology, 58(4), 1267-1274

HIDDEN HUNGER BRIDGES TO NON-COMMUNICABLE DISEASES

Helena. H* and Anusuya Devi K
Department of Nutrition & Dietetics,
PSG College of arts & science, Coimbatore-641014
*Corresponding author E-mail: helena11allah@gmail.com

Abstract:

Around 1/3rd of the population is affected globally by micronutrient malnutrition, one of the most serious problems in the world. When it comes to micronutrients, they are purely needed by humansin their day-to-day activities. like hormones (e.g., iodine needed for thyroxin), enzyme function (e.g., B complex vitamins), and for all the other important regulations in the body. Micronutrient malnutrition is compensated through fortification and enrichment, but still, school-going children are easily subjected to micronutrient deficiency, which possibly affects their growth and their cognitive development. This deficiency may result in serious illnesses like poor wound healing capacity, night blindness, anemia, and attention deficit during classes, impaired muscle development, bone weakness, etc. Thus, the lifestyle diseases were occurring to most of middle- aged people, and it is also because of the dietary pattern they follow from their childhood, if the diet is deficit in any one of the micronutrients it may possibly causes any one non communicable disease in later life and to avoid this problem the balanced diet should be followed, and it is concluded that the role of food choice is major in controlling the hidden hunger.

Keywords: Hidden hunger, non-communicable diseases, food choice

Introduction:

Micronutrient malnutrition is severe among growing age to developed people, micronutrient malnutrition is also called as “hidden hunger” which also includes all the vitamins and minerals in vitamins there are 2 classes they are water-soluble vitamins & fat-soluble vitamins and in minerals, there are two types they are micro and macro minerals the water-soluble vitamin includes B1-thiamin, B2-Riboflavin, B3-Niacin, B5-pantothenate, B6-Pyridoxin, B7-Biotin, B9-Folic acid, B12-Cobalamin and vitamin -C where the fat-soluble vitamins include vitamin A, D, E, K and the major minerals includes sodium, potassium, magnesium, calcium, phosphorus, chloride and the micro minerals such as iron, zinc, copper, selenium, chromium, Iodine, Manganese, molybdenum & fluoride. And these micronutrients are needed by the body in the required amount that amount is validated through recommended dietary allowances (fssai, 2001). Micronutrient deficiencies will possibly cause DNA damage following the identical mechanism as radiation and the micronutrient deficiency is likely to lead cancer in later life to avoid this condition micronutrients intake should be sufficient (Ames, 2006).

The micronutrient deficiencies also have a greater impact on obese people too. The obese healthyindividual the ones affected with diabetes mellitus are having low vitamin E concentrations in theirblood and also it is noted that vitamin c and beta carotene are also reduced and vitamin c is reducedamong obese French adults while the vitamin E & selenium concentrations were normal ,studies shows the importance of micronutrients among obese people (A Astrup *et al.*, 2010).In gut health, in this study the author finds out that vitamin A &C is responsible for maintaining good gut healthin mice and also for human host and the need for micronutrients is also increases

during pregnancyfor compensating iodine and iron deficiency to maintain balance there should be sufficient intakeof micronutrients. (Lise Roland *et al.,* 2021).

Non communicable diseases (NCDs) such as cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) account for more than 70% of global deaths each year. Of note, NCDs make up about 85% of premature deaths in moderate and medium-income countries. The elderly, adults as well as children, are all endangered to the adverse condition that contribute to NCDs. However, NCDs disproportionately impact vulnerable and disadvantaged groups in affluent countries. In the over few decades, the consumption of junk and processed foods has continued to rise rapidly in both developing and developed countries. Besides, calories obtained from fiber-rich foods (e.g., pulses, whole grains, roots) have been decreasing, whereas calories obtained from oils, fats, meat, and sugars have been accelerating rapidly globally. Dietary design and nutrient intake are influenced by this nutrition transition, which affects the threat of growing NCDs. On the other hand, physical inactivity, exposure to heavy metals (e.g., cadmium, mercury, lead), tobacco smog, or the toxic usage of alcohol also increases the risk of NCDs. As a result, prohibiting and management of NCDs are critical components of the management of NCDs. The benefits of nutrient-dense food-rich diets have been highlighted in terms of longevity, healthy aging, and morbidity. Furthermore, several researchers have attempted to identify the role of diets in NCDs, with the relationships between multiple individual nutrients, fruit, and vegetable intake and NCDs still being controversial. For instance, some studies, for example, have shown that n-3 polyunsaturated fatty acids have beneficial effects on arthritis. However, some studies have found no link between n-3 polyunsaturated fatty acid intake and the risk of arthritis. The latest study also manifest thiamine intake was correlated with minor risks of NCDs (e.g., hypertension, myocardial infarction or angina, T2DM and depression) (Hai duc nguyen *et al.,* 2022).

Hidden hunger

When people's diets do not provide enough nutrients to fulfil their needs, they experience hidden hunger or micronutrient deficiencies and do not receive the vital vitamins and minerals they require for healthy growth and development (FAO, 2014). It affects two billion people across the globe, and this affects certain groups within the population. For example, adolescents and teenagers may have an inadequate intake of milk and other sources of calcium, and elderly people in nursing homes and residential care have an inadequate vitamin D intake. Furthermore, despite there being an adequate supply of most micronutrients in the food available in nursing homes, there is a high incidence of biochemical deficiency for most micronutrients, including zinc, iron, vitamin C, and riboflavin. There are many possible causes of insufficient intake or absorption, including anorexia, inability to cut up food, or poor food presentation. Moreover, certain groups have increased requirements—expectant mothers require increased folate both before conception and in the first trimester; smokers require additional vitamin C, and people who are recovering from an acute illness or after surgery probably have multiple requirements. It would be entirely appropriate for groups of this sort to take supplements to ensure their total intake, including their diet (Shenkin, 2006), and the deficiency of micronutrients also results in overweight and obesity which are associated with many diseases. These include hypertension, diabetes mellitus, atherosclerosis, certain types of cancers, chronic kidney disease and increased overall cardiovascular risk. Others include asthma, osteoarthritis, and low back pain. Each 5 kg/m2 increase in BMI is associated with a 30% higher overall mortality risk and higher mortality due to

stroke, kidney disease, and diabetes mellitus in addition to reduced life expectancy by as much as ten years in those with BMI over 40 kg/m2. The public health implications of micronutrient disorders are also potentially huge. They do not only cause obvious clinical manifestations but are also responsible for a wide range of non-specific physiological impairments, leading to reduced resistance to infections, metabolic disorders, and delayed or impaired physical and psychomotor development. Thus, proper intake of micronutrients helps in controlling obesity and that helps to stay away from any one of the non-communicable diseases (Foluke A olatona *et al.*, 2020).

Hunger may play a role in noncommunicable disease (NCD) risk. This study used the 2012 Global School-based Student Health Survey from Bolivia to determine the association between hunger and risk factors for NCDs among adolescents. Hunger was associated with increased odds of nondaily fruit and vegetable consumption (adjusted odds ratio [AOR] = 1.21; P < .001), inadequate physical activity (AOR = 1.21; P = .001), and current tobacco use (hunger sometimes [AOR = 1.83; P < .001] or most of the time/always [AOR = 2.12; P < .001]). Interventions to reduce the burden of NCDs in Bolivia should address hunger, in addition to traditional behavioral risk factors (Matthew L. Romo, 2016).

Causes of micronutrient deficiencies

India is passing through the phase of economic transition and while the problem of undernutrition continues to be a major problem, prevalence of overnutrition is emerging as a significant problem, especially in the urban areas. The prevalence of overweight/ obesity is higher among the women (10.9%) compared to men (7.8%) in 4 8 rural areas. The prevalence of Diabetes Mellitus and Coronary Heart Disease (CHD) is also higher in urban areas as compared to their rural counterparts. The incidence rate of cancer is comparatively higher among women compared to men (NIN, 2011).

Vitamin A

Vitamin A deficiencies causes Xerophthalmia, anorexia, stunted growth, increased susceptibility to infections, blockage and expansion of hair follicles, and keratinization of epithelial (mucous) cells of the skin with attendant lack of normal differentiation are a few signs and symptoms of insufficiency. Xerophthalmia is characterize by abnormalities of the conjunctiva and cornea of the eye, including conjunctival and corneal xerosis, bitot's spot, coronal scarring and ulcerations, and night blindness (due to insufficient mucus production). Goblet cells in the conjunctiva vanish, epithelial cells grow and keratinize, and Bitot's spots form over the keratinized epithelia of the conjunctiva, among other conjunctival alterations. If the alterations in the cornea are significant and irreversible, keratomalacia may develop (such as with corneal perforation and loss of aqueous humor). Night blindness is a result of reduced rhodopsin production in the rod cells in the retina of the eye and may be one of the earliest indications of vitamin A deficiency related to vision. People with malabsorptive illnesses like steatorrhea (excessive fat in the stools) or pancreatic, liver, or gallbladder problems are among the conditions and groups that have an increased need for vitamin A. Additionally, vitamin A deficiency can occur in people with chronic nephritis, acute protein deficiencies, intestinal parasites, and acute infections. Measles infections are linked to high mortality rates in underdeveloped nations (Stephenson, 2001).

Vitamin D

Rickets, a condition marked by development retardation, failure of the bone to mineralize, and convulsions in newborns and children, is brought on by vitamin D insufficiency. Epiphyses

cartilage in babies with vitamin D deficiency continues to expand and grow without being replaced by bone matrix and minerals. Particularly noticeable are these results at the enlarged wrists, ankles, and knees. In addition, the movement like walking starts, legs bow and the knees knock will be so difficult. Adults who lack vitamin D have a mineralization disorder called Osteomalacia. Changes in the absorption and excretion of calcium and phosphorus cause thedefect. For instance, less calcium is absorbed when there is a vitamin D shortage (Zeghoud *et al.,* 1997).

Vitamin E

Vitamin E deficiency in humans is quite uncommon. Only a small number of demographic groups are at risk for deficit, including people with hepatobiliary system illnesses, particularly persistent cholestasis and fat malabsorption disorders such as cystic fibrosis (marked by pancreatic lipase deficiency) (characterized by decreased bile production). Those who have genetic flaws in either lipoproteins or the alpha -tocopherol transfer protein constitute a second group at risk (Traber *et al.,*1994; Sokol *et al.,*1993). Myopathy, ceroid pigment build-up, hemolytic- anemia, and degenerative neurological issues such as peripheral neuropathy, cerebellar ataxia, loss of vibratory sensitivity, and loss of limb coordination are some signs of vitamin E deficiency (Spool, 1988; Food & Nutrition Board, 2001).

Vitamin K

People who consume vitamin K-poor diets and who are taking prolonged antibiotic drug therapy are at risk for vitamin K deficiency. In addition to these symptoms and groups, those who have liver disease, biliary fistulas, obstructive jaundice, steatorrhea or chronic diarrhea, intestinal bypass surgery, chronic pancreatitis, and other disorders that affect fat absorption may also need to consume more vitamin K. Vitamin K is best absorbed when combined with dietary fat since it is fat soluble. People who malabsorb fat therefore also malabsorb fat-soluble vitamins. Measurement of non-carboxylated vitamin K-dependent proteins, such as prothrombin and osteocalcin, or the ratio of completely carboxylated protein is another method of determining vitamin K status in our body (Sokoll *et al.,* 1997).

B complex:

Numerous symptoms are caused by B complex deficiencies Vitamin B1- Beriberi, Vitamin B2 - Ariboflavinosis, Vitamin B3 - Pellagra, Vitamin B5 - Acne, Vitamin B6 - Microcytic Anemia, Vitamin B7- CNS Disorders, Vitamin B9 - Leucopaenia, and Vitamin B12 - Macrocytic Anaemia. Memory Loss can also result from a lack of these nutrients (Amarjeeth kaur *et al.,* 2015).

Vitamin C:

The deficient condition known as scurvy is due to inadequate vitamin C consumption. Scurvy commonly appears when plasma vitamin C concentrations fall to 0.2 mg/dL and the total body vitamin C pools fall below roughly 300 mg (kallenr *et al.,* 1979) (Levine, 1986). Many of the scurvy warning signs and symptoms are thought to be caused by a decrease in the synthesis of the amino acids hydroxyproline and hydroxylysine, which are necessary for the production of collagen. The most noticeable signs and symptoms are bleeding gums, small red skin lesions brought on by ruptured small blood vessels (petechiae), sublingual haemorrhages, easy bruising (ecchymoses and purpura), impaired fracture and wound healing, joint pain (arthralgia), loose and decaying teeth, and hyperkeratosis of hair follicles, particularly on the arms, legs, and buttocks (Hodges *et al.,* 1969). There are 4 H's. They are hemorrhagic signs, hyperkeratosis of hair

follicles, hypochondriasis (psychological manifestation), and hematologic abnormalities (associated with impaired iron absorption) are late symptoms of vitamin C (Levine, 1986).

Minerals

Micronutrient deficiency causes serious problems in which some of the mineral deficiencies are Calcium-bone weakness, Iodine-thyroid hormone malfunction, Iron-anemia, Magnesium impaired muscle and nerve function, Phoshorus -bone weakness, Potassium-fluctuate blood pressure, Sodium-fluid imbalances & fluctuate blood pressure, Selenium-prone to easy infection, Zinc-impairs immune function. These are some of the consequences of mineral deficiencies in our body (NIN, 2022).

Lifestyle diseases

Lifestyle diseases share the risk factors like prolonged exposure to three modifiable lifestyle behaviors -- smoking, unhealthy diet, and physical inactivity and result in the development of chronic diseases, specifically heart diseases, such as heart disease, stroke, diabetes, obesity, metabolic syndrome, chronic obstructive pulmonary disease, and some forms of cancer. Previously regarded as "Western diseases" or "diseases of affluence" specific to industrialised nations, these conditions are now generally referred to as non-communicable chronic diseases that fall within the category of degenerative diseases. Chronic disease places a significant financial load on health care and can lead to loss of independence, years of incapacity, or death. According to estimates from the World Health Organisation (WHO) in 2005, chronic illnesses were responsible for 61% of all deaths, or 35 million people, and 49% of the worldwide disease burden. The percentage of chronic disease-related mortality in the overall number of deaths worldwide is predicted to reach 70% by 2030, and the global (Fatma al-maskari,1996).

Micronutrients play a major role in health and in lifestyle diseases where Micronutrient deficiency suppresses the function of immune system resulting in degenerative diseases such as arthritis, cancer, cardiovascular disease and diabetes. Some vitamins, minerals, antioxidants, and/or other crucial micronutrients may be lacking in a person. According to studies, sickness, exhaustion, and chronic problems can be avoided by supplementing a diet with a potent antioxidant to make up for a deficit. There is solid proof that eating a lot of meals that are high in energy encourages weight growth. These energy-dense meals are heavily processed (low NSP) in high-income nations (and increasingly in low-income ones), which further reduces their nutritious value. Energy-dense meals typically contain a lot of fat (such as butter, oils, fried foods), sugar, or starch, whereas energy-dilute foods have a lot of water content and are rich in micronutrients. Several studies have secretly changed the energy density and fat content. It's also evidenced that micronutrients help to prevent serious damages caused by lifestyle diseases (Maulisheer jhawer, 2014).

1. Diabetes melitus

Similar to practically all metabolic processes, cofactors and vitamins from the diet are necessary for insulin signalling and glucose metabolism. Any of these micronutrient deficiencies have the potential to affect glucose metabolism and lead to insulin resistance. There is growing clinical data that supports this theory on the metabolic effects of particular deficiencies, such as those in vitamin D, chromium, biotin, thiamine, and vitamin C. These vitamins are known to be deficient at quite high rates in obese people and in diabetic patients, in contrast to vitamin E, which has little to no clinically shown benefit when given as a supplement. Clinicians should

advise obese patients who are at risk of developing type 2 diabetes to treat any potential shortages of these micronutrients. The obesity treatment strategy should adopt into this rational practice (Anderwald C and Hishinuma A,2012).

2. Cardiovascular diseases

An expanding amount of scientific data points to hyperhomocysteinemia, or increased homocysteine levels, as a separate risk factor for cardiovascular illnesses. The objective of the current study was to determine the prevalence and risk factors for hyperhomocysteinemia in Afghan refugee youth aged 10 to 19. In all, 206 healthy teenage males and girls were chosen at random from a Peshawar, Pakistan, refugee community in 2020. Following accepted procedures, socio-demographic information, anthropometric evaluation, and blood sample collection were all completed. Using a chemiluminescent microparticle immunoassay, serum homocysteine levels were measured, with values below 15 mol/L being considered hyperhomocysteinemia. The prevalence of hyperhomocysteinemia was 25% overall, with males having substantially higher mean homocysteine levels (14.1 mol/L) than girls (11.8 mol/L) ($p = 0.004$). Logistic regression with many variables Analysis showed a significant relationship between blood levels of vitamin B12 and folate (OR 0.1; 95% CI of 0.03 to 0.27; p 0.001) and hyperhomocysteinemia (OR 0.29; 95% CI of 0.14 to 0.62; p 0.01). Overall, the results of our study show a significant frequency of hyperhomocysteinemia among young Afghan immigrants who may be at a high risk of future cardiovascular problems. Nutritional and public health measures must be created and put into action immediately in order to control hyperhomocysteinemia, safeguard against associated conditions and their consequences in the future, and promote healthy ageing and wellbeing between these at-risk groups (Muhammad shabir khan *et al., 2022*).

3. Cancer

The average person needs 40 micronutrients in their diet. Vitamin B12, folic acid, B6, niacin, C, or E deficiency, iron deficiency, or zinc deficiency appear to imitate radiation in producing single- and double-strand breaks, oxidative lesions, or both, in DNA. The for each of these eight micronutrients, the proportion of the US population with a low intake (50% of the RDA) varies from 2% to 20%; half of the population may be deficient in at least one of these micronutrients. A substantially larger percentage of the impoverished and 10% of the US population are both folate deficient. Chromosome breaks result from the significant incorporation of uracil into human DNA (4 million/cell) caused by a folate deficit. This mechanism is most likely to blame for the elevated cancer risk and, maybe, the low blood pressure-related cognitive impairments intake of folate. Mechanistic arguments and some data point to vitamin B12 and B6 deficiency as another factor in increased uracil and chromosomal breakage. When compared to the population as a whole, the quarter that consumes the fewest fruits and vegetables (five servings daily is recommended) has around double the risk of most forms of cancer. This may be due to micronutrient insufficiency. Sixty-eight percent of adults and eighty percent of children and adolescents in America don't consume five pieces a day. There may be widespread micronutrient shortages (Bruce N Ames,1998).

Role of food choice in micronutrient malnutrition

Food choice plays a major role where the Strategies must therefore also place an emphasis on increasing overall food intake in addition to a broader variety of foods, as diets in underdeveloped nations typically lack several nutrients, including energy due to inadequate

amounts of food (Kraisid tortisiren *et al.,* 2009) (Dennis D Miller & J.V. Meenakshi,2013). The causative factors for micronutrient malnutrition are many, some are Poor quality diets, which are characterized by high intakes of food staples but low consumption of animal and fish products, fruits, legumes, and vegetables, which are rich sources of bioavailable minerals and vitamins, this is the main underlying cause of micronutrient deficiency, the author also stated that the majority of malnourished people are unable to afford high-quality micronutrient-rich meals and it may potentially result in negative impact on a child's ability to learn, impair their ability to fight off diseases, and lessen their livelihood of surviving. These shortcomings come at a catastrophic cost in terms of lives lost and reduced quality of life (Howarth Louis *et al.,* 2012).

Conclusion:

Micronutrient malnutrition is not a problem to ignore and move on, it is having a serious impact on society's health and future generations, as the micronutrients are vital for the body's function even with one of the deficiencies it will possibly lead to many other factors of problem in health. Currently India is the capital for diabetes mellitus and if the condition continues it may end up as, a capital for other non-communicable disease too, micronutrient is playing a hidden role in avoiding non communicable diseases hence it is important to create an awareness about the micronutrients among people, it is also important to make the people to include the micronutrient-rich foods in their diet to avoid the catastrophe. Eating healthy foods along with proper micronutrients should be especially encouraged among school-going children who are easily subject to infections and results in deficiencies as they are our future generation and future India their health should be taken care so let's all join our hands together to stop hidden hunger and non-communicable diseases.

References:

1. Bhaskar N. Recommended dietary allowances: Hyderabad:NIN;2001.
2. Bruce N Ames.DNA Damage from micronutrient deficiencies is likely to bea major cause of cancer.vol 475, issue 1:Science direct;2001.
3. A Astrup & S. Bugel. Micronutrient deficiency in the aetiology of obesity. 34,947-948: International journal of obesity;2010.
4. LiseVoland, Tiphaine Le Roy, Jean Debedat, Karine Clement. Gut microbiota and vitamin status in person with obesity: A key interplay. volume 23, issue 2: wisely online library; 2021.
5. Hai Duc Nguyen, Hojin Oh, Min-Sun Kim. Nutrition Research: Higher intakes of nutrients are linked with a lower risk of cardiovascular diseases, type 2 diabetes mellitus. Arthritis, and depression among Korean adults. Apr; 100:19-32. New York: Elsevier;2022.
6. ICN2 Second International Conference better nutrition better lives. Rome: Food and Agriculture Organization of the United Nations;2014.
7. A Shenkin. Micronutrients in health anddisease. 82(971):559-67. Liverpool:BMJ;2006.
8. Foluke A Olatona, Sunday A Aderibigbe, Eyitope O Amu, Oluseye OOnabanjo, Kelechi E Nnoaham. Micro- nutrient related malnutrition and obesity in a university undergraduate population and implications for non- communicable diseases. Nigeria:BST;2020.
9. Stephensen C. Vitamin A, infection andimmune function.21,167-192: Ana rev Nutr;2001
10. Zeghoud F, Vervel C, Guillozo H, Walrant-Debray O, Boutignon H, Garabedian M.Sub clinical vitamin D deficiency in neonates.65,771-778: AmJ Clin Nutr;1997
11. Traber M, Rader D, Acuff R, Bruver H,Kayden H. Discrimination between RRR- and all

racemic alpha tocopherolslabelled with deuterium by patients withabetalipoproteinemia.108, 27-37: Atherosclerosis;1994

12. Sokol R. Vitamin E deficiency and neurological disorders: In packer I, Fuchs J, meds. Vitamin E in health and disease. Pp. 815-849: Marcel Dekker;1993.
13. Sokol R. Vitamin E deficiency and neurological disease.8,315-373: AnnRev Nutr;1988
14. Food and Nutrition board, Institute of medicine dietary reference intakes.pp 82- 161: National Academy Press;2001.
15. Sokoll L, Booth S, O'Brien, Davidsonk, Tsaioun K, Sadowski J. Changes in serumosteocalcin, plasma hydroquinone, urinary gamma carboxyglutamic acid in response to altered intakes of dietary phylloquinone in human subjects.65,779-784: Am J Clin Nutr;1997.
16. Amarjeeth Kaur. Biological functions of vitamin B complex and effects on human health in both excess and deficiency levels.3, 11: Pharmatutorjournal;2015.
17. Kallner A, Hartmann D, Hornig D. Steady-state turnover and body pool of ascorbic acid in man.32,530–39: Am J Clin Nutr;1979.
18. Levine M. New concepts in the biology and biochemistry of ascorbic acid.314,892–902: N Engl J Med ;1986.
19. C. Anderwald and A. Hishinuma. The malnutrition of obesity: micronutrients deficiencies that promotediabetes.103472. doi:10.5402/2012/103472. USA: Michael via;2012.
20. Muhammad Shabir khan, Anum Saeedullah, Simon C. Andrews, Khalid Iqbal, Syed abdul Quadir, barbar Shahzad, Zahoor Ahmed, Muhammad Shahzad. Adolescent afghan refugees display a high prevalence of hyperhomocystenemia and associated micronutrient deficiencies indicating an enhanced risk of cardiovascular disease in later life. Apr 22;14(9):1751. doi: 10.3390/nu14091751.Pakistan nutrients;2022.
21. Bruce N Ames. Micronutrient prevent cancer and delay aging.vol 102-103, Pp.1-690.Ireland: Elsevier;1998.
22. Hodges R, Baker E, Hood J, Sauberlich H, March S. Experimental scurvy in man. 22,535–48: Am J Clin Nutr ;1969
23. Levine M. New concepts in the biology and biochemistry of ascorbic acid.314,892–902: N Engl J Med ;1986.
24. Fatma al-maskari. Lifestyle Diseases: An economic burden on the health service. Geneva: UN Chronicals;1996.
25. Maulishree Jhawer. Undetected Nutrient Deficiencies: The cause of ill health. Medindia;2014.
26. Kraisid Tontoserin, Guy Nantel& Lalita Bhattacharjee. Food based strategies to meet the challenges of micronutrient malnutrition in the developing world. 2nd edition: Cambridge University;2009
27. Dennis D. Miller, Ross M. Welch. Food system strategies for preventing micronutrient malnutrition.42,115-128:science direct;2013
28. Howarth Bouis, Erick Boy-Gallego, J.V. Meenakshi. Micronutrient malnutrition: Prevalence, Consequence and interventions. 1, 29: International plant nutrition institute;2012

A REVIEW ON NON- DAIRY PROBIOTIC PRODUCTS

N. R. Indra Devi* and R. Sughanya
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore - 641014
*Corresponding author E-mail: indradevinr@gmail.com

Abstract:

In India fermented foods play an important role in everyday's life. Fermented foods help in maintaining intestinal micro biota and homeostasis in the human body. Fermented non - dairy probiotics foods act as an alternative for lactose intolerant people. Fermented foods are packed with macro and micro nutrients, phytochemicals and other functional components during fermentation of cereals and legumes. This review deals with the importance of cereals, legumes, fruits, and vegetables included in the preparation of non - dairy probiotic products.

Keywords: Fermented foods; Intestinal Micro biota; Phytochemical; Non – dairy probiotic.

Introduction:

In today's growing world population, people need proper nutrition along with proper food. The consumer preferences have changed from an energy giving diet to a balanced diet along with nutritional health benefits. In India, fermented foods serve as an integral part of their life. The fermented foods are developed for their valuable nutritional property and for its food preservation (Ishra, 2013, Swain *et al.,* 2014). In traditional fermented food preparation, microorganisms play an important role in the improvement of bioactive components and help to maintain intestinal microbiota (Fijan, 2014). It maintains homeostasis in the human body. The probiotic microorganisms will prevent intestinal tract infection, improves lactose metabolism, stimulates calcium absorption and increase the synthesis of vitamin B. Fermented foods are rich in vitamins especially vitamin B (nicotinic acid and Folic acid), minerals, dietary fiber, phytochemicals, amino acids and also increases the digestibility and quality of food (Motarjemi *et al.,* 1996 and Blandino *et al.,* 2003). Fermented foods include probiotic dairy foods, idly, dhokla, pickles, uttapam and adai (Fijan, 2014). Lactic acid bacteria are widely involved in the fermentation process and it is regarded as safe (Generally Regarded as Safe (GARS)) and they do not cause any side effects; it is a non - pathogenic, acid tolerant and bile tolerant (Dunne *et al.,* 1999).

Importance of Cereals and Legumes

Consumption and utilization of Cereals and Legumes are high in developing countries (National Health and Medical Research Council, 2003) states that cereals including barley, maize, wheat, rice, oats, sorghum, rye and millet provides 56% of energy and 50% of protein. Whole cereals contain increased amounts of phytochemicals, vitamins and minerals (Slevin, 1999). Legumes are known as poor man’s meat and a good source of complex carbohydrates, protein, minerals and B vitamin (Tharanathan and Mahadevamma, 2003). Generally consumed legumes include red gram, green gram, black gram, green peas. Legumes have anti- nutritional factors like phytates, tannins, cyanogenic agents which need specific processing techniques to make them suitable for human consumption (Reddy and Pierson, 1983). Cereals lack essential amino acids like lysine and legumes lack in methionine (Iqbal *et al.,* 2006).

Consuming pulses and whole grains in combination (such as rice and beans) can provide adequate amounts of essential amino acids and meet human protein needs. Pulses are deficient in one of the amino acids (methionine) but rich in another amino acid lysine, whereas, cereals have high methionine and low lysine content. Thus, the combination of cereal-pulse is needed to ensure the body gets the required protein from these sources (https://www.ncbi.nlm.nih.gov).

Non - dairy probiotics

Non-dairy probiotic products as a alternative for lactose intolerance people. Many people are suffering from Lactose intolerance (Silanikove *et al.,* 2015). It is caused due to the absence of lactase enzymes by an intestinal brush which converts Lactose into absorbable sugars (glucose and galactose). For infants, the active activity of lactase enzymes is high for some period (Wahlqvist, 2015). For the person, lacking lactase enzyme includes symptoms like bloating gastric pain, cramps, diarrhea and gas production in the gastrointestinal tract. It is rich in protein, starches, minerals, fibers and vitamins. For lactose intolerant people, non - dairy probiotics foods are used as therapeutic treatment products (Deng *et al.,* 2015).

Fruit based probiotic food products

Due to their high nutritional value and abundance in vitamins, minerals, phytochemicals, antioxidants, dietary fibre, and other nutrients, fruits are an excellent vehicle for functional meals (Yoon *et al.,* 2004). Fruits are nutritious, energising, and have a flavour profile that is pleasing to the palate and can be used with probiotics (Panghal *et al.*, 2017 b).

Fruits require fast processing due to their short shelf life and high perishability in order to minimise post-harvest losses. The creation of probiotic products can help increase product availability and market value (Panghal *et al.,* 2017 a). Fruits and vegetables are a suitable substrate since they are free of lactose, cholesterol, and other dairy allergies that prevent certain people from consuming dairy probiotics (Luckow and Delahunty, 2006). Fruits like pineapple, cranberries, strawberries, sweet limes, mangoes, grapes, cashew apples, olives, and oranges, among others, are used to make probiotic goods.

Probiotic grapes

Malganji et al (2015) prepared Turkey's traditional probiotic drink, Hardaliye, from grapefruit and are fermented with lactic acid bacteria primarily, as well as with crushed mustard seeds and benzoic acids. Results shows that etric oil from mustard seeds affects yeast and gives the final product a distinctive flavour. By influencing the yeast, benzoic acid inhibits or reduces alcohol synthesis. Hardaliye has a pH range of 3.21 to 3.97, which can be slightly raised by adding ginger or clove. Depending on the grape variety and preparation method, hardaliye's phytochemical and antioxidant levels differ (Coskun, 2017). *L. casei subsp. pseudoplantarum* and *L. paracasei subsp. paracasei* are the major probiotic bacteria employed in the fermentation of hardaliye, followed by *L. sanfranciscensis* (formerly known as *L. sanfrancisco*), *L. vaccinostercus, L. pontis, L. acetotolerans, and L. brevis*. In connection with this study (Guven *et al.,* 2009) also investigated the lactic acid bacteria *L. plantarum, L. delbrueckii*, and *L. rahamnosus* ability to ferment grape juice. They discovered that the pH was decreased by up to3.7 due to lactic acid generation of up to 0.27%.

Sweet lime probiotic

According to Khatoon and Gupta (2015), estimated the suitability of sugarcane and sweetlime juice in probiotic beverage as a soul source for growth of beneficial microorganism. They also checked the suitability of culture growth of (*Lactobacillus acidophilus*) checked with various combination with various herbs like ashwagandha (*Withania sominifera*), green tea (*Camellia sinensis*), in refrigeration temperature for 3 weeks. The result indicated that physicochemical parameters like pH, TSS and acidity were found suitable for the growth of (*Lactobacillus acidophilus*). They observed fast reduction viability in sweet lime juice during storage, where as antioxidant activity was found high during storage period.

Orange probiotic juice

In probiotic orange juice, L. plantarum was used to ferment probiotic orange juice, which was then compared to a standard product. According to Luckow and Delahunty's (2004) assessment, 10% (v/v) of the perceived off flavour is concealed by tropical fruit liquids; primarily pineapple, mango, or passion fruit, which explains why consumers tolerate probiotic drinks less.

Pomegranate juice

Fresh juice is an important source of powerful antioxidants such vitamin C, vitamin E, anthocyanins, phenolics, ascorbic acid, coenzyme Q-10, and alpha-lipoic acid. It also contains 85.4% water. Pomegranate juice has a higher antioxidant content than both red wine and green tea (Thakur and Sharma, 2017). Pomegranate has elements that are good for health as well as antiviral, antibacterial, anticancer, and antimutagenic properties. In an effort to create a pomegranate fermented beverage, Thakur and Sharma (2017) introduced it with probiotic cultures (10%) of L. bulgaricus and L. plantarum (1:1) and allowed it to ferment for 7 hours. The result showed that fermented probiotic beverage contained the necessary amount of probiotic cultures (109 CFU/mL) and microbiological analysis implies the beneficial for preserving the health of the gastro intestinal tract.

Vegetable based probiotic products

Vegetables provide health-promoting substances that help to create, repair, and maintain the body's alkaline reserve. They are also high in carbohydrates, vitamins, and minerals (Yadav *et al.*, 2014). Probiotics can be prepared with ingredients like vegetable cabbage, carrot root, tomato, beetroot, onion, ginger, and peanuts. For vegetable-based probiotic foods, lactic acid bacteria such as *L. acidophilus, L. plantarium, L. casei*, and *B. longum* can be used. The fermentation of lactic acid increases the nutritional value of foodproducts.

Carrot and Beetroot

Shalgam is a lactic acid-fermented soft drink that is crimson, hazy, and sour and is made with turnips, black carrots, broken wheat flour, salt, and water. Mineral, vitamin, amino acid, and polyphenol concentrations in Shalgam are high. Salt, baker's yeast (*Saccharomyces cerevisiae*), water, chopped black carrots and turnips were added to a fermentation chamber and kept for three to five days at room temperature (Erten *et al.*, 2008). The genus Lactobacillus makes up 89.63% of the LAB microflora in shalgam juice, followed by Leuconostoc (9.63%) and Pediococcus (0.74%). Halgam typically had a shelf life of three months at 40c in a sealed container, but pasteurisation and the addition of benzoic acid can prolong that time to one year (Tanguler and Erten, 2012a).

According to Panghal *et al.* (2017 b), beetroot juice also has great potential for the development of probiotic drinks. The non-dairy probiotic beverage Kanji, which has Indian origins, is made from carrots and beets, which are high in beta-carotene, tocopherol, and ascorbic acid and are regarded as vitaminized foods. The fermentation process can be carried out naturally or with the aid of probiotic bacteria such L. *acidophilus, L. plantarum*, and *L. casei*. Due to its high concentration of phytochemicals and phytonutrients, it has several medical benefits and acts as a cooling agent for the human body.

Moringa Leaf

Vanajakshi *et al.,* (2015) prepared a fermented probiotic beverage with L. plantarum, Enterococcus hirae by combining beetroot (Beta vulgaris L.) and moringa (*Moringa oleifera*) in various ratios (1:1, 1:2, 1:3, and 1:4) and fermented with ----for 48 hrs at 37c. The fermented moringa leaf based beetroot beverage showed anti bacterial activity against food-borne pathogens such as Bacillus cereus, Escherichia coli, Listeria monocytogenes, and *Staphylococcus aureus*. It also exihibited radical scavenging activity (20.79%) with a phenolic content of 5mg/ml and had minerals (mg/ml) like 11.8 of calcium and 0.2 of iron.

Kombucha

Tea leaves can be used to make the probiotic beverage kombucha (fermented tea), which is also loaded with antioxidants like vitamins C and B2 and polyphenols like catechins (Jayabalan *et al.,* 2014). Probiotic bacteria like *Saccharomyces ludwigii, S. cerevisiae, S. bisporus, Torulopsi*s sp., and *Zygo saccharomyces* are used to ferment kombucha.

The protective effect of kombucha beverage is mainly due to polyphenol activity, compounds produced during fermentation, and the synergistic effect of the different compounds found in the tea (jayabalan *et al.,* 2014.)

Research conducted by Fu *et al.,* (2014) used different types of kombucha to compare free-radical scavenging abilities against 2, 2-diphenyl – picrylhydrazyl (DPPH), hydroxyl radicals and superoxide radicals. Different types of tea were used to prepare kombucha: low-cost green tea, black tea and tea powder and fermentation process was 90 h. the result showed that kombucha made with green tea had the highest free-radical scavenging ability against DPPH, hydroxyl radicals and superoxide anions.

Wax Gourd

A probiotic product made from vegetables called Yan-dong-gua was created utilising wax gourds (Lan *et al.,* 2009). Yan-dong-gua is fermented with the aid of the bacteria *W. paramesenteroides* and *W. cibaria*. Wax gourd that had been cleaned, quartered, and sun-dried was combined with sugar, salt, and fermented soyabean and let to ferment. Taiwanese rice wine, or mijiu, is typically introduced in small amounts during the early stages of fermentation. The remaining fermentation is then carried out in an airtight container. The fermenting process typically takes one month, but it can take up to two months. It is primarily used as seasoning in pork, fish, and meatballs. These results suggest that *W. Cibaria* and *W. Paramesenteroides*.

Broccoli/Cabbage

Yan-tsai-shin is a probiotic made from fermented broccoli vegetables (members of the cabbage family) (Chen *et al.,* 2013) and commonly used bacterial strains were *L. plantarum, Enterococcus sulphurous, W. paramesenteroides, W. minor, Leuconostoc mesenteroides*, and *W.*

cibaria for fermentation. Another well-known probiotic made with cabbage product by the lactic acid bacteria (*L. plantarum, L. brevis, L. rhamnosus, and L. Plantarum*) is sauerkraut (Wang *et al.,* 2010; Yang *et al.,* 2010).

The ingredients used to make the probiotic kimchi were red cabbage, garlic, Pediococcus, Leuconostoc, Lactococcus, Enterococcus, and Streptococcus. These ingredients were used to ferment pepper, onion, ginger, and radish (Nam and Ahn, 2016) at the right temperature, pH, and acidity level. These kimchi goods are Korean, Japanese, and Chinese in origin. Kimchi is a good source of dietary fibre, vitamin C, beta carotene, and chlorophyll, all of which are helpful for health. Kimchi has disease-preventing properties due to its antimutagen, antioxidative, and angiotensin-converting enzyme inhibitory properties (Oh *et al.,* 2005).

In China, paocai, which is made from cabbage, celery, cucumber, and radish and contains the bacteria Leuconostoc mesenteroides, Leuconostoc brevis, Leuconostoc lactis and Leuconostoc fermentum (Yan *et al.,* 2008; Feng *et al.,* 2012)? Sayurasin is a probiotic food from Indonesia made from mustard and cabbage that has been fermented with *L. mesenteroides, L. confused L. plantarum,* and *P. pentosaceus*.

Cereals and legumes based probiotic products

Cereals and legumes are rich in vitamins, minerals, protein, carbohydrates, fiber and oligosaccharides. Cereals and legumes are used to prepare probiotic products including sorghum, maize, finger millet, soybeans, rice, and oats. Some traditional rice based fermented foods includes idly, dosa, dhokla, uttapam, selroti, babru, ambeli, adai and vada, sour rice, sez, appam and anarshe. The proportions and preparation methods differ from one region to another region (Blandio *et al.,* 2003; Ghosh *et al.,* 2015). These are fermented naturally or either by using some kind of starter.

Microbial fermentation improves the nutrient pool. Fermentation products are much better than processed foods and it gives good flavour, aroma, texture and taste. Idli is the most acceptable cereal- pulse based fermented products particularly in south India (Blandio *et al.,* 2003). Next to idli, dosa plays a major role and it's a thin crispy pancake. It is considered as a vegan diet for individuals with wheat allergies or gluten intolerance. Dhokla is a soft, spongy fermented cake which is very popular in southern and northen part of india. Dhokla has low glycemic index and helps to reduce blood cholesterol.

Microbes associated with rice - based fermentation

Cereals with added starch encourage the growth of common types of microorganisms (Vaidya and Sheth, 2011). They primarily come from the environment (naturally or spontaneously) or from the inclusion of a starting culture (controlled fermentation by mono-culture or multi-culture). These microorganisms secrete several metabolites. Enzymes boost their own growth; it stops the spread of infections and contributes to the medicinal and nutritional potential. Lactic acid bacteria (LAB), lactobacilli, bifidobacteria, yeasts and moulds are the most prevalent microorganism.

Lactic acid is produced during the fermentation of carbohydrates by lactic acid bacteria (LAB). LAB belongs to a functional group that is employed by food microbiologists rather than an evolutionary group that is carefully determined. They are safe and used for both healthy food and other purposes and for the quality and welfare of people (Satish kumar *et al.,* 2013). They

consist of acid-tolerant (pH 5.0), gram positive bacteria that are non spore-forming, non-motile, non-respiring, catalase-negative cocci or rods. Aerococcus, cornebacterium, enterococcus, lactobacillus, lactococcus, leuconostoc, oenococcus and pediococcus are regarded to be LAB genera.

LAB fermentation in cereal – containing foods offers a natural way to concentrate and improve nutrients such as minerals, vitamins and essential amino acid synthesis. To destroy undesirable components like antinutrient, mycotoxin and other endotoxin and to enrich with therapeutic components such as phenolics, prebiotics, probiotics, antioxidant, antimicrobial, and other bioactive substance, then change the sensory qualities (taste, aroma, texture, consistency and array of other qualities). They serve as preservation against damaging effects of spoilage and pathogenic organisms, facilitates decreased energy use while cooking and improve product safety (Holzapfel, 1997).

Ethnic rice – based fermented beverages

In contrast to alcoholic beer made from barley malt in western nations, rice based beverages or rice beer are an uncommon sort of food product that are only available in a few tropical areas of Asia- Pacific countries. Traditional libations come in a variety of colours, from clear items to turbid liquid or thick gruels. The main ingredient is air dried cooked rice powder, and conventional starting tablets or dust are used to make a variety of beverages (Tamang *et al.,* 2010).

A distinctive ancient culture on the Indian subcontinent involved the manufacture of starter using specific plant species (Ghosh *et al.,* 2014). The functional microorganisms for microorganisms for mixed culture and multi – stage fermentation of rice are varied groupings of endophytic organisms from the pant kingdom, which cannot be achieved by employing old ferments.

In addition, herbal items are excellent sources of medicinal and preservative metabolites that give fermented rice a good flavour (Sekar and Mariappan, 2007). The fermentation involves the two – stage fermentation. Solid state fermentation occurs when moulds develop on raw materials, which are then saccharified and gelatinized. After that, lactic acid bacteria and yeast that produce alcohol can grow more easily on semi- liquid substrates. The relationship between various microorganism groups and their respective concentrations are crucial for the development of a traditionally fermented foods's acceptable sensory quality (Jeyaram *et al.,* 2011; Ghosh *et al.,* 2015). The final fermented undistilled beverages, which typically include large levels of probiotics and other beneficial components and little alcohol, are consumed straight away (Mishra, 2013).

Conclusion:

Cereals and legumes have some inherent nutritive limitations like essential amino acids, limited bioavailability of mineral content due to the presence of antinutritional factors. Fermentation process improves overall nutrition level and increases physiological functions. The fruits, vegetables, cereals and legumes based probiotic products act as a substitute for lactose intolerant people and act as a nutraceutical component. Major challenge in non-dairy probiotic products is product acceptability by consumers. Selected microorganisms for non-dairy

probiotics products should possess the ability to tolerate acid, bile, colonization in human intestine and non-pathogenic GRAS (Tripathi and Giri, 2014).

References:

1. Blandino A, Al-Asceri ME, Pandiella SS, Cantero D and Webb C., 2003. Cereal based fermented foods and beverages. Food Res Int., 36:527-543.
2. Chen, Y. S., Liou, M. S., Ji, S. H., Yu, C. R., Pan, S. F., & Yanagida, F. (2013). Isolation and characterization of lactic acid bacteria from yan- tsai- shin (fermented broccoli stems), traditional fermented food in Taiwan. Journal of applied microbiology, 115(1), 125-13.
3. Coskun, F. (2017). A Traditional Turkish Fermented Non-Alcoholic Grape-Based Beverage,"Hardaliye". Beverages, 3(1), 2. 3(1): 2.
4. Erten, H., Tanguler, H., & Canbaş, A. (2008). A traditional Turkish lactic acid fermented beverage: Shalgam (Salgam). Food Reviews International, 24(3), 352-359.
5. Feng, M., Chen, X., Li, C., Nurgul, R., & Dong, M. (2012). Isolation and identification of an Exopolysaccharide- Producing lactic acid bacterium strain from chinese paocai and biosorption of Pb (II) by its exopolysaccharide. Journal of food science, 77(6), 111-117.
6. Fijan S., 2014. Microorganisms with claimed probiotic properties: an overview of recent literature. InternationalJournal of Environmental Research and Public Health. 11, 4745-4767.
7. Ghosh K, Maity C, Adak A, Halder SK, Jana A, Das A, Parua S, Das Mohapatra PK, Pati BR and Mondal KC. Ethnic preparation of Haria, a rice-based fermented beverage, in the province of Lateritic West Bengal, India. Ethnobot Res App 2014; 12:39-49.
8. Ghosh K, Ray M, Adak A, Dey P, Halder SK, Das A, Jana A, Parua (Mondal) S, Das Mohapatra PK, Pati BR and Mondal KC. Microbial, saccharifying and antioxidant properties of an Indian rice based fermented beverage. Food Chem 2015; 168:196-202.
9. Gupta S and Abu-Ghannam N., 2012. Probiotic fermentation of plant based products: possibilities and opportunities. Crit Rev Food SciNutr.; 52:183-199.
10. Güven, S., & Aksoy, M. (2009). Some modifications in hardaliye production. II. In Traditional Foods Symposium Abstract Book. Van, Turkey (pp. 675-678).
11. Holzapfel W. Use of starter cultures in fermentation on a household scale. Food Control 1997; 8:241-258.
12. Iqbal A, Khalil IA, Ateeq N and Khan MS., 2006. Nutritional quality of important food legumes. Food Chemistry, 97:331-335.
13. IshraHN., 2013. Fermented milks and milk products as functional foods – a review. Crit Rev Food SciNutr; 53:482-496.
14. Jayabalan, R., Malbaša, R. V., Lončar, E. S., Vitas, J. S., & Sathishkumar, M. (2014). A review on kombucha tea—microbiology, composition, fermentation, beneficial effects, toxicity, and tea fungus. Comprehensive Reviews in Food Science and Food Safety, 13(4), 538-550.
15. Jeyaram K, Tamang JP, Capece A and Romano P. Geographical markers for Saccharomyces cerevisiae strains with similar technological origins domesticated for rice-based ethnic fermented. Beverages production in North East India. Antonie Van Leeuwenhoek 2011; 100:569-578.

16. Koehler P, Wieser H. Chemistry of Cereal Grains. In: Gobbetti M, Gänzle M, editors. Handbook on Sourdough Biotechnology. Springer; Boston MA, USA: 2013. pp. 11–45.
17. Klein G, Pack A, Bonaparte C and Reuter G. Taxonomy and physiology of probiotic lactic acid Bacteria. Int J Food Microbiol 1998; 41:103-125.
18. Lan, W. T., Chen, Y. S., & Yanagida, F. (2009). Isolation and characterization of lactic acid bacteria from Yan-dong-gua (fermented wax gourd), a traditional fermented food in Taiwan. Journal of bioscience and bioengineering, 108(6), 484-487.
19. Luckow T and Delahunty C., 2004. Which juice is 'healthier'? A consumer study of probiotic non-dairy juice drinks. Food Quality and Preference, 15(7), 751-759.
20. Malganji, S., Sohrabvandi, S., Jahadi, M., Nematollahi, A., & Sarmadi, B. (2015). Effect Of Refrigerated Storage on Sensory Properties and Viability of Probiotic in Grape Drink. Applied Food Biotechnology, 3(1), 59-62.
21. Mishra S and Mishra HN. Technological aspects of probiotic functional food development. Nutrafoods 2013; 11:117-130.
22. Motarjemi Y and Nout MJR. 1996. Food fermentation: a safety and nutritional assessment, Joint FAO/WHO Workshop on Assessment of Fermentation as a Household Technology for ImprovingFood Safety, World Health Organization.
23. Nam, E. S., & Ahn, J. K. (2016). Isolation of Lactobacillus curvatus KNOUC4148 from Kimchi and its properties as a probiotic. Int. J. Curr. Microbiol. Appl. Sci, 5, 284-296.
24. National Health and Medical Research Council (2003). Dietary Guidelines for Australian Adults. Endorsed 10 April 2003. Common-wealth of Australia: Canberra.
25. National Institutes of Health (gov), 2016.Health Benefits of Cereal Grain- and Pulse-Derived Proteins. (https://www.ncbi.nlm.nih.gov
26. Oh, S. Y., Lee, J. H., Jang, D. K., Heo, S. C., & Kim, H. J. (2005). Relationship of Nutrients and food to colorectal cancer risk in Koreans. Nutrition research, 25(9), 805- 813.
27. Pakbin B, Razavi, SH, Mahmoudi R and Gajarbeygi P., 2014. Producing probiotic peach juice. Biotechnology and health sciences, 1(3).
28. Panghal A, Virkar K, Kumar V, Dhull SB, Gat Y and Chhikara N., 2017 b. Development of Probiotic Beetroot Drink. Current Research in Nutrition and Food Science Journal, 5(3).
29. Reddy NR, Pierson MD, Sathe SK, Salunkhe DK and Beuchat, LR, 1983. Legume-based fermented foods: Their preparation and nutritional quality. Critical Reviews in Food Science & Nutrition, 17(4):335-370.
30. Savitri and Bhalla TC. Traditional foods and beverages of Himachal Pradesh. Indian J Tradit Know 2007; 6:17-24.
31. Silanikove N, Leitner G and Merin U., 2015. The interrelationships between lactose intolerance and the modern dairy industry: global perspectives in evolutionary and historical backgrounds. Nutrients, 7(9), 7312-7331.
32. Slavin J L, Martini M C, Jacobs D R and Marquart L., 1999. Plausible mechanisms for the protectiveness of whole grains. The American journal of clinical nutrition, 70(3): 459s-463s.
33. Stanton C, Gardiner G, Meehan H, Collins K, Fitzgerald G, Lynch PB and Ross RP, 2001. Marketpotential for probiotics. Am J ClinNutr 73:476S-483S?

34. Swain MR, Anandharaj M, Ray RC and Rani RP., 2014. Fermented fruits and vegetables of Asia: a potential source of probiotics. Biotechnol Res Int., 250424; 1-19.
35. Tamang JP, Okumiya K and Kosaka Y. Cultural adaptation of the Himalayan ethnic foods with Special reference to Sikkim, Arunachal Pradesh and Ladakh. Himalayan Stud Monogr 2010; 11:177-18.
36. Tanguler, H., & Erten, H. (2012). Occurrence and growth of lactic acid bacteria species during the fermentation of shalgam (salgam), a traditional Turkish fermented beverage. LWT-Food Science and Technology, 46(1), 36-41.
37. Tharanathan RN and Mahadevamma S., 2003. Grain legumes a boon to human nutrition. Trends in Food Science and Technology, 14(12):507-518.
38. Tripathi MK and Giri SK., 2014. Probiotic functional foods: Survival of probiotics during processing and storage. Journal of functional foods, 9, 225-241.
39. Vaidya RH and Sheth MK. Processing and storage of Indian cereal and cereal products alter its resistant starch content. J Food Sci Technol 2011; 48:622-627.
40. Vanajakshi, V., Vijayendra, S. V. N., Varadaraj, M. C., Venkateswaran, G., & Agrawal, R. (2015). Optimization of a probiotic beverage based on Moringa leaves and beetroot. LWT-Food Science and Technology, 63(2), 1268-1273.
41. Wahlqvist M L., 2015. Lactose nutrition in lactase non persistence. Asia Pacific journal of clinical nutrition, 24(S1), s21-s25.
42. Wu YV, Wall JS.1980.Lysine content of protein increased by germination of normal and high-lysinesorghums. J.Agric.FoodChem., 28:455–458. doi: 10.1021/jf60228a046.
43. Yadav DN, Sharma M, Chikara N, Anand T and Bansal S., 2014. Quality characteristics of vegetable-blended wheat–pearl millet composite pasta. Agricultural Research, 3(3), 263-270.
44. Yang, Z., Li, S., Zhang, X., Zeng, X., Li, D., Zhao, Y., & Zhang, J. (2010). Capsular and Slime-polysaccharide production by Lactobacillus rhamnosus JAAS8 isolated from Chinese sauerkraut: potential application in fermented milk products. Journal of Bioscience and bioengineering, 110(1), 53-57.
45. Yan, P. M., Xue, W. T., Tan, S. S., Zhang, H., & Chang, X. H. (2008). Effect of Inoculating lactic acid bacteria starter cultures on the nitrite concentration of fermenting Chinese paocai. Food control, 19(1), 50-55.
46. Yoon KY, Woodams, EE and Hang Y D., 2004. Probiotication of tomato juice by lactic acid bacteria. Journal of microbiology (Seoul, Korea), 42(4), 315-318

REVIEW ON NUTRITIONAL PROPERTIES AND HEALTH BENEFITS OF SOME EXOTIC FRUITS

K. E. Keerthipriya* and K. Anusuya Devi
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore – 641014
*Corresponding author E- mail: keerthipriyaa1212@gmail.com

Abstract:

Exotic fruits play a vital role in human diet due to the presence of bioactive compounds. Exotic fruit consumption and processing is widely increasing due to its nutritional properties and Health benefits. The fruit processing industry deals with the substantial number of by- product's produced at the various stages of the processing chains, such as peels, seeds, and unused flesh. This review article focuses on the origin, cultivated areas, nutritive values, health benefits of some exotic fruits like dragon fruit, rambutan, Durian, custard apple, etc. As these exotic fruits have many health benefits like anti-diabetic, anti-cancer, hepatoprotective, cardiovascular, anti-aging, antioxidant, anti-inflammatory, probiotic potential.

Introduction:

The main objective of this review was to describe the nutritional properties and Health benefits of some exotic fruits that are locally available. This review focuses on exotic fruits origin, cultivation and harvest, botanical aspects, chemical composition, nutritive value and Health benefits. The exotic fruits have many nutritional benefits as it is rich in nutrients needed for the human body. They have protective effect against diabetes, obesity, cardiovascular, hepatoprotective. Nutritional components are frequently employed in many countries as preventative medicines to prevent or control metabolic syndrome because effective preventive and therapeutic techniques for these potentially fatal health conditions frequently have negative side effects (Samir Devalaraja *et al.,* 2011)

Dragon fruit

Dragon fruit is grown since 1990 in the large scale which has a origin of Mexico and central and south America mostly grown in west Bengal. At present available in Vietnam, china, Mexico, Colombia, Nicaragua, Ecuador, Thailand, Malaysia, Australia, Indonesia, united states and India. About 73% of production is in Vietnam, china and Indonesia. Whereas, Vietnam is the first leading producer has production of about 1 million metric tons and china is the second leading producer (Nobel and La Barrera, 2004; Nie *et al.,* 2015). Israel and Thailand are major dragon fruit suppliers for European countries. Dragon plant once planted will grow up to 20years; 1 hectare could amount about 800 dragon fruit plant. The import value is exceeded 500MT in last 5 years. Dragon fruit is the 5th most imported fruit from Asia exported to china after lychee, longan, banana and mango (Crane *et al.* 2017)

There are 4 different varieties of dragon fruit

1. Red skin, white flesh (hylocereus undatus)
2. Red skin, red flesh (hylocereus polyrhizus) comes mainly from Israel and Malaysia.

3. Red skin, purple flesh (hylocereus costaricencis) from Guatemala, Nicaragua, Ecuador and Israel.
4. Yellow skin, white flesh (hyloceras megalanthu) Colombia and Ecuador. (Mercado- Silva 2018)

Nutritional value

100g of dragon fruit pulp contains moisture (84.0-86.0g), little protein (0.93 – 1.33g), fat (0.40-1.01g), crude fibre (0.88- 1.84g), carbohydrate composition (10.4 – 12.3g), glucose (4.63 – 6.39g), fructose (2.16-4.06g), sorbitol (0.33g), vitamin c (1.0 – 6.3g), minerals (1.95 – 7.4mg), potassium (181.0 – 321.0 mg) (Thi-Thuy-Hai Luu1 et. al, 2021). Another part of the pitaya, the young stem, also contains high nutritional values, including raw protein (10.0–12.1 g 100 g–1), raw fibre (7.8–8.1 g 100 g–1), and several minerals such as P, K, Ca, Mg, Na, Fe, Zn, in which Fe amounts to 7.5–28.8 mg/kg–1 of dry mass (Ortiz-Hernández and Carrillo-Salazar *et al.*, 2012) The dragon fruit has low energy than banana or jackfruit equal to durian, mango and pineapple, the carbohydrate content is lower and the minerals such as iron, zinc, sodium, magnesium than are higher than other exotic fruits and rich in potassium.

Health benefits

Dragon fruit is a powerful natural antioxidant those extracts has beneficial activities against diabetes, obesity, hyperlipidaemia and cancer (Wu *et al.* 2006) along with it has cardiovascular and hepatoprotective properties, cardiovascular protective compounds and prebiotic potential (Luo *et al.* 2014). The pitaya is rich in phytochemicals, polyphenols and flavonoid compound. It exhibits high potential as a natural agent to drive away aging-associated diseases such as cancer, atherosclerosis, hypertension, Alzheimer's disease, Parkinson's disease. The peel of the pitaya has an antimicrobial, anti-hyperlipidaemia, anti- anaemic, anti-obesity activities. The stem and flowers have a wound healing property (Velnar *et al.*, 2009).

Durian (King of Fruit)

The scientific name of durian is *Durio zibethinus* L. It was believed that durian is a native of Malaysia (Kostermans *et al.* 1958; 1992). Zeven and Zhukovsky (1975) report that durian originated in the centre of diversity in Borneo and Sumatra. The natives of durian are westernGhats of India, Malaysia and also found in central and eastern Asia, the Caribbean, Florida, brazil, Australia, Puerto rico and many pacific islands. It is also available in India. Durian is the important crop of India, Myanmar, china, srilanka, Malaysia, Indonesia, Thailand and Philippines. They also note the discovery of 19 species in the Borneo Island, though there are 14 species that are considered local and wild species, 14 from Sabah, 16 from Sarawak, 7 from Sumatra Island, and 11 from Malaysia, in which 5 species are considered local and native.

The varieties of durian are Kradum Thong, Kanyao and Chanee (Department of Health, 2007) once ripe have their own specific natural distinct smell which is actually caused by the presence of sulphur or different kinds of substances such as Thioles, Thioethen and Esters that have tiny volatile molecules (Nanta, 1991). The genus Durio contains at least 6 different kinds of edible species such as

- Wild durian (*D. Dulcis* Becc.)

- Durian with mounted pedicel type (*D. Graveolens* Becc.)
- Wild durian (*D. Kutejensis* Becc.),
- Durian with long spikes type (*D. Oxleyanus* Griff.)
- Durian tortoise type (*D. Testudinarum* Becc), and
- The native durian type (*D. Zibethinus* Murr)

Nutritional value

100 grams of durian contains moisture (62.5 g), protein (2.1 g), fat (3.3 g), carbohydrate (31.2 g), fibre (1.4 g), ash (0.9 g), calcium (29 mg), phosphorous (34 mg), iron minerals (1.1 mg), beta carotene (46 mg), Vitamin A (8 mg), thiamine (0.16 mg), riboflavin (0.23 mg), niacin equivalent (2.5 mg), and Vitamin C (35 mg) (Maimunah Mohd Ali *et al.*, 2020)

Health benefits

Various health advantages of durian fruit are mainly due to its high vitamin and mineral content (Nordin *et al.*, 2017). It is believed that using the fruits, leaves, and seeds of the durian to cure numerous human illnesses will have an antipyretic effect (Ho & Bhat *et al.*, 2015). The high polyphenol and flavonoid content of durian serves as an antioxidant and an antiproliferative, which can lower blood glucose levels (Muhtadi *et al.*, 2015). Durian has antibacterial, anti-inflammatory, antidiabetic, antioxidant, immunodulatory properties. It is useful in fever, boils, wounds, skin disease, convulsions, diuretic, constipation, ophthalmic disorders and snake bite. It has short shelf life.

Rambutan

It is a fruit that originated in Malaysia, and its name comes from the Malay word "Rambut" which means "Hair," in reference to the soft thorns that cover the fruit's exterior. The ovoid rambutan fruit has a red (or yellow) pericarp. It has soft thorns all over it that range in colour from yellow to red or green (Akhtar *et al.*, 2017; Arenas *et al.*, 2010; Li *et al.*, 2018). Currently, Malaysia, Thailand, Indonesia, and India are the countries where rambutan fruit is grown. In the Americas, however, production is concentrated in the nations of the humid tropics: Colombia, Ecuador, Honduras, Costa Rica, Trinidad and Tobago, Cuba, and Mexico (Castillo-V *et al.*, 2017). In the 1950s, varieties of rambutan from Malaysia and Indonesia were introduced to Mexico. Numerous varieties that were introduced to the state of Chiapas have since been developed into the R-104, R-133, R-148, R-115, R-134, R-161, R-170, R-3, R-156, R-162, and R-162 varieties (Caballero-Pérez *et al.*, 2011; Fraire, 2001, p. 41; Nez, 2006) by selective breeding. In other Mexican states, including Oaxaca, Tabasco, Guerrero, Colima, San Luis Potos, Nayarit, and Michoacán, rambutan plantations have been established using vegetal materials.

The rambutan is made up of the following components: 27.4% of its total weight, 13.2% of its peel, 11.7% of its pulp, 2.53% of its seed, and 1.60% of its embryo (Sols-Fuentes, Camey-Ortz, Hernández-Medel, Pérez-Mendoza, & Durán-de-Bazá, 2010). It is also praised for its exotic appearance and reviving taste (Ong *et al.*, 1998). According to Sirisompong, Jirapakkul, and Klinkesorn (2011), this fruit is eaten in the following forms: fresh, processed, stuffed with a piece of pineapple, and canned in syrup. Additionally, this fruit is used to make juices, jellies, and jams

in nations like Malaysia and Thailand (Morton, 1987). Based on the seeds, it is consumed in Mexico as liquor, canned goods, juice, and chocolate.

Nutritive value

The pulp of rambutan is eaten raw, and the main component of the fruit is water (Fraire, 2001). Watson (1984) determined the chemical composition of rambutan fruit from 100 g of pulp: water (83 g), caloric value (63 cal), protein (0.8 g), carbohydrates (14.5 g), calcium (25 mg), vitamin C (20-45 mg), iron (3 mg).

Health benefits

For centuries, rambutan (*Nephelium lappaceum* L.) has been used as a traditional medicine to prevent diabetes and hypertension. Furthermore, in Malaysia, dried rambutan fruit peel is used as a traditional medicine for fever, dysentery, diarrhea, upset stomach, and as an anthelmintic (Mahmood *et al.,* 2018b). Rambutan leaves relieve headaches and bark can be used as an astringent.

Anti-nutritional aspects of Rambutan fruit

It is necessary to assess the nutritional and anti-nutritional content because the nutritional value and anti-nutritional content have not received much attention, particularly when it comes to the waste products of fruits, seeds, and peels. Thus, the anti-nutrient contents of rambutan pulp, seed, and peel were assessed in dry and fresh samples; substances like saponin, alkaloids, hydrocyanic acid, phenols, oxalate, tannins, and phytates were discovered in all parts of the fruit. (Suganthi *et al.,* 2016)

Custard apple

According to the Indian Council of Agricultural Research (ICAR), Custard apple is widely grown in tropical climate in America and West Indies. It is introduced to India from tropical America. In India, the major cultivating areas are Andhra Pradesh, Maharashtra, Karnataka, Bihar, Orissa, Assam and Tamilnadu. The scientific name of custard apple is *Annona squamosa* L. (Annonaceae). The tree *Annona squamosa* is famous for its tasty fruits, and it starts out as a little sapling that develops to be up to 8 metres tall. The tree has broad, haphazard branches with thick leaves and bark that is brownish or light brown. (Manoj kumar,2001). *Annona squamosa* has been used as a natural remedy and in a variety of different food uses, such as its pulp's use as an ice cream flavouring agent and the fruit's 50– 80% edible portion, which can be pulped to make juice.

Nutritive value

It has significant vitamin C content of 35 to 42 mg per 100 g, as well as notable amounts of dietary fibre, vitamin B1 (thiamine), and potassium.(Zahid, M, Int. J. Pharm. Sci. Res. 2018, 9, 1745–1759).Minerals such as phosphorus (P), potassium (K), iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), copper (Cu), selenium (Se), and zinc (Zn), in addition to vitamins like ascorbic acid (A), thiamine (B1), riboflavin (B2), niacin (B3), and B9, are present in significant amounts in ASLs (folic acid). These minerals are necessary for the maintenance of a healthy human body because they facilitate a number of processes, including the preservation of strong teeth and bones, the contraction and relaxation of muscles, blood clotting, blood

pressure regulation, nerve function, immune system health, energy metabolism, and the activity of numerous enzymes (Akram *et al.*,2020).

Health benefits

In numerous nations, extracts from the Annona squamosa plant's bark, roots, leaves, stems, fruits, peels, and seeds have been used in traditional pharmacological treatments to treat a wide range of illnesses, including diarrhoea, epilepsy, haemorrhage, fever, and tumours. Annona squamosa fruit functions as a sedative in cases involving heart diseases and can be used to alleviate vomiting and treat tumours. Annona squamosa seed powder is used to eradicate lice, while leaf extract is used to calm boils and treat ulcers (Anaya-Esparza, L.M, Food Res. Int. 2020). Annona squamosa leaves (ASLs) are rich in pharmacological characteristics and biological activities, including antioxidant, antibacterial, antidiabetic, antiviral, anticancer, and hepatoprotective capabilities. As a result, ASLs have the potential tobe valued. Fruit and leaves from Annona squamosa. Glycosides, phytosterols, sugars, oils, saponins, tannins, alkaloids, phenols, flavonoids, peptides, and different acetogenin substances all contribute to these functions (Al-Nemari *et al.*,2020). Numerous active substances, including acetogenins and flavonoids, found in Annona squamosa also contribute to the plant's cytotoxic, antimalarial, antidiabetic, and immunosuppressive properties, according to phytochemical analyses. ASL extract can considerably lower blood glucose and lipid peroxidation while maintaining plasma insulin and lipid profiles (Zahid *et al.*,2018).

Table 1: Nutritive value per 100grams of fruit pulp

(Fraire, 2001; Maimunah Mohd Ali *et al.,* 2020; Thi-Thuy-Hai Luu1 *et al.,* 2021)

	Dragon Fruit	Durian	Rambutan	Custard apple
Moisture	86	62.5	83	80.1
Energy (g)	670	147	63	101
Carbohydrate (kcal)	12.3	31.2	14.5	25.3
Protein (g)	1.33	2.1	0.8	1.7
Fat (g)	0.4	3.3	0	0.7
Fibre (g)	1.84	1.4	3	2.5
Calcium (g)	8.5	29	25	30
Phosphorous (mg)	22.5	34	1.7	21
Iron (mg)	1.9	1.1	3	0.7
Thiamine (mg)	0.04	0.16	1.3	0.1
Riboflavin (mg)	0.05	0.23	3.5	0.1
Niacin (mg)	0.16	2.5	3.9	0.500
Vitamin c (mg)	20.5	35	45	19.2
Magnesium (mg)	45	0	4.4	17.8

Conclusion:

The above review article explains the origin, botanical aspects, varieties, nutritional properties and Health benefits of some exotic fruits available locally like dragon fruit, durian, rambutan and custard apple due to the developing demand for the usage of exotic fruits for its beneficial properties. Exotic fruits have high health benefits compared to other fruits.

References:

1. Akhtar, M. T., Ismail, S. N. & Shaari, K. (2017). Rambutan (Nephelium lappaceum L.). E. M. Yahia (Ed.) In Fruit and Vegetable Phytochemicals (pp. 1227- 1234). Autonomous University of Querétaro, Mexico: John Wiley & SonsLtd
2. Akram, M.; Munir, N.; Daniyal, M.; Egbuna, C.; Găman, M.A.; Onyekere, P.F.; Olatunde.,2020. A. Vitamins and Minerals: Types, sources and their functions. In Functional Foods and Nutraceuticals; Springer International Publishing: Berlin/Heidelberg, Germany.
3. Al-Nemari, R.; Al-Senaidy, A.; Semlali, A.; Ismael, M.; Badjah-Hadj-Ahmed, A.Y.; Ben Bacha, A,.2020. GC-MS profiling and assessment of antioxidant, antibacterial, and anticancer properties of extracts of Annona squamosa L. leaves. BMC Complement. Med. Ther.
4. Anaya-Esparza, L.M.; de Lourdes García- Magaña, M.; Abraham Domínguez-Ávila, J.; Yahia, E.M.; Salazar-López, N.J.; González-Aguilar, G.A.; Montalvo- González, E. Annonas,.2020.: Underutilized species as a potential source of bioactive compounds. Food Res. Int.,138
5. Caballero-Pérez, J. F., Arévalo-Galarza, L., Avendaño-Arrazate, C. H., Cadena- Iñiguez, J., Valdovinos-Ponce, G., & Aguirre-Medina, J. F. (2011). Cambios físicos y bioquímicos durante el desarrollo y senescencia de frutos de rambután (Nephelium lappaceum L.). Revista Chapingo Serie Horticultural
6. Castillo-Vera, A., López-Guillén, G., & Sandoval-Esquivez, A. (2017). History of the rambutan crop (nephelium lappacceum) in Mexico
7. Crane J.H., Balerdi F.C., Maguire I. (2017): Pitaya growing in the home landscape. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food andAgricultural Sciences, University of Florida
8. Hernández-Hernández.C, C.N. Aguilar, R. Rodríguez-Herrera, A.C. Flores- Gallegos, J. Morlett-Chávez, M. Govea- Salas , J.A. Ascacio-Valdés.,2019.
9. Durain in Thailand, A success story. Asia- Pacific Asoociation of Agricultural research institute
10. Kaiser Mahmood, Hanisah Kamilah, Abd Karim Alias & Fazilah Ariffin.,2018. Nutritional and therapeutic potentials of rambutan fruit (Nephelium lappaceum L.) and the by-products: a review. Journal of Food Measurement and Characterization volume 12, pages1556-1571
11. Kostermans, A.J.G.H. 1958. The genus *Durio Adans*. (Bombacaceae). Reinwardtia, Published by Herbarium Bogoriense. Kebun Paya, Indonesia.
12. Kostermans, A.J.G.H. 1992. *Durio macrantha* Kostem., species nova(Bombacaceae) from North Sumatra. Reinwardtia.
13. Lee-Hoon Ho, Rajeev Bhat.,2015. Exploring the potential nutraceutical values of durian (*Durio zibethinus* L.) – An exotic tropical fruit. Food chemistry, volume 168, 80-89
14. Luo H., Cai Y., Peng Z., Liu T., Yang S. (2014): Chemical composition and *in-vitro* evaluation of the cytotoxic and antioxidantactivities of supercritical carbon dioxide extracts of pitaya (dragon fruit) peel.Chemistry Central Journal: 8
15. Maimunah Mohd Ali, Norhashila Hashim., 2020. - Exploring the chemical composition,

emerging applications, potential uses, and health benefits ofdurian: A review.

16. Manoj kumar, sushil changan, maharishi tomar, radha., 21 april 2001: Custard Apple (*Annona squamosa* L.) Leaves: Nutritional Composition, Phytochemical Profile, and Health-Promoting Biological Activities
17. Mercado-Silva E. M. (2018): Pitaya - *Hylocereus undatus* (Haw). In: Rodrigues S., de Oliveira Silva E., de Brito E.S. (eds): Exotic Fruits Reference Guide. 1st Ed. Academic Press: 339–349.
18. Morton Collectanea, University of Miami, Coral Gables, Florida, USA.,1987. Fruits of warm climates .pp.517 pp. ref.p. 446- 483
19. M. Muhtadi, H. Haryoto, Tanti Azizah Sujono, Andi Suhendi,.2015. Antidiabetic and Antihypercholesterolemia Activities of Rambutan (*Nephelium lappaceum* L.) and Durian (Durio zibethinus Murr.) Fruit Peel Extracts. Journal of Applied Pharmaceutical Science Vol. 6 (04), pp.190-194
20. Nanta Maraneth. 1991. Nutritive values of durian. Sirirat Journal. 43(7): 520-521 (In Thai language).
21. Nie Q., Gao G.L., Fan Q., Qiao G., Wen X.P., Liu T., Cai Y.Q. (2015): Isolation and characterization of a catalase gene "HuCAT3" from pitaya (*Hylocereus undatus*) and its expression under abiotic stress.
22. Nobel P. S., La Barrera E. (2004): CO2 uptake by the cultivated hemiepiphytic cactus, Hylocereus undatus. Annals ofApplied Biology
23. Norhanim Nordin, Rosnah Shamsudin, Azrina Azlan, Mohammad EffendyYa'acob.,2017. Dry Matter, Moisture, Ash and Crude Fibre Content in Distinct Segments of 'Durian Kampung' Husk. World Academy of Science, Engineering and Technology International Journal ofChemical and Materials Engineering Vol:11, No:12.
24. Ortiz-Hernández Y.D., Carrillo-Salazar J.A. (2012): Pitahaya (*Hylocereus* spp.): A short review. Comunicata Scientiae
25. Peter K. C. Ong, Terry E. Acree, EdwaR, H. Lavin.,1998. Characterization ofVolatiles in Rambutan Fruit (*Nephelium lappaceum* L. J. Agric. Food Chem. 46, 2, 611–615
26. Rambutan (*Nephelium lappaceum*L.): Nutritional and functional properties,Trends in food science and technology, volume 85, 201-210
27. Samir Devalaraja, Shalini Jain, Hariom Yadav., 2011. Exotic fruits as therapeutic complements for diabetes, obesity and metabolic syndrome. Food researchinternational 44, 1856-1865.
28. Thi-Thuy-Hai Luu, Truc-Linh Le, Nga Huynh, Pablo Quintela-Alonso, 2021- Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam, Czech Journal of Food Sciences, 39.
29. Velnar T., Bailey T., Smrkolj V. (2009): The wound healing process: An overviewof the cellular and molecular mechanisms. Journal of International Medical Research, 37
30. Wu L.C., Hsu H.W., Chen Y.C., Chiu C.C., Lin Y.I., Ho J.A.A. (2006): Antioxidant and antiproliferative activities of red pitaya. Food Chemistry.
31. Zahid, M.; Mujahid, M.; Singh, P.K.; Farooqui, S.; Singh, K.; Parveen, S.; Arif, M. *Annona squamosa* linn, (Custard apple): An aromatic medicinal plant fruit with immense nutraceutical andtherapeutic potentials (Review). Int. J.Pharm. Sci. Res, 9, 1745–1759.

HEALTH BENEFITS OF MUNTINGIA CALABURA: A REVIEW

V. Manjula* and B. Bobby
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore - 641014
*Corresponding author E- mail: manjusanju2509@gmail.com

Abstract:

Numerous medicinal plants can be found in Indonesia, and the local community has long used them to treat illnesses. The use of medicinal plants in traditional Indonesian medicine and the potential for the discovery of new medications. For instance, the well-known medicinal plant *Muntingia calabura L*. sometimes referred to as kersen, a plant that has been used to heal many illnesses all throughout the world. Scientists have been looking into and identifying the pharmacological properties and phytochemical makeup of the entire M. calabura L. plant in recent years. Regarding *M. calabura*, all of the plant's parts, including the leaves, fruits, flowers, stem bark, bark, and roots, have historically been used to cure a variety of illnesses. The therapeutic potential of kersen for drug discovery has been shown by the research.

Keywords: *Mutingia calabura*, Phytochemicals, Pharmacological properties.

Introduction

Important therapeutic aid for treating human maladies can be found in medicinal plants. In impoverished nations around the world, almost 80% of the population relies on traditional medicine as their primary form of healthcare. It's interesting to note that plant extracts are used in about 85% of traditional medicine. Since the last 20 years, there has been a resurgence of interest in the use of plants and plant-based medicines due to increased knowledge of the health risks and toxicities associated with the improper use of synthetic pharmaceuticals and antibiotics. But there are still a lot of medicinal plants whose potential pharmacological usefulness has to be explored. *M. calabura* (Jamaica Cherry) is one of the plants that just received the designation of medicinal plant.

Jamaica Cherry trees are small, quickly growing trees that, when fully grown, can grow to heights of up to 40 feet. The delicate leaves feature an alternating phyllotaxy and are evergreen. The tops of the leaves are dark green, and the undersides are light green. The core of the tiny, white blossoms is made up of yellow stamens. The small, rounded fruits are numerous and range in colour from red to yellow, depending on the cultivar.

Taxonomy

The cherry plant, *M. Calabura L.* in Latin, is categorized as follows in systematic taxonomy (Mahmood *et al.*, 2014):

Kingdom **:** Plantae
Sub kingdom **:** Viridiplantae
Infrakingdom **:** Streptophyta (landplants)
Superdivision **:** Embryophyta
Division **:** Tracheophyta(Vascularplants)
Subdivision **:** Spermatophyta
Class **:** Magnoliopsida

Subclass **:** Dialypetalae
Order **:** Malvales
Family **:** Muntingiaceae
Genus **:** *Muntingia*
Species **:** *M. calabura*

Phytochemical constituents

From 1991 to the present, numerous phytochemical components have been identified from different *M. calabura* sections. Phytocomponents of *Muntingia calabura* L (Su B *et al.,* 2013) are.

1	(2S)-50-hydroxy-7,8,30,40-tetramethoxyflavan	11	3,8-dimethoxy-5,7,40-trihydroxyflavone
2	Cabreuvin	12	Pinocembrin
3	7-hydroxy isoflavone	13	8-methoxy-3,5,7-trihydroxyflavone
4	Isoliquiritigenin	14	Chrysin
5	20,40-dihydrochalcone	15	3,30-dimethoxy-5,7,40-trihydroxyflavone
6	5-hydroxy-3,7,8,40-tetramethoxyflavone	16	7-hydroxy flavone
7	dihydroxy-3,7,8-trimethoxyflavone	17	(2S)-7-hydroxy flavanone
8	5-hydroxy-3,7,8-trimethoxyflavone	18	Pinostrobin
9	Gnaphaliin	19	Isokaemferide
10	Ermanin	20	Pinobanksin

Pharmacological properties

1. Anti-diabetic activity

The antidiabetic activity of an ethanol extract of *Muntingia calabura* leaves in mice that had been given an alloxan overdose. By comparing the blood glucose levels of experimental animals before and after alloxan intoxication, the researchers conducted antidiabetic activity tests and found that the extract decreased blood glucose levels by (Herlina *et al.,* 2018). The aqueous extract of *Muntingia calabura* was tested again in the same year by in splenic cell suspension purified from BALB/c mice. The researchers discussed how the production of IL-6 directly affected the experimental animals' body weight and blood glucose levels (Rifa'i *et al.,* 2018).

Additionally, the inverse link between the amount of insulin-producing pancreatic islet cells and IL-6 production has been examined. According to the findings, giving test extract to hyperglycemic mice resulted in a considerable drop in blood sugar levels, probably as a result of the extract's ability to decrease IL-6 production from CD68 cells.

Another attempt was made in the same year *in-vivo* antidiabetic potential of an aqueous extract of *Muntingia calabura* leaves. Using glibenclamide (0.65 mg/kg) as a reference medication, the researchers first examined the antidiabetic potential of aqueous extract in insulin-deficient animal models. They discovered a notable reduction in blood glucose levels. Later, they used metformin (135 mg/kg) as a reference medicine to assess the extract's antidiabetic efficacy

in insulin-resistant animal models, and they found that extract administration decreased insulin resistance by (Aligita *et al.,* 2018).

2. Antifungal activity

The ethanol extracts of the leaves and stem of *M. calabura L*. show antifungal properties that are effective against Candida albicans Buhian (WPC, *et al.*, 2016). The roots of *M. calabura L*. exhibit antifungal activity against *Phytophthora sp., Colletotrichum sp., Alternaria solani, Pythium sp., Aspergillus niger, Fusarium oxysporum f.sp lycopersici,* and *Rhizoctonia solani* when extracted in methanol, chloroform, and petroleum ether at a concentration of 100 mg/mL (Ramasamy *et al.* 2017).

3. Antibacterial activity

S*almonella enteritidis, Citrobacter freundii, P. aeruginosa, Klebsiella pneumoniae, Vibrio cholerae, Pseudomonas aeruginosa,* and *Salmonella typhi* bacteria are all resistant to the aqueous extract of *M. calabura L*. leaves at 100.000 ppm a study by (Zakaria *et al.,* 2006). The aqueous bark extract of this plant possesses antibacterial action against *P. aeruginosa, Bacillus cereus,* and *Micrococcus luteus,* according to a study by Sibi *et al.* (2012). Additionally, aqueous fruit extract exhibits antibacterial action against *M. luteus* and aqueous leaf extract has antibacterial activity against *M. luteus* and *P. aeruginosa*.

At a concentration of 100.000 ppm, the methanol extract of *M. calabura L. leaves exhibits antibacterial action against the bacteria C. freundii, K. pneumoniae, Vibrio cholerae, V. parahaemolyticus, and S. typhi*. According to a study by Sibi *et al.* (2012), the fruit extract was efficient against Serratia marcescens, the leaf extract had added antibacterial action against P. aeruginosa, and the methanol bark extract had antibacterial activity against B. cereus and M. luteus. Additionally, the research by Buhian *et al.* (2016) revealed that *B. subtilis, Staphylococcus aureus, S. typhimurium, P. aeruginosa,* and *Escherichia* coli bacteria are all susceptible to the antibacterial effects of ethanol extra cts of *M. calabura L*.'s leaves and stems.

4. Anti-inflammatory activity

Considerable anti-inflammatory action was demonstrated by the oral administration of 100, 250, and 500mg/kg BW of the ethanol extract of the stem bark in the rat study by (Mondal *et al.,* 2013). Additionally the polyphenol extract of *M. calabura L*. fruit administered orally at 200 and 400 mg/kg BW significantly reduced inflammation the research by (Gomathi *et al.,* 2013).

5. Anti-proliferative activity

The anti-colon cancer effects of methanol extract from the leaves of *Muntingia calabura* on male Sprague Dawley rats that had colon cancer caused by azoxymethane (AOM) was examined by (Nasir *et al.,* 2017). This is the initial investigation into *Muntingia calabura*'s ability to prevent colon cancer. First, researchers used HPLC analysis to check leaf samples for the presence of rutin, a substance known to have anti- inflammatory, antioxidant, and anti-colon cancer properties. Additionally, they performed a UHPLCESI-MS study on the extract, and the results revealed the presence of various flavonoids, including ferulic acid, pinocembrin, and gallic acid, which are known to have anticancer properties.

6. Anti-oxidant activity

The methanol extract of *Muntingia calabura* leaves' intracellular antioxidant capacity in the growth of T3T fibroblast cells under both normal and oxidative stress conditions. They performed an intracellular reactive oxygen species (ROS) assay and observed that the presence of phenols and flavonoids in methanol extract caused a reduction in intracellular levels of ROS in T3T fibroblast cells under both normal and oxidative stress conditions was shown by (Rahmawati *et al.*, 2018).

7. Anti-hypertensive activity

The water-soluble fraction (WSF) of a methanol extract of *M. calabura* leaves was found to have antihypertensive effect (Shih CD.,2006). Rat's femoral veins were given injections of the fraction at doses of 10, 25, 50, 75, and 100 mg/kg. Mean systemic arterial pressure (MSAP), heart rate (HR), and baseline blood pH, gas, and electrolytes (Na+, K+, hematocrit) were the parameters examined. Protein extraction and Western blot analysis were used in the biochemical study, and the chemiluminescence test was used to quantify the plasma nitrate levels.

The butanol-soluble fraction (BSF) of the methanol extract of M. calabura leaves was tested at doses of 10, 25, 50, 75, and 100 mg/kg for its antihypertensive effects. The rat's femoral veins received systemic injections of BSF. Following the delivery of test solutions, the temporal changes in MSAP and HR were tracked for 2 hours. According to the findings, bradycardia and hypotension were induced by intravenous BSF administrations at doses between 10 and 100 mg/kg in Witar-Kyoto (WKR) normotensive and spontaneously hypertensive (SHR) rats (Shih CD.,2009).

8. Cardio-protective activity

Utilizing a rat model of myocardial infarction brought on by isoproterenol, researchers examined the cardioprotective properties of an aqueous extract of *M. calabura* leaves. Alanine transaminase (ALT), aspartate transaminase (AST), creatinine phosphokinase (CK), lactate dehydrogenase (LDH), and serum uric acid level were the parameters assessed in both the cardiac tissues and blood. According to the findings, the doses of 200 and 300 mg/kg were found to have a noticeable impact (Nivethetha M *et al.*, 2009).

9. Anti-rheumatic activity

In a rat model of rheumatoid arthritis, the antirheumatic activity of *M. calabura*'s ethanol extract of leaves and its various fractions, including ethyl acetate, n-hexane, and water, was

examined. The ethanol extract and its fractions were said to help reduce inflammation, and a histopathology analysis also revealed a decrease in cartilage loss, fibrin deposition, pannus development, inflammatory cell influx, and synovitis **(**Sarimanah J *et al.*, 2017).

10. Antiulcer activity

Against ethanol and indomethacin-induced gastric ulcer rat models, a different investigation on the antiulcer potential of methanolic extract of *M. calabura* leaves (at 25, 50, 100, 250, and 500 mg/kg) was undertaken. The extract significantly and dose-dependently reduced the development of ethanol-induced stomach ulcers at all dosages. Additionally, all doses of the extract had a substantial and dose-dependent inhibitory effect on the stomach ulcer caused by indomethacin. A histopathological analysis showed that the extract has the potential to counteract the toxic effects of ethanol and indomethacin and to restore the stomach's mucosal architecture to a nearly normal state, equivalent to the protection provided by ranitidine.

11. Acute toxicity studies

Rats were given dosages of 300, 500, and 2000 mg/kg of a methanol extract of *M. calabura* leaves in an attempt to test for acute toxicity. After administering the extract, the first 2-3 hours were spent watching for any indicators of toxicity, and the following 24 hours through 14 days were spent watching for percentage mortality. As no indicators of toxicity or mortality were observed, the findings indicated that the extract was safe up to a level of 2000 mg/kg (Triswaningsih D *et al.*, 2017).

Another attempt was made in rats investigate the acute toxicity of an oral ethanol extract of *M. calabura* leaves at doses of 2000 and 5000 mg/kg. No clinical symptoms of weakness, morbidity, or mortality were noted up to 14 days after the extract administration (Balan T *et al.*, 2014). The ethanolic extract of *M. calabura* leaves can be taken up to 5000 mg/kg without risk, according to other haematological, serum biochemical, and histopathological studies in rats that supported these findings (Karthyaini, 2012).

Conclusion:

As seen by the rise in publications on the pharmacological potential of many traditionally recognised or recently discovered medicinal plants, there has been an upsurge interest in the pharmacological potential of plants recently for an effort to extract pure and useful lead from plants. It is important to note that, in accordance with the World Health Organization (1999), a medicinal plant is any plant that includes compounds in one or more of its components that can be utilised therapeutically or that serve as precursors for the semi-synthesis of chemo-pharmaceuticals. Such a plant will have portions used in the control or treatment of a disease condition, including leaves, flowers, stems, bark, roots, rhizomes, fruits, grains, or seeds, and as a result, includes chemical components that are medically active. Regarding *M. calabura*, all of the plant's parts, including the leaves, fruits, flowers, stem bark, bark, and roots, have historically been used to cure a variety of illnesses.

References:

1. Aligita W, Susilawati E, Sukmawati IK, Holidayanti L and Riswanti J: Antidiabetic activities of *Muntingia calabura* L. leaves water extract in type 2 diabetes mellitus animal models. The Indonesian Biomedical J 2018; 10(2): 165-70.
2. Balan T, Sani MH, Suppaiah V, Mohtarrudin N, Suhaili Z, Ahmad Z. Antiulcer activity of

M. calabura leaves involves the modulation of endogenous nitric oxide and nonprotein sulfhydryl compounds. Pharm Biol. 2014;52(4):410–8.

3. Buhian WPC, *et al.* Bioactive metabolite profiles and antimicrobial activity of ethanolic extracts from *Muntingia calabura* L. leaves and stems. Asian Pacific Journal of Tropical Biomedicine. 2016; 6(8): 682–685.
4. Buhian WPC, *et al.* Bioactive metabolite profiles and antimicrobial activity of ethanolic extracts from *Muntingia calabura* L. leaves and stems. Asian Pacific Journal of Tropical Biomedicine. 2016; 6(8): 682–685.
5. Gomathi R, *et al.* A dietary antioxidant supplementation of Jamaican cherries (*Muntingia calabura* L.) attenuates inflammatory related disorders. Food Science and Biotechnology. 2013; 22(3): 787–794
6. Herlina H, Amriani A, Solihah I and Sintya R: Antidiabetic activity test of ethanolic seri leave's (*Muntingia Calabura* L.) Extract in Male Rats Induced by Alloxan. Science and Technology Indonesia 2018; 3(1): 7-13.
7. Karthyaini SK. Pharmacognostic evaluation, *in-vitro* antioxidant and *in-vivo* anti-inflammatory studies of *M. calabura* Linn. J Global Trends Pharm Sci. 2012;3:805–11.
8. Mahmood ND, *et al.* Muntingia calabura: A review of its traditional uses, chemical properties, and pharmacological observations. Pharmaceutical Biology. 2014; 52:12, 1598–1623
9. Md. Nasir NL, Kamsani NE, Mohtarrudin N, Othman F, Md. Tohid SF and Zakaria ZA: Anticarcinogenic activity of *Muntingia calabura* leaves methanol extract against the azoxymethane-induced colon cancer in rats involved modulation of the colonic antioxidant system partly by flavonoids. Pharmaceutical Biology 2017; 55(1): 2102- 9.
10. Mondal S, *et al.* Investigation of analgesic, anti-inflammatory and antipyretic activities of ethanol extract from *Muntingia calabura* stem bark. Pharmawave. 2013; 6(13): 56–64.
11. Nivethetha M, Jayasarij J, Brindha P. Effects of M. calabura L. on isoproterenol- induced myocardial infarction. J Med Singapore. 2009;50(3):300–2.
12. Preethi K, Vijayalakshmi N, Shamna R, Sasikumar JM. *In-vitro* antioxidant activity of extracts from fruits of *M. calabura* linn. from India. Pharmacogn J. 2010;2(14):11–8. doi:10.1016/S0975- 3575(10)80065-3.
13. Rahmawati AN, Astirin OP and Pangastuti A: Intracellular antioxidant activity of *M. calabura* leaves methanolic extract. Nusantara Biosc 2018; 10(4): 210- 14.
14. Ramasamy R, *et al.* Solvent extraction and evaluation of antifungal activity of *Muntingia calabura* root against fungal phytopathogens. International Journal of Current Microbiology and Applied Sciences. 2017; 6(7), 77–83.
15. Rifa'i M, Wahyuningsih MD, Lestari ND, Soewondo A, Ibrahim M and Tsuboi H: Flow cytometric analysis of proinflammatory cytokine production in hyperglycemic mouse model. Recent Patents on Food, Nutrition & Agriculture 2018; 9(2): 119-26.
16. Sarimanah J, Adnyana K, Sukandar E, Kurniati Y. The antirheumatic activity of *Muntingia calabura* l. Leaves ethanol extract and its fraction. Asian J Pharm Clin Res. 2017;10(1):84–6.
17. Shih CD, Lee HH. Activation of nitric oxide signaling pathway mediates 1489 hypotensive

effect of *M. calabura* L. (Tiliaceae) leaf extract. Am J Chin Med. 2006;34(5):857–72. doi:10.1142/S0192415X0600434X

18. Shih CD. Activation of nitric oxide/cGMP/PKG signaling cascade mediates antihypertensiveeffects of *M. calabura* in anesthetized spontaneously hypertensive rats. Am J Chin Med. 2009;37(6):1045–58. doi:10.1142/S0192415X0900748X.
19. Sibi G, *et al.* Potential use of *Muntingia calabura* L. extracts against human and plant pathogens. Pharmacognosy Journal. 2012; 4(34), 44–47.
20. Su B, *et al.* Activity-guided isolation of the chemical constituents of *Muntingia calabura* using a quinone reductase induction assay. Phytochemistry. 2013; 63: 335–341.
21. Triswaningsih D, Kumalaningsih S, Pratikto W. Estimation of Chemical Compounds and Antioxidant Activity of *Muntingia Calabura* Extract. Int J ChemTech Res. 2017;10(3):17–23.
22. Zakaria ZA, *et al.* The *in-vitro* antibacterial activity of Corchorus olitorius and *Muntingia calabura* extracts. Journal of Pharmacology and Toxicology. 2016; 1: 108–114.

REVIEW ON ANALYSIS OF GUMMY BEARS WITH *MORINGA OLEIFERA* GUM

Nithish V* and L. Uthira
Department of Nutrition & Dietetics,
PSG College of Arts & Science, Coimbatore – 641 014
*Corresponding author E-mail: nithish.v1241@gmail.com

Abstract:

The Miracle Tree, also known as *Moringa oleifera*, has proven valuable both medically and commercially. The most frequently cultivated member of the monogeneric Moringaceae family, which is native to south Asia, is the species *Moringa oleifera*. The tropics and subtropics place a great emphasis on and nurture this quickly expanding plant. Every portion of the tree is useful for either nutritional or economic uses because to its high nutritional values. Gums are organic components of plants, which are essentially inexpensive and plentiful. Gums are a natural polymer that can be used to create delivery systems with a variety of benefits, including biocompatibility, biodegradability, and cost effectiveness. Drug release modifiers in pharmaceutical dosage forms need a variety of additives, such as thickeners, emulsifiers, viscosities, and sweeteners, among others. When it influences the medication release, it should be compatible, non-toxic, stable, and commercially viable. The gum serves as a dissolving agent, binder, and a good mucoadhesive polymer. The gum shows considerable promise for manufacturing uses, particularly in the food, textile, and pharmaceutical industries. The requirement for the gum is changed in order to adjust the physicochemical qualities. This study's objective is to evaluate the use of a confectionery product made with *Moringa oleifera* gum, which will enable the development of new goods with increased nutritional and practical value.

Introduction:

Plants have always been important to mankind, regardless of age or location, since the beginning of time (Mahmood *et al.*, 2010). Numerous plant species 1 have been utilised for many years as traditional medicines for different ailments as well as food supplements (Jung, 2014). One of the oldest types of treatment for a variety of illnesses is herbal medicine, which has a reasonably high uptake for obvious reasons including being affordable, accessible, and blending with peoples' sociocultural lives. According to the WHO, the greatest place to get a range of medications is from herbal or medicinal plants (Olayemiv *et al.*, 2016). According to Mahmood *et al.* (2010), these were, are, and will always be advantageous from a dietary, social, cultural, religious, environmental, and human health standpoint.

As all of its parts are good sources of protein, vitamins, minerals, and carotenoids, the moringa plant has found extensive usage in the world economy, as well as in nutrition and medicine (Olayemiv *et al.*, 2016). The name *M. oleifera* Lam. (syn. *Moringa pterygosperma Gaerthn, Moringa moringa Millsp*.) means "generic root" in the Dravidian language of India. Kelor, Marango, Moonga, Mlonge, Mulangay, Nébéday, Saijhan, and Sajna, as well as Benzolive, are further regional names. Horseradish tree, Drumstick tree, Never Die tree, West Indian Ben tree, or Radish tree are some of the English names for this plant (Rebecca *et al.*, 2006). *M. oleifera*, which is indigenous to the sub-Himalayan region of India, has naturalised in a

number of tropical and subtropical areas of the world, including the Middle East, Africa, America, Asia, the Philippines, Cambodia, and the Caribbean islands.

The genus *Moringa oleifera* has thirteen species in the world (Bhargave A *et al.,* 2015), They are: *M. oleifera* (North-western India), *M. arborea* (Kenya), *M. borziana*, *M. concanensis*, *M. drouhardii* (South-western Madagascar), *M. hildebrandtii*, *M. longituba, M. ovalifolia, M. peregrine, M. pygmaea, M. rivae, M. ruspoliana* and *M. stenopetala* (Agarwal, 2016).

The majority of gums utilised in the creation of new preparations are naturally occurring and modified gums. Acacia gum, tragacanth, agar, starch, and other additives are utilised in the development of pharmacological dosage forms (Patil *et al.,* 2011). Based on the synthetic and semi-synthetic excipients, the origin of natural excipients is chosen. This is mostly because to the excipients' low cost, relaxing effect, accessibility, and non-irritative nature (Deogade *et al.,* 2012). These polysaccharides, which can raise the viscosity of a solution, are derived from natural sources. It also functions well as thickeners, gelling agents, emulsifiers, stabilisers, and other things (Choudhary *et al.,* 2014).

The gums procured from herbal resources are now used in many newly developed drug delivery systems which in turn results in better stability and processing. Examples of such delivery systems are microspheres, Nano spheres, nanoparticles, liposomes, hydrogels, Aquasomes, etc. In food industry, these natural gums are usually implemented as food additives and as drug molecule carrier in case of delivery systems (Bhosale *et al.,* 2014). This review deals with the nutritional and pharmaceutical benefits of the *Moringa oleifera* gum.

***Moringa oleifera* gum**

Gum is obtained from exudes of *Moringa oleifera* (family: Moringaceae) stem. The gum is a polyuronide constituting of L-arabinose, D-galactose, and glucuronic acid in the preparation of 10: 7: 2, rhamnose present in traces. For its ability to gel, this gum has been the subject of studies. The gum's gelling concentration was discovered to be between 7 and 8.5% w/v. The pseudoplastic flow and viscosity of the gels were discovered to be perfect for topical application binding and release retardant properties. Tablets of several batches were made and tested for drug release. With rising excipient proportions and falling gum proportions, it was shown that medication release increased. Fickian release mechanism was discovered to exist. The exudate from the stems of *Moringa olifer* is what makes moringa gum. The gum that emerges from the stem is originally white in colour, but after prolonged exposure, it turns reddish brown or brownish black. The gum's uses in the pharmaceutical and other industries are classified as "stabilisers," "binders," "mucoadhesive," "disintegrates," "sustained and controlled release matrix," and additionally, "nutraceutic," "therapeutic," and "cost-effective" qualities worldwide (Wang *et al.,* 2005).

Advantages of natural gums:

1. Biodegradable:

These polysaccharides signify the accessibility of biodegrable polymers which naturally have no adverse effect on the natural resources such as humans, environmental health factor. Example: Eye and skin irritation

2. Biocompatible and non-toxic:

The naturally occurring plant materials compromises of vitamins, fatty acids, minerals and carbohydrates which tranquil the repeating sugar units as polysaccharides, lactose, glucose, rhamnose, fructose, monosaccharaides and sucrose and therefore, are innocuous.

3. Low cost:

The synthetic material, when compared over the natural polymers, the most preference is given to the natural resources due to the easy accessibility, economic in nature and the production cost is much cheaper.

4. Environmental-friendly processing

Due to the straightforward production techniques involved, gums from various sources can be readily collected in large quantities at various times of the year (Mehta *et al.*, 2011).

5. Local availability:

The wide bids in developing country for a diverse nature of applications in industries, manufacturing, R and D the worldwide management helps in the production of naturally occurring sources as plant materials like tragacanth, guar gum, xanthum gum, cashew gum, etc (Seshadri *et al.,* 2003).

6. Better patient tolerance:

When natural resources compared with the synthetic materials there is few gamble of adverse events/ effects and side effects seen. Example: Cross-povidone, PMMA and Povidone, etc. (Sonika *et al.*, 2020).

Pharmaceutical applications

1. Food industry

Polysaccharides have a broad application in various types of gums which includes the stabilizing agent such as (Carob gum and Guar gum), immediate Pudding (Carrageenan's), Stabilizers for ice-cream, Food and Beverages, Baked products, Confectionaries, water retention, meat (agar) and dairy stuffs and sauces (Xanthum gum, Alginates, Pectin, Moi gum, Tragacanth, Gum Arabic) (Morton *et al.,* 1991).

2. Binder:

Moringa olifera gum is mined from the bark exudate which is used for the evaluation and manufacturing of tablets and capsules for its binding properties (Mahmood *et al.,* 2010).

3. Detoxification or water purification:

Moringa olifera is mined from the seeds which consist of the water soluble proteins have the ability to remove the harmful ingredients and deeds as effective coagulants for the purification of water. For purifying water the natural polymers have charged molecules of proteins which are able to settle the organics, mineral particles and allow the seeds for coagulation effect to alum. This is able to flocculate the bacterial cells as gram positive and negative and also used as biosorbant for the abstraction of cadmium (Ramachandran *et al.,* 1980).

4. Nutritional value:

The olifera gum in nutrition plays a lead role in the dietary supplements due to its high amount of the nutrition, vitamins (B2, B6 and C), magnesium, calcium, proteins, iron, carotenoids, provitamin A 9(Mehta *et al.*, 2011; Pandey *et al.*, 2012). The olive oil is the refined seed oil obtained from Moringa olifera which has essential fatty acids in it and the lipid

composition of these seeds are even greater than that of soyabean which makes it more nutritionally significant (Abdull *et al.,* 2014). This tree serves as a sustainable and economically nutrient rich food supplement, for those who are suffering from malnutrition.

Table 1: Comparison of nutrient content in Moringa and other food (Jarald *et al.*, 2012)

Content of	Moringa	Other food
Vitamin A	6,780 mg	Carrot- 1,890 mg
Vitamin C	220 mg	Orange- 30 mg
Calcium	440 mg	Cow milk- 120 mg
Potassium	259 mg	Banana- 88 mg
Protein	6.6 g	Cow milk- 32 g

From ancient times the Moringa olifer is used for numerous purposes as these compromises of the nutritional content which includes the Proteins, Calcium, Potassium, Vitamins such as Vitamin A and C which are in the human consumption. Different nutrition plays different role in human life to cure the illness, disorders. This includes calcium which helps in preventing the osteoporosis and makes the teeth strong where potassium is the essential content for the functioning of the brain and nerve cells. Similarly vitamin A deed protection against the diarrhea, skin rashes, orthopedics disease and heart ailment as well vitamin C act as antibiotic which fight against the flu and cold (Jarald *et al.,* 2012)

Pharmacological applications

1. In blindness and eye sight:

Beneficality of *Moringa olifera* is that by eating the leaf powder, pods and the leaves encloses the high amount of Vitamin A which preclude the darkness, night blindness in children (Morton *et al.,* 1991).

2. Cardiac and circulatory stimulant:

Moringine acts on the sympathetic nervous system and a cardiac stimulant (Morton *et al.,* 1991).

3. Antihypertensive, diuretic and cholesterol lowering activities:

The activities of olifera gum comprises of the numerous parts which are beneficial in various ways such as the roots, leaves, flowers, seeds, fruit and leaf juice all these have specific role. The compounds Thiocarbamate glycoside, Mustard oil found the molifer leaves to be liable in blood lowering effect as well leaf juice of the Moringa have a stabilizing effect. All these measures of Moringa olifer subpart plays a harmonizing effect in retaining the diuretic activity, lowers the phospholipids, serum cholesterol, Very Low-Density Lipoproteins (VLDL), Low Density Lipoproteins (LDL), Atherogenic Index Lipid, reduction in lipid profile of heart where all these are the functions of fruits and the seeds of this plant have the diuretic property.

4. Antispasmodic, antiulcer and hepatoprotective activities:

The hepato-protective and antispasmodic activities have the significant role which is due to the presence of quercitin which is a well-known flavonoid found in the Moringa roots (Mahajan *et al.,* 2007).

5. Antibacterial and antifungal activities:

Antibacterial activity has been potently observed with the help of the morgania roots, substituting as a potent antimicrobial agent. Petrygospermin is the principle compound helping it to be anti-microbial agent and anti-fungal properties (Gupta *et al.,* 2012).

6. Antitumor and anticancer activities:

Anti-tumor and anti- malignancy cytotoxicity behavioural activity could be observed in the extract derived from the stems and seeds (Anwar *et al.,* 2007; Sreelatha *et al.,* 2011; Atawodi *et al.,* 2010). Accompanying, the activity against the tumors and the malignant cells could also be seen from the extract of Moringa leaves. Moringa seed's extract actively affects hepatic carcinogenesis, metabolism of enzymes and antioxidant parameters.

7. Antioxidant activity:

Different aerial and root system parts of *M. oleifera* mainly attributes to chemical constituents like ascorbic acid (Vit. C), β-carotene (Charoensin *et al.,* 2014; 2012), quercetin, kaempferol (Ogbunugafor *et al.,* 2012), and phenolic acids (Siddhuraju *et al.,* 2003; Vongsak *et al.,* 2013; Satish *et al.,* 2013). Different extract solvent systems like ethanol, methanol and acetone has been investigated for its anti-oxidative properties (Gupta *et al.,* 2012; Kumbhare *et al.,* 2012; Abalaka *et al.,* 2012; Doughari *et al.,* 2007; Kekuda *et al.,* 2010; Bhattacharjee *et al.,* 2006; Moyo *et al.,* 2012; Oluduro *et al.,* 2012). To support the findings different in-vivo and in-vitro assays against the different part of plant have been done by the researchers.

8. Antimicrobial activity:

A wide activity against the different bacteria has been reported previously reported for the different parts of plant including leaves (Rahman *et al.,* 2009; Thilza *et al.,* 2010; Thilza *et al.,* 2010) and pods (Arora *et al.,* 2014). Different bacteria include some examples like *E. coli, S. typhi, P. aeruginosa, E. cloace, P. vulgaris, S. aureus, M. kristinae, E. aerogenes, Shigella, B. cereus, Streptococcus-B-haemolytica, B. subtilis, K. pneumonia, B. megaterium, S. lutea, B. sterothermophilus, S. pyogenes, V. cholera, S. entridis, enteropathogens* and wound bacteria. In addition, the antiviral activities of seeds against HSV-1 (Ali *et al.,* 2004; Lipipun *et al.,* 2003; Nworu *et al.,* 2013; Sudha *et al.,* 2010; Stohs *et al.,* 2015) and that of leaves against Epstin Barr Virus (EBV), HIV and HSV-1 (Waterman *et al.,* 2014; Coppin *et al.,* 2013; Cheenpracha *et al.,* 2010; Inbathamizh *et al.,* 2012;) have also been tested successfully.

9. Anti-inflammatory activity:

Playing an important role as anti-inflammatory agents including 4-[(α-L-rhamnosyloxy) benzyl] isothiocyanate, 4- [(4′-O-acetyl-α-L-rhamnosyloxy)benzyl]isothiocyanate (Maheshwari *et al.,* 2014; Pandey *et al.,* 2012;), quercetin, kaempferol glucosides, 4-[2-O-acetyl- α-L-rhamnosyloxy) benzyl]isothiocyanate, 4-[(3-O-acetyl-αrhamnosyloxy) benzyl]isothiocyanate, 3,5-dihydroxy-6-methyl-2,3dihydro4H-pyran-4-1, 9-octadecenamide, aurantiamide acetate and 1,3-dibenzyl urea (Sulaiman *et al.,* 2008; Lee *et al.,* 2013; Muangnoi *et al.,* 2012; Farooq *et al.,*2012) in different parts of M. oleifera have been reported. Further investigation in references to the anti-inflammatory activity of leaves of M. olifera has been reported. Further (Bose *et al.,* 2007; Dangi *et al.,* 2002; Kumar *et al.,* 2012), it was concluded that's the anti-inflammatory activity could be seen at molecular level by inhibiting the inflammation signalling pathways. The

role of leaf and root extracts in treatment of inflammation and that of pod extracts in amelioration of inflammation associated disorders have been extensively studied (Nandave *et al.,* 2009).

10. Cardio-protective activity:

As a potent cardio protective dug it actively alters the circulatory system/capillaries and reduce mortality and morbidity as a consequence of coronary heart diseases which is due to the presence of gossypetin, quercetagenin and proanthocyanidins (Rachmawati *et al.,* 2014; Gupta *et al.,* 2012). Main components responsible for the cardio protective action are O-[2′-hydroxy-3′-(2″-heptenyloxy)]-propyl undecanoate, O-ethyl-4-[(α-L (rhamnosyloxy)-benzyl] carbamate, methyl p-hydroxybenzoate [130, 124], and 4-(α - L-rhamnosyloxy benzyl)-O-methyl thiocarbamate (Sudha *et al.*,2010; Hannan *et al.,* 2014) (correspond to the hypotensive nature of the plant as a whole, while N- α-Lrhamnopyranosyl vincosamide from the bark is reported to exhibit cardioprotective effects. The hypotensive and bradycardiac activities of leaves are attributed to niazinin, niazimicin, niaziminin, niazimin, niazirin, niazicin, niazirinin, niazirin 4-[(4′-O-acetyl-α-rhamnosyloxy) benzyl] isothiocyanate (Ganguly *et al.,* 2008; Divi *et al.,* 2012; Jain *et al.,* 2010) and glucomoringine. Due to the presence of alkaloids and Flavonoids it potently effects the blood pressure and AGE (angiotensin converting enzymes).

11. Immunomodulatory activity:

Immunomodulaters activity is observed mainly by the leaves of the plant as it doesn't only exhibit the immunomodulaters activity it does also possess immune stimulatory activities. The activity of the plant is mediated the reduction of cyclophosphamide which is responsible for the immunosuppression as it mediates the cellular and Humoral immunity (Jaiswal *et al.,* 2009).

12. Neuroprotective Effect

Ashok *et al.* (2003) revealed that leaves exert a neuroprotective effect by promoting neuronal survival and outgrowth. The extracts of the leaves reported to exhibit a protective effect against Alzheimer's disease by altering the brain monoamine levels and electrical activity.

Therapeutic use

Moringa is rich in a variety of relatively unique phytochemicals termed glucosinolates and isothiocyanates as well as a variety of phytochemicals with the simple sugar rhamnose. Treatment with Moringa or with phytochemicals derived from this has showed antiulcer, effect on immunological response, spasmolytic activities, hypocholesterolemic effects, and antibacterial activity in a variety of detoxication and antioxidant enzymes and biomarkers.

Other health benefits

It acts against the harmful conditions like Headache, antimicrobial (syphilis, typhoid, dental carries), asthma, fever, diuretic, digestive disorders, rheumatism, nervous disorders, Rubefacient and improves the reproductive health (Fahey, 2005).

Conclusion:

Moringa oleifera gum has numerous benefits like pharmaceutical, pharmacological and it also has numerous advantages. As there are so many healthy gains present in the gum, new food products can be developed using this gum. The mechanism of action should be evaluated and examined. There are no evidences for the presence of any toxic components as it is used as a pharmaceutical compound. Formulation of food products with increased nutrient content can be done with the incorporation of *Moringa oleifera* gum.

References:

1. Abalaka, M. E., Daniyan, S. Y., Oyeleke, S. B., and Adeyemo, S. O. (2012). The antibacterial evaluation of *Moringa oleifera* leaf extracts on selected bacterial pathogens. Journal of Microbiology Research, 2(2), p. 1-4.
2. Abdull Razis, A. F., Ibrahim, M.D., and Kntayya, S. B. (2014). Health benefits of *Moringa oleifera*. Asian Pacific Journal of Cancer Prevention, 15(20), p. 8571- 8576.
3. Agarwal V. (2016) The Magical Moringa Ayurveda college.
4. Ali, G. H., el-taweel, G. E., and Ali, M. A. (2004). The cytotoxicity and antimicrobial efficiency of *Moringa oleifera* seeds extracts. International Journal of Environmental Studies, 61(6), p. 699-708.
5. Anwar, F., Latif, S., Ashraf, M., and Gilani, A. H. (2007). *Moringa oleifera*: a food plant with multiple medicinal uses. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 21(1), p. 17- 25.
6. Arora, D. S., and Onsare, J. G. (2014). *In-vitro* antimicrobial evaluation and phytoconstituents of *Moringa oleifera* pod husks. Industrial Crops and Products, 52, p. 125- 135.
7. Atawodi, S. E., Atawodi, J. C., Idakwo, G. A., Pfundstein, B., Haubner, R., Wurtele, G., and Owen, R. W. (2010). Evaluation of the polyphenol content and antioxidant properties of methanol extracts of the leaves, stem, and root barks of *Moringa oleifera* Lam. Journal of Medicinal Food, 13(3), p. 710-716.
8. Bhargave A, Pandey I, Nama KS, Pandey M. "*Moringa oleifera* Lam. - Sanjana (Horseradish Tree) - A Miracle food plant with multipurpose uses in Rajasthan-India-An overview." Int. J. Pure App. Biosci. 2015
9. Bhattacharjee, I., Chatterjee, S. K., Chatterjee, S., and Chandra, G. (2006). Antibacterial potentiality of Argemone mexicana solvent extracts against some pathogenic bacteria. Memórias do Instituto Oswaldo Cruz, 101(6), p. 645-648
10. Bhosale, R. R., Osmani, R. A. M., and Moin, A. (2014). Natural gums and mucilages: a review on multifaceted excipients in pharmaceutical science and research. International Journal of Pharmacognosy and Phytochemical Research, 15(4).
11. Bose, C. K. (2007). Possible role of *Moringa oleifera* Lam. root in epithelial ovarian cancer. Medscape General Medicine, 9(1), p. 26.
12. Charoensin, S. (2014). Antioxidant and anticancer activities of *Moringa oleifera* leaves. J. Med. Plants Res, 8(7), p. 318-325.
13. Cheenpracha, S., Park, E. J., Yoshida, W. Y., Barit, C., Wall, M., Pezzuto, J. M., and Chang, L. C. (2010). Potential anti-inflammatory phenolic glycosides from the medicinal plant *Moringa oleifera* fruits. Bioorganic and medicinal chemistry, 18(17), p. 6598-6602.
14. Choudhary, P. D., and Pawar, H. A. (2014). Recently investigated natural gums and mucilages as pharmaceutical excipients: An overview. Journal of pharmaceutics, 2014.
15. Chumark, P., Khunawat, P., Sanvarinda, Y., Phornchirasilp, S., Morales, N. P., Phivthong-ngam, L. and Klaiupsorn, S. P. (2008). The *in-vitro* and ex vivo antioxidant properties,

hypolipidaemic and antiatherosclerotic activities of water extract of *Moringa oleifera* Lam. leaves. Journal of ethnopharmacology, 116(3), p. 439-446.

16. Coppin, J. P., Xu, Y., Chen, H., Pan, M. H., Ho, C. T., Juliani, R., Wu, Q. (2013). Determination of flavonoids by LC/MS and anti-inflammatory activity in *Moringa oleifera*. Journal of Functional Foods, 5(4), p. 1892- 1899.
17. Dangi, S. Y., Jolly, C. I., and Narayanan, S. (2002). Antihypertensive activity of the total alkaloids from the leaves of *Moringa oleifera*. Pharmaceutical biology, 40(2), p. 144-148.
18. Deogade, U. M., Deshmukh, V. N., and Sakarkar, D. M. (2012). Natural Gums and Mucilage's in NDDS: Applications and Recent approaches. International Journal of PharmTech Research, 4(2), p .799-814.
19. Doughari, J. H., Pukuma, M. S., and De, N. (2007). Antibacterial effects of Balanites aegyptiaca L. Drel. and *Moringa oleifera* Lam. on *Salmonella typhi*. African Journal of biotechnology, 6(19).
20. Fahey, J. W. (2005). *Moringa oleifera*: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for life Journal, *1*(5), 1-15.
21. Farooq, F., Rai, M., Tiwari, A., Khan, A. A., and Farooq, S. (2012). Medicinal properties of *Moringa oleifera*: An overview of promising healer. Journal of Medicinal Plants Research, 6(27), p. 4368-4374.
22. Gupta, R., Mathur, M., Bajaj, V. K., Katariya, P., Yadav, S., Kamal, R., and Gupta, R. S. (2012). Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. Journal of diabetes, 4(2), p. 164-171.
23. Inbathamizh, L., and Padmini, E. (2012). Gas chromatography-mass spectrometric analyses of methanol extract of *Moringa oleifera* flowers. International Journal of Chemical and Analytical Science, 2(5).
24. Jaiswal, D., Rai, P. K., Kumar, A., Mehta, S., and Watal, G. (2009). Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats. Journal of ethnopharmacology, 123(3), p. 392-396.
25. Jarald, E. E., Sumati, S., Edwin, S., Ahmad, S., Patni, S., and Daud, A. (2012). Characterization of *Moringa oleifera* Lam. gum to establish it as a pharmaceutical excipient. Indian Journal of Pharmaceutical Education and Research, 46(3), p. 211-216.
26. Jung IL. (2014). "Soluble Extract from *Moringa oleifera* Leaves with a New Anticancer Activity." Plos one.
27. Kekuda, T. P., Mallikarjun, N., Swathi, D., Nayana, K. V., Aiyar, M. B., and Rohini, T. R. (2010). Antibacterial and Antifungal efficacy of steam distillate of *Moringa oleifera* Lam. Journal of Pharmaceutical Sciences and Research, 2(1), p. 34.
28. Kumar, V., Pandey, N., Mohan, N., and Singh, R. P. (2012). Antibacterial and antioxidant activity of different extract of *Moringa oleifera* Leaves–an *in-vitro* study. International Journal of Pharmaceutical Sciences Review and Research, 12(1), p. 89-94.
29. Kumbhare, M. R., Guleha, V., and Sivakumar, T. (2012). Estimation of total phenolic content, cytotoxicity and in–vitro antioxidant activity of stem bark of *Moringa oleifera*. Asian Pacific Journal of Tropical Disease, 2(2), p. 144-150.

30. Lee, H. J., Jeong, Y. J., Lee, T. S., Park, Y. Y., Chae, W. G., Chung, I. K., and Moon, S. K. (2013). Moringa fruit inhibits LPS-induced NO/iNOS expression through suppressing the NF-κ B activation in RAW264. 7 cells. The American journal of Chinese medicine, 41(05), p. 1109-1123.
31. Lipipun, V., Kurokawa, M., Suttisri, R., Taweechotipatr, P., Pramyothin, P., Hattori, M., and Shiraki, K. (2003). Efficacy of Thai medicinal plant extracts against herpes simplex virus type 1 infection *in-vitro* and *in-vivo*. Antiviral research, 60(3), p. 175-180.
32. Mahajan, S. G., and Mehta, A. A. (2007). Inhibitory action of ethanolic extract of seeds of *Moringa oleifera* Lam. on systemic and local anaphylaxis. Journal of immunotoxicology, 4(4), p. 287-294.
33. Mahmood KT, Mugal T, Haq IU. (2010). "*Moringa oleifera*: a natural gift-A review." J. Pharm. Sci. & Res.
34. Mehta, J., Shukla, A., Bukhariya, V., and Charde, R. (2011). The magic remedy of *Moringa oleifera*: an overview. Int J Biomed Adv Res, 2(6), 215-227.
35. Morton, J. F. (1991). The horseradish tree, *Moringa pterygosperma* (Moringaceae)—a boon to arid lands? Economic botany, 45(3), p. 318-333.
36. Moyo, B., Oyedemi, S., Masika, P. J., and Muchenje, V. (2012). Polyphenolic content and antioxidant properties of *Moringa oleifera* leaf extracts and enzymatic activity of liver from goats supplemented with *Moringa oleifera* leaves/sunflower seed cake. Meat science, 91(4), p. 441-447.
37. Muangnoi, C., Chingsuwanrote, P., Praengamthanachoti, P., Svasti, S., and Tuntipopipat, S. (2012). *Moringa oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide-stimulated RAW 264.7 murine macrophage cell lines. Inflammation, 35(2), p. 445-455.
38. Mukesh Nandave, Shreesh Kumar Ojha, Sujata Joshi, Santosh Kumari, and Dharamvir Singh Arya. *Moringa oleifera* Leaf Extract Prevents Isoproterenol-Induced Myocardial Damage in Rats: Evidence for an Antioxidant, Antiperoxidative, and Cardioprotective Intervention.Journal of Medicinal Food.Feb 2009.47-55.
39. Nworu, C. S., Okoye, E. L., Ezeifeka, G. O., and Esimone, C. O. (2013). Extracts of *Moringa oleifera* Lam. showing inhibitory activity against early steps in the infectivity of HIV-1 lentiviral particles in a viral vector-based screening. African Journal of Biotechnology, 12(30).
40. Ogbunugafor, H., Igwo-Ezikpe, M., Igwilo, I., Ozumba, N., Adenekan, S., Ugochukwu, C., and Ekechi, A. (2012). *In-vitro* and *in-vivo* evaluation of antioxidant properties of *Moringa oleifera* ethanolic leaves extract and effect on serum lipid indices in rat. Macedonian Journal of Medical Sciences, 5(4), p. 397-403.
41. Olayemiv AT, Olanrewaju MJ, Oloruntoba AC. (2016). "Toxicological evaluation of *Moringa oleifera* Lam seeds and leaves in Wistar rats." Pharmacogn. Commn.
42. Oluduro, A. O. (2012). Evaluation of antimicrobial properties and nutritional potentials of *Moringa oleifera* Lam. leaf in South-Western Nigeria. Malaysian Journal of Microbiology, 8(2), p. 59-67.

43. Patel, M. T., Patel, J. K., and Upadhyay, U. M. (2012). Assessment of various pharmaceutical excipient properties of natural *Moringa oleifera* gum [Mucoadhesion, disintegration, binder]. International journal of pharmacy and Life sciences, 3(7).
44. Patil, D.N. (2011) Application of Chemical Modified Herbal Gums in Delivery of Drug. KLE University College of Pharmacy, Belgaum-590010.
45. Rachmawati, I., and Rifa'i, M. (2014). *In-vitro* immunomodulatory activity of aqueous extract of *Moringa oleifera* Lam. leaf to the CD4+, CD8+ and B220+ cells in Mus musculus. The Journal of Experimental Life Science, 4(1), p. 15-20.
46. Rahman, M. M., Sheikh, M. M. I., Sharmin, S. A., Islam, M. S., Rahman, M. A., Rahman, M. M., and Alam, M. F. (2009). Antibacterial activity of leaf juice and extracts of *Moringa oleifera* Lam. against some human pathogenic bacteria. CMU J Nat Sci, 8(2), p. 219.
47. Ramachandran, C., Peter, K. V., and Gopalakrishnan, P. K. (1980). Drumstick (*Moringa oleifera*): a multipurpose Indian vegetable. Economic botany, p. 276-283.
48. Rebecca HSU, Midcap S, Arbainsyah, Witte LD. (2006): "*Moringa oleifera*: medicinal and socio-economic uses. International Course on Economic Botany." National Herbarium Leiden, Netherlands
49. Rockwood JL, Anderson BG, Casamatta DA. "Potential uses of *Moringa oleifera* and an examination of antibiotic efficacy conferred by m. oleifera seed and leaf extracts using crude extraction techniques available to underserved indigenous populations." International journal of phytothearpy research 2013
50. Satish, A., Kumar, R. P., Rakshith, D., Satish, S., and Ahmed, F. (2013). Antimutagenic and antioxidant activity of *Ficus benghalensis* stem bark and *Moringa oleifera* root extract. International Journal of Chemical and Analytical Science, 4(2), p. 45-48
51. Seshadri, S., and Nambiar, V. S. (2003). Kanjero (*Digera arvensis*) and drumstick leaves (*Moringa oleifera*): nutrient profile and potential for human consumption. World review of nutrition and dietetics, 91, p. 41-59.
52. Siddhuraju, P., and Becker, K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. Journal of agricultural and food chemistry, 51(8), p. 2144-2155.
53. Sreelatha, S., Jeyachitra, A., and Padma, P. R. (2011). Antiproliferation and induction of apoptosis by *Moringa oleifera* leaf extract on human cancer cells. Food and Chemical Toxicology, 49(6), p. 1270-1275.
54. Sonika, S. D., Singh, T. G., Arora, G., & Arora, S. (2020). Moringa gum: a comprehensive review on its physicochemical and functional properties. *Plant Archives*, *20*(1), 3794-3805.
55. Stohs, S. J., and Hartman, M. J. (2015). Review of the safety and efficacy of *Moringa oleifera*. Phytotherapy Research, 29(6), p. 796-804.
56. Sudha, P., Asdaq, S. M., Dhamingi, S. S., and Chandrakala, G. K. (2010). Immunomodulatory activity of methanolic leaf extract of *Moringa oleifera* in animals. Indian J Physiol Pharmacol, 54(2), p. 133-140.

57. Sulaiman, M. R., Zakaria, Z. A., Bujarimin, A. S., Somchit, M. N., Israf, D. A., and Moin, S. (2008). Evaluation of *Moringa oleifera* aqueous extract for antinociceptive and anti-inflammatory activities in animal models. Pharmaceutical biology, 46(12), p. 845.
58. Thilza, I. B., Sanni, S., Isah, Z., Sanni, F., Talle, M., and Joseph, M. (2010). *In-vitro* antimicrobial activity of water extract of *Moringa oleifera* leaf stalk on bacteria normally implicated in eye diseases. Academia arena, 2(6), p. 80-82.
59. Vongsak, B., Sithisarn, P., Mangmool, S., Thongpraditchote, S., Wongkrajang, Y., and Gritsanapan, W. (2013). Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. Industrial crops and products, 44, p. 566-571.
60. Wang, Q., and Cui, S. W. (2005). Understanding the physical properties of food polysaccharides. Food carbohydrates: chemistry, physical properties, and applications, 162-214.
61. Waterman, C., Cheng, D. M., Rojas-Silva, P., Poulev, A., Dreifus, J., Lila, M. A., and Raskin, I. (2014). Stable, water extractable isothiocyanates from *Moringa oleifera* leaves attenuate inflammation in vitro. Phytochemistry, 103, p. 114-122.

CONSUMER PERCEPTIONS TOWARDS ORGANIC FOOD

Prathusha R* and Bobby B
Department of Nutrition & Dietetics,
PSG College of Arts & Science, Coimbatore – 641 014
*Corresponding author E-mail: prathusha2028@gmail.com

Abstract:

Different nations have varying requirements for items to be certified as "Organic," hence, there is no agreed-upon definition of what constitutes an "Organic" product. In simple words, organic foods are those that have undergone minimal processing to preserve their nutritional value, free of artificial additives, preservatives, or irradiation. Conventional meat and dairy products are those that are made from animals that were bred using growth hormones and antibiotics, and conventional vegetables and fruits are those that are cultivated by the application of fertilizers and pesticides. Organic products are produced using environmentally friendly procedures and growing methods that take into account both the properties of the finished product and the manufacturing processes. Food that is grown organically has better nutritional qualities, which will probably lead to higher levels of public health. This review aims to provide an evaluation of the literatures on the consumer perception towards organic food.

Keywords: Organic foods, Consumer perception, Awareness, Public health

Introduction:

The purpose of this review is to understand how various consumers view organic food items, which are becoming more and more well-liked in recent years as people's concerns about their health and environment are growing. The understanding of how various customers view organic food products has greatly benefited from this study. The organic customer profile is defined by demographic elements as well as lifestyle and environmental attitudes. The short-term prospects of organic agricultural production depend largely on consumer demand. Therefore, technology is necessary to educate customers about the importance of organic food production because it helps consumers and also improves the market dynamics of organic products. A comprehensive understanding of consumer willingness and the forces that drive behavioral responses to naturally produced foods is critical, although this varies from continent to continent and around the world. This review is crucial to support the different benefits of organically farmed foods in light of consumer interest in them (Greene *et al.*, 2017).

The aim of this review is to provide an evaluation of the literature on consumer attitudes towards organic food. In order to investigate the advantages of organic farming, it is necessary to first understand how consumers perceive difficulties with food systems and food quality. Consumer food valuation is influenced by knowledge and public understanding. As a result, consumers require clear, accurate and trust worthy information about organic food. Consumers believe they are more informed if organic food information is provided and this information influences their perceptions.

Literature review on organic foods and consumer perception

The decision to buy organic food is influenced by a variety of factors, including gender, age, income, education, and the presence of children in the home. The main drivers include

worries about nutrition and health, superior flavor, environmental protection, food safety, distrust of traditional foods, concern for animal welfare, support for the neighborhood economy, freshness, curiosity, or because they are deemed trendy. Studies on consumers are continuing to show that customer's hopes for the health benefits of organic food rank among the top reasons they purchase these goods, and public interest in the findings of this research on this subject is expected to be high (Wier and Anderson, 2003; Chen, 2007; Zakowska, 2008).

Being environmentally conscious is supposedly only available to middle-class people. Instead of picking between products that are sustainable and those that are not, consumers prefer to have a choice among sustainable goods (Shroeder, 2003). Both industrialised and developing countries are becoming more aware of the growing need for foods that are produced organically (Chander *et al.,* 2011).

A study on consumer shopping experience was relevant to identify feeling and measure customer perceptions towards purchase of products in retail environment, thus it is necessary that retailers create something, a positive shopping experience, for Customers use both concrete and abstract advantages to encourage the purchase and use of organic food products (Atulkar and Kesari, 2016).

Kuhar and Juvancic in 2008 did a countrywide survey related to purchasing behavior of integrated fruit and veggies that are organic and found that purchases of organic food was most important greatly their accessibility in the retail market for goods, following consumer wealth, health and environmental factors, and product aesthetic appeal. Based on this research, they created an ordered transparency model of consumer preference to quantify several factors that affect how frequently people buy fruits and vegetables grown organically. By taking targeted knowledge and awareness-raising measures, the demand for fruits and vegetables produced organically and sustainably could be significantly boosted.

Organic food contains only one-third of pesticides that conventional food does (Baker *et al.,* 2002). Lower exposure equals lower risk. Nearly all conventional foods will have lower levels of pesticide residues than the regulatory maximum limits. Consumers are concerned about GMOs and synthetic additives in fruits and vegetables, as well as agrochemicals, hormones, and medications used in animal farming. As a result, organic foods are generally considered to be safe, grown using ecologically and environmentally responsible practises that do not require synthetic inputs like pesticides and chemical fertilisers, and are free of genetically modified organisms (GMOs) and do not process with irradiation, industrial solvents, or chemical food additives (Singh and Verma, 2017).

Organic food and products have grown in popularity in recent years as a result of consumers strong belief that organic products are safe and clean. Food preferences and choices have a strong influence on one's physical and physiological well-being. Even if the number of people buying organic food has greatly increased, they are still at the affective loyalty stage. Additionally, the organic market is still in the acceptance phase (Chandrasekhar, 2014).

Numerous attempts were performed to identify and comprehend the components affecting the Purchase Intention and Practical Purchase of Organic Food inside the Indian Urban market in light of the promising expansion of Organic Food in the Asia area. The findings show that the main variables impacting customers' purchasing intentions are quality, health, and

environmentally friendly practises. However, the customer's decision is unaffected when it comes to actually purchasing the product that was made using an environmentally friendly approach. This is anticipated to assist marketers in moving customers from purchase consideration to actual purchase. Organic food consumption is more likely to increase among consumers that care about foods that are natural, the sensory as well as emotional attraction of food, and green consumption habits (Lockie *et al.,* 2004).

Given their significant roles in determining a family's food, women were found to have better health consciousness and to be innovators for change regarding healthier diets (Fagerli and Wandel, 1999). Additionally, according to *Yiridoe et al.,* (2005), they are more concerned about the potential health effects that involve chemical residues and preservatives. Women are more dedicated to eating organic foods, upholding environmental principles, and believing that it is appropriate to pay extra for environmental benefits. In comparison to conventional food, organic food contained more Vitamin C (Soil Association, 2000).

While people were aware of images and availability, they were not completely loyal to organic food products. Marketers need to develop genuine promos that can both be realistic and moral, along with availability of products in both terms of volume and diversity, to successfully promote organic food items. Given that food is the primary determinant of one's health, consumers in the present environment are much more health concerned and selective about what they eat. Consumers began promoting the consumption of foods cultivated organically after swiftly realising the detrimental effects of synthetic fertilisers and synthetic pesticides on their health. With the opening of specialised organic outlets, specific organic countertops in supermarkets, specialised stalls in specialised farmer markets, and farm-side selling, the demand for organic food is growing, especially in metropolitan areas. Pesticide residues are among the harmful food pollutants that have been linked to genotoxic, carcinogenic, neurodestructive, endocrine, and allergic effects. They tend to appear in higher concentrations in goods made from conventionally grown plants. Scientific data support that dietary exposure of children to organophosphorus pesticides, measured as the level of pesticide metabolites in urine, is much lower on an organic than on a conventional diet (Curl *et al.,*2003).

More than 150 comparative studies on food, which includes grains, potatoes, bread, milk, fruit, vegetables, beer, wine, eggs and food products created from them, were reviewed by Woese *et al.,* in 1997. The investigations looked at sensory testing, animal feeding experiments, and levels of ambient pollutants and pesticide residues. It was discovered that conventional food items that have had mineral fertilisation appear to have a higher nitrate level than vegetables and potatoes that have received organic fertilisation. Lower residue levels of pesticide were identified in organically grown vegetables and fruit (Woese *et al.,* 1997).

SWOT analysis for organic food market

(Source: https://www.researchgate.net/publication/357377698_organic_food_in_india_health_and Environmental_advantages_and_disadvantages)

Comparison of organic and non-organic products

Organic Produce vs. Non organic Produce

Organic produce	**Conventionally-grown produce**
Uses natural fertilizers – manure, compost	Grown using synthetic or chemical fertilisers
Weeds are naturally-controlled using crop rotation, hand weeding, mulching and tilling	Weeds are controlled with chemical herbicides, commonly glyphosate – the dreaded *Roundup*
Pests are controlled naturally – birds, insects and traps or naturally-derived pesticides	Pests are controlled with synthetic or chemical pesticides
Organic meat, dairy and eggs	Conventionally-reared meat, dairy and eggs
Livestock given organic, hormone-free and GM-free feed	Livestock given growth hormones and non-organic, GM feed
Natural approaches such as clean housing, rotational grazing, and a balanced diet are used to prevent disease	Drugs and antibiotics are frequently used to prevent disease
Livestock must have access to outdoor areas	Livestock may or may not have access to outdoor areas

Source: https://www.izabellanatrins.com/5-reasons-organic-this-autumn/

Sustainable products are always seen as the expensive option (Market & Opinion Research International Limited (MORI), 2003). It may be problematic to determine the characteristics of organic foods based just on visual inspection (Yiridoe *et al.*, 2005). According to Denver Christensen (2015) and Nguyen *et al.*, (2019), the majority of consumers of organic food believe that organic products are distinctive from those produced using conventional farming methods. If you look at it another way, the reason that certain customers do not purchase organic produce is related to their perception that it is not healthier than conventional produce

(Watson, 2012). There is therefore ongoing interest in and debate about whether foods produced organically are superior than or the same as counterparts grown conventionally, and if so, with regard to of what characteristics. This is because these beliefs run counter to consumers' line of reasoning (Yiridoe *et al.*, 2005).

Consumer believes that organic food consumption helps to reduce stress level and maintains an energetic lifestyle. The study also discovered that respondents had no objections to spend even higher costs because of it is beneficial for health. Sivathanu in 2015 also revealed that due to the impression of organic food items as being safe, wholesome, environmentally friendly, and healthful, customers prefer to purchase them.

Labels, health concerns, environmental concerns, brand advertising, brand safety, accessibility, price, freshness, and shop location were identified by Pandurangarao *et al.*, in 2017 as the top 10 factors influencing consumers to purchase organic food. Out of these, the three most important variables are safety, environment, and health.

Conclusion:

Organic food market is steadily increasing worldwide. Customers buy organic food because they think it is safer, healthier, and of greater quality because it is naturally produced. The use of synthetic pesticides and mineral fertilisers is forbidden in organic agriculture, which is based on general and specific guidelines that have a significant impact on the chemical content of organic foods. The significant production of organic livestock uses forage- and pasture-based diets (Paoletti, 2015)

A review of the study also revealed that the availability of the market can influence consumer preferences and choices for purchasing organic food products. This paper thereby offers crucial data that there will be increased demand for organically grown food products in the future, so it is high time for producers, traders, consumers, and the government itself to focus on the organic niche market.

References:

1. Atulkar.S & Kesari.B., 2016. Shopping Of Hypermarket Shoppers On Weekends, Indian Journal Of Marketing, 46(11), 36-49.
2. Baker BP, Benbrook CM, III EG, Benbrook KL., 2002. Pesticide residues in conventional, integrated pest management (IPM) - grown and organic foods: Insights from three US data sets. Food Additives and Contaminants, 19(5), 427–46.
3. C.L. Curl, R.A. Fenske, K. Elgethun., 2003. Organophosphorus pesticide exposure of urban and suburban preschool children with organic and conventional diets, Environ. Health Perspect. 377–382.
4. Chander.M, Bodapati.S, Mukherjee.R. &Kumar.S., 2011. Organic livestock production: An emerging opportunity with new challenges for producers in tropical countries. Revue Scientifiqueet Technique International Office of Epizootics, 30(3), 569–583.
5. Chandrasekhar, 2014. Consumers Perception towards Organic Products – A Studyin Mysore City. International Journal of Research in Business Studies and Management. 1(1):52-67.
6. Chen M.F. 2007. Consumer attitudes and purchase intentions in relation to organic foods inTaiwan: moderating effects of food-related personality traits, Food Qual. Prefer.,

18:1008–1021.

7. Denver S. and Christensen T, 2013 Organic food and health concerns: A dietary approach using observed data. NJAS-Wageningen Journal of Life Sciences. 74,9–15
8. Dr. Chandrashekar H M., 2014. Consumers Perception towards Organic Products –A Study in Mysore City .International Journal of Research in Business Studies and Management.1(1):52-67.
9. Elayaraja M and Vijai C., 2021. Organic food in India: Health and Environmental Advantages and Disadvantages. 45.688-695.
10. Fagerli R.A. and Wandel M., 1999. Gender differences in opinions and practices with regard to a 'Healthy diet', Appetite. 32:171-190.
11. Greene C., Ferreira G., Carlson A., Cooke B. and Hitaj C., 2020. Growing organic demand provides high-value opportunities for many types of producers. Amber Waves.
12. Kuhar A and Juvancic L., 2008. Determinants of Purchasing Power for Organic and Integrated Fruits and Vegetables, Slovenia, Agricultural Economics Review. 11(2),70-83.
13. Lockie S., Lyons K., Lawrence G. and Mummery K., 2002. Eating Green: Motivations behind organic food consumption in Australia, SociologiaRuralis, 42(1),23-40.
14. Nguyen H. V., Nguyen N., Nguyen B. K., Lobo A and Vu P.A., 2019. Organic food purchases in an emerging market: The influence of consumers personal factors and green marketing practices of food stores. International Journal of Environmental Research and Public Health. 16(6),1037.
15. Pandurangarao D, Chiranjeevi K, Rao D. S, 2011. Factors Affecting Consumers to Buy Organic Food Products in Hyderabad and Secunderabad. International Journal of Business and Management Invention. 6(3),24-30.
16. Paoletti F., 1970, Chemical Composition of Organic Food Products. Retrieved from https://link.springer.com/referenceworkentry/10.1007/978-3-642-36605-5_23.
17. Raji S. 2021. A study on consumer perception and behavior towards organic food products in Tirunelveli district, Sambodhi (UGC Care Journal). 43:23-28.
18. S.Zakowska Biemans, 2008. Consumers values and motives regarding organic food products in Poland, in Proceedings of the 2nd Scientific Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy. 1(2):506–509.
19. Shafie F. A and Rennie D., 2012. Consumer perceptions towards organic food. Procedia – Social and Behavioral Sciences. 49:360–367.
20. Sharma G., Dewan R and Bali S., 2014. Factors Influencing Consumer Buying Behavior and Awareness towards Organic Food: A Study of Chandigarh Panchkula Consumers. International Journal of Science and Research. 5(2):689-696
21. Shroeder M. J. A. 2003. Food Quality and Consumer Value, Springer, Berlin Heidelberg. 12:21-23
22. Singh A and Verma P., 2017. Factors influencing Indian consumers' actual buying behavior towards organic food products. Journal of Cleaner Production. 167:473–83.
23. Sivathanu B. 2015. Factors Affecting Consumer Preference towards the Organic Food Purchases. Indian Journal of Science and Technology. 8(33):1-6.
24. Soil Association, 2000, Organic farming, food quality and human health: A review of the

evidence, Soil Association, Bristol

25. Watson S., Retrieved May 21, 2020. Organic food no more nutritious than conventionally grown food. Harvard Women's Health Watch. 2:1-3
26. Wier M and Anderson L.M., 2003, Demand for organic foods—attitudes, values and purchasing behaviors, Newslett. Danish Res.Center Farm, 2:1–3.
27. Woese K, Lange D, Boess C and Bogl K. W., 1997. A comparison of organically and conventionally grown foods - Results of a review of the relevant literature, J Sci Food Agriculture, 74:281-293
28. Yiridoe E.K, Bonti-Ankomah, S and Martin R C., 2005. Comparison of consumer perceptions and preference toward organic versus conventionally produced foods: A review and update of the literature. Renewable Agriculture & Food Systems. 20(4), 193–205

PICA DISORDER – RARE CASE STUDIES

Ramya R.* and Anusuya Devi K.
Department of Nutrition & Dietetics,
PSG College of Arts & Science, Coimbatore-641014
*Corresponding author E-mail: ramyarajendran2001@gmail.com

Abstract:

Diet is the essential and very important aspect of life for mankind to survive in this world. There are numerous ways for dietary source, food will be cultivated from the lands; then it will be from plants, animals, sea and so on. The food is the important fuel for the human to run in this developing hectic modernized world. Some people may have cravings to eat non nutritious stuffs and this kind of behavior is said to be an eating disorder called Pica. Pica is the condition in which the people have urge to eat non-nutritious stuffs and non-nutritious foods. This kind of eating is in increased rate due to various factors such as anorexia, not having that much interest to eat food items, poverty, psychiatric problems and so on. The main causative factor for this disorder is unknown still now. This practice is more common among the people such as infant, pregnant women and children with developmental disorder. There are some interrelations between the mental stability of the person and this eating disorder. This entire review article deals with the diagnosis, management and terminologies and some rare case reports are also discussed. This article shows how this disorder becomes addiction and that leads to health-related issues for the person who is having this kind of disorder.

Keywords: Diet, Pica, Health problems, addiction, mental stability, case reports.

Introduction:

The Latin name for "magpie" is "pica," which means "a bird of uncontrolled hunger, which can burst to eat almost everything" (B. Parry-Jones and W.LL. Parry-Jones, 1992). A strange desire for the consumption of either edible or inedible items is known as a pica. Medical journals have been describing the ailment for ages. In the sixth century AD, a pregnant woman experienced one of the earliest cases of pica. Since then, there have been numerous accounts of cases of pica in which the sufferers have acknowledged ingesting substances including ice cubes, clay, dried pasta, chalk, starch, paste, Kayexalate resin, tomatoes, lemons, cigarette butts, hair, lead, and laundry starch. Pica has been seen in men and women of all ages and ethnicities, but it is more common in the lower socioeconomic levels and is most noticeable in people with developmental difficulties (Yasir Khan *et al.*, 2010). There are numerous signs that pica causes health problems related to personal injury, sanitation, and malnutrition—all common issues of public health. As a public health problem, it is most timely to examine the issues of concern, provide documentation from the related literature, and offer hypotheses for further study.

A multicultural phenomenon known as "pica," or the repetitive consumption of non-nutritive substances, has been documented throughout history. The word "pica" itself comes from observations of the magpie, a kind of bird known for its opportunistic and indiscriminate eating habits. Allotriophagia is the correct term for the disorder, despite the fact that it is rarely used in the literature on medicine. Those who have pica consume a wide variety of things. The most frequent substances in adults are starch (amylophagia), ice (pagophagia), and clay and soil

(geophagia), all of which have been connected to pregnancy. Pica comprises xylophagia (wood), trichophagia (wool, hair), acuphagia (sharp things), and coniophagia (dust) in children who have developmental deficits. If the dust is from lead-based paint chipping, coniophagia can coexist alongside plumbophagia (lead consumption). Coprophagia (eating faeces) is a condition that affects both individuals with dementia and children with ASD (Young *et al.,* 2008).

Pica is a medical disorder in which a person is habitual to eat non-food stuff. It is not a disease but a medical disorder found in children, pregnant women and some animals who feel hunger to eat different things like soap, plaster, paints, pencil chewing, gum, paper, coal etc. People who having this kind of eating disorder always urge to eat the non-nutritive stuffs or non-nutritive foods. These people have uncontrolled appetite to eat these food stuffs. The patient exhibits inappropriate behaviour; this behaviour is not consistent with social, customary, or cultural norms. Pica in humans can develop from extreme famine, malnutrition, or undernutrition. Pica is directly linked to a deficiency in several minerals including calcium, zinc, phosphorus, or iron as well as nutrients like thiamin, niacin, and vitamins C and D. The best and initial method of treating a patient with pica is therapy. According to Young *et al.* (2008), some medications may be useful in lowering aberrant eating. (Young *et al.,* 2008).

Prevalence of Pica:

Pica shows increased incidence in some populations, including infants, pregnant women, people with certain neurological disorder, developmental disabilities some psychiatric patients etc. The prevalence of this eating disorder is at exceeding rate but its route cause is unknown. The pregnant women who have this disorder think that this is the symptom and sign of pregnancy, this is still a myth followed by Indian people up to date (Michelle Kelly, 2010).

Diagnosis of Pica:

Four diagnostic criteria for pica include the following:

(a) Consuming non-nutritive foods on a regular basis for at least one month;

(b) Consuming non-nutritive foods that are out of proportion to one's developmental stage;

(c) Eating behavior is not part of a culturally sanctioned practice;

(d) If the eating behavior occurs exclusively during the course of another mental disorder, it is sufficiently severe to warrant independent clinical attention (APA, 1994), (Michelle Kelly, 2010).

Health issues and Pica:

1. Gastrointestinal Distress (An intestinal disorder)

People use pica as a self-soothing technique when they experience gastrointestinal distress. The normal gastrointestinal distress is caused by exposure to toxins and microbes within the gastrointestinal system. Gastrointestinal distress may result from mechanical stimulation of the digestive system. The common pica outlets include eating raw starch, also known as amylophagia, or eating dirt, or geophagia. Consuming dirt will raise the pH of their digestive tract and make it more basic, which will have a calming impact on someone with pica. By ingesting things like soil, people could reduce the bioavailability of viruses and toxins in the digestive tract (Kettaneh *et al.,* 2005).

2. Micronutrient deficiency

Micronutrients are necessary nutrients that must be taken in at particular daily milligramme levels or in trace amounts. One typical micronutrient deficiency linked to pica is iron deficiency. The effects of iron deficiency include pregnancy, ongoing bleeding, an imbalanced diet, and reduced iron absorption (Kettaneh *et al.*, 2005). The body can't use the necessary amounts of iron because iron is exchanged and absorbed in the duodenum of the small intestine, which results in iron deficiency anaemia. Prior to the occurrence of the iron shortage, pica was an active behaviour that occurred in this type of situation. Glossitis, an inflammation of the tongue, can cause a swollen tongue, tongue pain, or a subtle change in the colour of the tongue due to Pica. Occasionally, pagophagia (eating ice) is practised to lessen the discomfort it causes.

3. Mental disorder

People's bodies' overall health may be impacted by the meals they eat. The actions that are taken are influenced by a variety of systems that take place within the human body (Chalker, 2017).

Management of Pica:

Pica is caused by a variety of internal and external variables, hence there is no single treatment for the illness. Depending on the patient's or person's categorization, this eating problem is treated and managed differently. This eating disorder will be treated with medication, therapy, and psychological control.

1. Medication

There are some medications used and helped to manage this kind of eating disorder. But that are not effective in the prevention of this disorder. In case of the psychological based condition, these medications will enhance the habit of eating. Currently there are no medications specifically approved to treat pica. Some evidence suggests the drug that enhance dopaminergic functioning. Example: Olanzapine (Aihole *et al.*, 2017).

2. Therapy

A crucial part of providing mental health services for children with pica is educating those who have the illness and their families about it, including any potential causes, risks, and treatment options. ensuring that the children are in a safe environment free from toxins and other hazardous substances that could cause them damage removing the desirable non-food items from the home. congratulating the children for choosing healthy foods over harmful ones that they might have otherwise consumed. Increasing the level of supervision will deter people from trying to eat items that aren't food and force them to abstain (Sehar Munir and Imran Qadir, 2010).

3. Mental health management

In some circumstances, behavior-based treatment may be beneficial. This can be accomplished through visual inspection with the eyes, teaching the pica patient to distinguish between edible and inedible materials, and imprinting not them a negative opinion of the harmful material. Sehar Munir and Imran Qadir (2010) state that outpatient care is widely used for pica patients.

Terminologies of Pica:

There are numerous non nutritious stuffs which are eaten by the people who is having this particular disorder having different names according to the substances they eat.

S. No.	Term	Definition
1	Pagophagia	Compulsive ice chewing
2	Plumbophagia	Eating lead
3	Tricophagia	Eating hair, wool & other fibers
4	Coniophagia	Eating dust
5	Geophagia	Eating earth, soil or clay
6	Cautopyreiophagia	Eating burned matchsticks
7	Lithophagia	Eating stones
8	Acuphagia	Eating sharp objects
9	Xylophagia	Eating wood or derivatives of wood such as paper

Rare case reports:

Acuphagia

A woman in her seventies who had swallowed coins, nuts, wire, plastic, dog fur conditioner, and dried flowers was the subject. She compared her urge to consume the mentioned non-food items to a smoker's need for cigarettes, placing her desire on a par with that. She didn't say she was addicted to the non-food products, just that she required them to reduce her anxiety. She eventually entered a mental facility and gave the impression of being a well-organized person. The researchers hypothesized that she acted evasively towards the coins when they were offered to her at the unit because she felt embarrassed. Her cognitive abilities were evaluated by the researchers using a variety of tasks and tests. The findings showed that she was displaying a decline in frontal lobe of the brain-related cognitive function and performance. She had frontotemporal atrophy, according to further images. According to the researchers Rose, Porcerelli, and Neale (2000), specific brain injuries can affect atypical eating behaviours.

Obsessive-Compulsive disorder

In a case study that was done in 2008, Herguner, Ozyildirim, and Tanidir examined a person who had been using pica for five years. The person, a ten-year-old child, had been ingesting carpet and fabric fibres. He described his behaviour as irresistible and said that before ingesting the fibres, he would feel some strain. He claimed to feel better at ease after consuming the fibres. Using the Yale-Brown Obsessive-Compulsive Scale, his level of obsessive-compulsive disorder symptoms was evaluated. His overall score was 19, out of a potential 40, which indicates that the severity of his OC symptomatology is moderate. Fluoxetine, a standard treatment for obsessive-compulsive disorder, was given to this patient for nine months. At a one-year checkup, he showed no signs of pica behaviour. Due to the cessation of pica-related behaviours in response to selective serotonin reuptake inhibitors, this case study lends support to the concept that pica is connected to obsessive-compulsive spectrum disorders (Bhatia & Gupta, 2007).

Rapunzel syndrome

A 5-year-old female with broncho-pulmonary dysplasia and bilateral sensor-neural deafness who was born at 25 weeks gestation presented to the emergency room 1.5 weeks prior with poorly localised abdomen pain and three days prior with postprandial emesis. After eating,

she would curl up in anguish before feeling relieved after vomiting. Although he was able to use sign language to communicate, the young child seemed to be in some discomfort. The mother made a statement about her son's early satiety and his persistently low appetite. There was no prior history of fever, recent sickness, diarrhea, or acid reflux. Her bowel habits remained unchanged. The child had underweighted in relation to height and had always grown at a slower rate. A firm, non-tender, ballotable mass of roughly 10 cm by 6 cm was found during an abdominal exam and extended into the right upper quadrant. She made obnoxious bowel noises. The remainder of the physical exam went as expected. The tiny intestinal loops were dilated, the stomach had a significant amount of soft tissue density, and there were several air fluid levels in the abdomen. Laboratory testing only found pyuria and concentrated urine. The full metabolic panel, pancreatic enzymes, and total blood count were all within normal limits (Kariholu *et al.*, 2008).

Xylophagia (Paper eating)

A 32-Year-old woman with a history of homozygous sickle cell anemia was started on anticoagulation with apixaban (5mg BID) for superior vena cava thrombosis and pulmonary embolism. Other complications of disease included CVAs and several admissions for pain crises were also included. The presence of several foreign bodies throughout the colon was discovered during a colonoscopy, making it challenging to move the colonoscope past the sigmoid colon. With the help of a large volume of water evacuation, the patient was given additional polyethylene glycol 3350 and electrolytes before undergoing a second colonoscopy. This second colonoscopy revealed small toilet paper fragments from the sigmoid colon up to the terminal ileum, which were easier to see after being removed from the colon. (Veena Gonuguntla *et al.*, 2009).

Cautopyreiophagia

Cautopyreiophagia is a rare variant of PICA in a female adolescent: A case report of cautopyreiophagia was reported first from India, in a female adolescent aged 16 years who is from the rural areaThe patient was sent to the psychiatric community clinic after complaining of abdominal pain at the gynaecology community clinic. She claimed that for the last four to five years, she had been eating burned matchsticks. She would initially taste the burned tip of a couple of matchsticks, or take 1-2 of them. The amount was gradually increased to 10–20 matchsticks every day. The patient denied experiencing symptoms including anxiety, panic attacks, low mood, or a ritualistic pattern of actions or thoughts (Daniel Kurtz *et al.*, 2020).

Giant colonic lithobezoar

Colonic Litho bezoar is rare in children more so in adults. A 5-year-old male child with a history of diarrhea associated with passing of stones in the stools for 3 days. The child did not have any vomiting, pain, abdomen or fever. The child was taken to a local doctor, where abdominal radiography was done, abdominal radiography was done The infant was steady and cooperative during the examination; the abdomen was soft and undistended, and the rectal examination revealed a crenated, stony feel. After being hospitalised, tap water enemas were started twice daily. He then passed stones in his faeces that ranged in size from 5 mm to 2.4 cm. The year 2020 (Aihole *et al.*, 2017)

Sapophagia

A young boy who consumed soap compulsively for two years eventually acquired iron deficiency anaemia, which was effectively treated with fluoxetine. This is an uncommon instance

of soap eating presenting with iron deficiency anaemia. A 28-year-old male patient complained of being exhausted, having severe exertional breathlessness, and having a pallid complexion. Haemoglobin was 7.2 g/dl, serum iron was 38 mcg/dl, serum ferritin was 5.1 ng/ml, total iron binding capacity was 430 mcg/dl, and he had microcytic hypochromic anaemia, all of which were suggestive of iron deficiency anaemia based on his blood workHe was started on an oral iron replacement regimen. We eliminated all potential sources of iron deficient anaemia. A referral to psychiatry was made when the patient revealed that she had been eating bath soap on a regular basis for the previous two years. When specifically questioned, the patient admitted that he first tasted his soap two years ago when he was in the shower and enjoyed the flavour. Both fluoxetine and oral iron therapy were kept up for two and six months, respectively. (Disha Mukherjee and colleagues, 2022)

Sodium chloride Pica

A patient with iron deficient anaemia is suffering from recurrent nephrolithiasis due to sodium chloride pica. A Caucasian woman in her 30s who had previously dealt with menorrhagia, anaemia, and recurrent calcium nephrolithiasis showed in for pre-operative assessment as she was undergoing ureter lithotomy. She described how she usually ate ice chips and many spoonfuls of salt directly from the salt shaker throughout the day. For years, she had fought with these desires, which upset her and disrupted her regular tasks. The ferritin level was 3 ng/ml and the haemoglobin level was 10.9 g/dL, according laboratory findings (Brittany Rogers *et al.,* 2017).

Acuphagia / Hyalophagia

A 20-year-old woman's esophagogastroduodenoscopy found a group of bangles with sharp ends that were 2 to 6 cm long and took up over 50% of the stomach's antral and body space without creating any symptoms. The hospital received the patient. A blood test was performed after inserting Ryle's tube. Plain x-ray of erect abdomen was done to examine the sharp bangles. There are 44 pieces of bangles, which are taken out by surgical procedures. Then psychiatric counselling is given to her and anti-depressive drugs are suggested to that person. (Kariholu *et al.,* 2008)

Conclusion:

This hidden surprise “PICA” is new and a rare condition existing in the world. The etiology for this disorder is unknown still now. The prevalence rate should be assessed in proper manner to find out majority of people who have this disorder and analysis for other health problems are also examined with the accurate comparison with the normal biochemical parameters. There are numerous rare case reports existing along with emotional disturbances which pave way for the health-related problems that will cause digestion related problems, cavity problems, breathing distress, bloating and constipation etc. (Brittany Rogers *et al.,* 2017).

References:

1. Abu-Hamden D.K., Sondheimer, J.H., & Mahajan, S.K., 1985. Cautopyreiophagia. Causes of life – threatening hyperkalemia in a patient undergoing hemodialysis. Journal of the American Medical Association, 79, 517519.
2. Aseem Mehra, Sandeep Grover, 2021. Cautopyreiophagia as a rare variant of PICA in a female adolescent: a case report, Indian Journal of Psychological Medicine;43(2),180-181.

3. Brittany Rogers, Joshua Kramer, Stephanie Smith, Vincent Bird, Eric I Rosenberg, 2017. Journal of medical case reports (11,1-4,), Sodium chloride pica causing recurrent nephrolithiasis in a patient with iron deficiency anemia: A case report
11. Chalker, A. E. (2017). The psychopathology of pica: Etiology, assessment, and treatment. Journal of Eating Disorders, 9(2), 1-2
4. Daniel Kurtz, Ibrahim Azar, Hajra Khan, Kirthi Lilley, Indryas Woldie, 2020. Xylophagia (paper eating): Arare form of pica, Clinical case reports 8(12),3546-3547.
5. Disha Mukherjee, Souvik Mondal, Supartha Barua, Sujit Sarkhel, 2022. Sapophagia: A rare case of compulsive soap-eating presenting with iron deficiency anemia, Indian Journal of Psychiatry 64(6), 611-612, November– December 2022.
6. Ella P. and Lacey, 1990. Broadening the perspective of PICA: literature review, southern Illinois university, carbonade, IL 62901.
7. Jayalakshmi Shripati Aihole, 2020. Giant colonic lithobezoar: a rare case report, Journal of Indian association of pediatric surgeons, mar-apr; 25(2): 103105.
8. Kariholu P.L., Jakareddy R., *et al.*, 2008. PICA – a case of acuphagia or hyalophagia?, Indian Journal of Surgery 70, 144-146.
9. Michelle Kelly, Pica: A., 2010. Literature Review, volume 36, no .2/3 , page 41- 47, December 2009/ January
10. Parry -jones B. and Parry -Jones W.LI., 2018. PICA: Symptom or Eating Disorder? A historical Assessment, published by Cambridge University Press;02 January, The British Journal of Psychiatry, Volume 160 Issue 3.
12. Parry-Jones B. and. Parry-Jones W.LL, 1992. Pica: Symptom or eating disorder? A Historical Assessment, British journal of Psychiatry, 160, 341-354.
13. Rachel Moline, Sharon Hou, Julia Chevrier, Kristel Thomassin, (2020). A systematic review of the effectiveness of behavioral treatments for pica in youths, clinical psychology & psychotherapy 28(1), 39-55.
14. Renuka Nagarale , Mandar Todkar, Shadab Bhatta , Samiya Hamdule, quarina saikah and Mohammed ali esmaeili, 2022. Assessment of different eating disorders pertaining its knowledge and effects on oral and general health amongst adolescents and adults in western India, International Journal of Applied Dental Sciences,; 8(1):88-93.
15. Sehar Munir and Imran Qadir, 2010. College of pharmacy, G.C university , Faisalabad, Pakistan, Pathophysiology and Management of Pica , Pharmacologyonline 3: 677-681
16. Susila Francis, Nalini Sirala Jagadeesh, Rajeshwari Singaravelu, Aruna Subramaniam, 2022. The influence of pica practice on nutritional status, stress and anxiety of pregnant women, volume 17,101-133, September.
17. Veena Gonuguntla, MD and Divya – Devi Joshi, MD, FAAP, 2009. Rapunzel Syndrome: A comprehensive review of an unusual case of trichobezoar, Clinical Medicine & Research, September 1, vol 7 no 3, 99-102.
18. Yasir khan, Glenn Tisman, 2010. Journal of Medical Case Reports, , Pica in iron deficiency: a case series, 4:86.
19. Young SL, Wilson MJ, Miller D, Hillier S., 2008. Toward a comprehensive approach to the collection and analysis of pica substances, with emphasis on geophagia materials, September. https://doi.org/10.1371/journal.pone.0003147

THE RISE OF MILLETS IN COMMERICAL FOOD PRODUCTS- A REVIEW

K. P. Santhoshini* and J. Sridevi
Department of Nutrition & Dietetics,
PSG College of Arts & Science, Coimbatore-641014
*Corresponding author E-mail: k.p.santhoshini@gmail.com

Abstract:

Millets are agronomic group of grass which contain protein, antioxidant and other nutrient needed for the body and boosts our gut microbes and helps in digestion. Millets had been the major staple food in India. In recent times the food and their consumption is totally different because of the environment and lifestyle pattern. In olden days the millets were used in their Daily diet. Compared to other grains, millets are easy to grow so their consumption rate is higher. But nowadays the intake of millets and their usage is varied comparing past to present life. The most beneficial aspect of millets is that they are Gluten-free that protect from heart diseases and other condition. There are different types of millets and they have their specific nutritional properties.

Keywords: Millets, Types of millets, Benefits, Recent days, Consumption

Introduction:

Millets are belonging to the Poaceae family of cereal grasses. In India the production of millets is high due to their climatic sustainability and other conditions. Millets are good in dietary fibres and rich vitamin A, vitamin B, calcium, potassium, iron and antioxidant. Millet contributes economic efficiency of the farmers and it's considered as the next super food for too many families. The most widely grown millet in India is Pearl millet along with other types of millets (Smith, 1996).

Majority of the millet is polysaccharide and they are made up of amylopectin and amylase. The presence of polyphenols, tannins and phytates provide antioxidant activity and the millet form is a mirror of life. (Stanely and Shanmugam, 2013).

Different types of millets

There are several different types of millet, each with its unique nutritional and culinary characteristics. Some of the most common types of millet include: Pearl millet (*Pennisetum glaucum*), Finger millet (*Eleusine coracano*), Koda millet (*Paspalum setaceum*), Proso millet (*Penicum miliaceum*), Foxtail millet (*Setaria italic*), Little millet (*Panicum sumatrense*), Barnyard millet (*Echinochloa utilis*), Sorghum (*Sorghum bicolo*r) (Obilana, 2002).

Sorghum

Sorghum is a warm season crop. They are made up of pericarp, endosperm and germ which are classified into four groups 1) grain sorghum 2) forage sorghum 3) grass sorghum 4) Sudan sorghum. They are grouped according to their characteristics based on color and thickness of pericarp, color and type of endosperm (Macraeet *et al.*, 1993).

Finger millet

Many nations' primary crops include finger millet. They are diverse, very nourishing, and easily digestible. Grain that has been sprouted is advised for new-borns and the elderly. In addition to being used to manufacture beer and liquor, finger millet also produces by products that are fed to livestock. Although finger millet is predominantly utilised as a food grain, it is not

frequently used for livestock since it is of lower quality for animals than maize, sorghum, and pearl millet. In India, it is occasionally used to feed growing animals, ill and convalescing animals, as well as new-born calves (FAO, 2012).

Pearl millet

A significant grain, fodder, and stover crop historically, pearl millet is largely grown in dry and subtropical regions of many developing nations. Production limitations brought on by illnesses are becoming more significant as pearl millet agriculture spreads into previously untapped regions in temperate and affluent nations. The growing conditions of drought, poor soil fertility, and high temperatures are ideal for pearl millet. It works effectively in soils with low pH or excessive salinity. It can be produced in regions where other cereal crops, such maize or wheat, would not thrive because of its resilience to challenging growth circumstances (Saleh *et al.*,2013).

Proso millet

Proso millet is an annual crop with its origins in Central Europe. It is a low-maintenance crop that is frequently employed in organic farming systems. Proso millet can assist in achieving continual crop rotation and preventing a summer fallow. Proso millet is a useful intercrop between two crops that require a lot of water and pesticides because of its shallow root system and tolerance to atrazine residue. As a result of the previous crop's stubbles enabling more heat to enter the soil, millet grows more quickly and early (Chethan and Malleshi, 2007).

Kodo millet

The tropics and subtropics of the world are home to a large population of this millet. It is an annual grass that has small, round seeds that used for making flour, porridge, and other food products. It is very easy to digest and it has high protein, low fat and high fibre content. It also includes a lot of lecithin and is great for boosting the nervous system. Niacin, B6, folic acid, and other B vitamins, as well as minerals including calcium, iron, potassium, magnesium, and zinc, are abundant in Kodomillets. Kodo millets are suitable for gluten-intolerant people because they are free of gluten. For postmenopausal women exhibiting symptoms of cardiovascular disease, such as high blood pressure and high cholesterol levels, regular ingestion of Kodomillet is particularly advantageous (De wet, 2006).

Foxtail millet

One of the first millets to be cultivated in the world was foxtail millet. Foxtail millet continues to play a significant role in global agriculture and is currently produced in second-place overall in the globe. It will increase in height from sea level to 2,000 metres. It cannot stand standing water. Due to its early maturity, foxtail millet can sometimes avoid droughts despite its moderate drought tolerance. It can be planted as a short-term catch crop because of its rapid growth. It can thrive in a variety of soils, climates, and elevations. Its grain is fed to poultry and caged birds as well as used for human consumption (Dida *et al.*, 2006).

Barnyard millet

Barnyard millet is a multipurpose crop that is strong in protein and low in carbohydrates, making it a gift from nature for today's sedentary human population. Linoleic acid is the main fatty acid in barnyard millet, followed by palmitic and oleic acid. Moreover, it exhibits a strong retrogradation of amylase, which promotes the creation of more resistant starches. Thus, it may be

suggested to people who have diabetes mellitus and cardiovascular disease. The best results from barnyard millet come from lowering cholesterol and blood glucose levels (FAO, 1995).

Little millet

Little millet has smaller seeds than normal millet does. With the exception of size, this cereal's species resembles proso millet in habits. It is a herbaceous annual plant. A reliable capture crop because of its early maturity and resilience to unfavourable agroclimatic conditions is little millet. Stover is a beneficial cow feed. (Sampath, 1986).

Health benefits

Millets are rich in micronutrients and mainly they are gluten free and non-allergenic and also rich in bioactive compounds and other essential amino acids. Compared to rice and wheat the millets are twice nutritious and contains proteins, vitamins and minerals (Truswell 2002; Gupta *et al.,* 2012). The impact of functional food security increased production and consumption of millets for sustainability of health among population in both developed and developing countries.

The millet-based functional foods in a healthy diet cause a significant decrease in blood glucose and HbA1c, which are important markers for diabetes. Millets are rich sources of dietary fibre and flavonoids and polyphenols that provide benefits in diabetes, heart diseases and cause reduction in cholesterol (Vinoth and Ravindran, 2017).

- Good for digestion: Millet is an excellent source of fibre, which helps to keep the digestive system healthy. Thus, the high fibre content in millet can help to prevent constipation and other digestive disorder.
- Lower cholesterol levels: Millet contains compounds called phytosterols. Which have been shown to reduce cholesterol levels in the body. A study published in the Journal of Agricultural and Food Chemistry found that consuming millet regularly helped to lower LDL or “bad” cholesterol levels in the blood.
- Reduce the risk of heart disease: Due to its high fibre content and the presence of antioxidants, millet may also help to reduce the risk of heart disease. A study published in the Journal of Cardiovascular Disease Research found that consuming millet reduced the levels of triglycerides, which are a type of fat that can increase the risk of heart disease.
- Help in weight loss: Millet is a low-calorie food that can help in weight loss. It is also richin fibre, which can help to keep you feeling full for longer periods. A study published in the International Journal of Food Sciences and Nutrition found that consuming millet regularly helped to reduce body weight, body fat, and waist circumference (Bhadre, M.A *et al.*, 2019).
- Help in the prevention of type 2 diabetes: Millet is a complex carbohydrate that is digested slowly, which can help to regulate blood sugar levels. A study published in the Journal of Food Science and Technology found that consuming millet help to lower blood glucose levels in people with type 2 diabetes (A.Aissaoui*et al.,* 2016).

Table 1: Nutritional composition of various millets

Millets	Protein (g)	Carbo hydrates (g)	Dietary fibre(g)	Calcuim (mg)	Iron (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Totalfolates (mg)
Sorghum	9.97	67.68	10.22	27.60	3.95	0.35	0.14	2.10	39.42
Finger millet	7.16	66.82	11.18	364	4.62	0.37	0.17	1.34	34.66
Pearl millet	10.96	61.78	11.49	27.35	6.42	0.25	0.20	0.86	36.11
Proso millet	12.50	70.04	-	0.020	-	0.41	0.28	4.50	-
Kodo millet	8.92	66.19	6.39	-	2.34	0.29	0.20	1.49	36.49
Foxtail millet	12.30	60.09	-	-	-	0.59	0.11	3.20	-
Barnyard millet	6.20	65.55	-	-	-	0.33	0.10	4.20	-
Little millet	8.92	65.55	6.39	16.06	1.26	0.26	0.05	1.2	36.20

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN -2007

Millet food products

Millets before consumption undergo processing techniques including decorticating, malting, fermentation, roasting, flaking and grinding and thus help in improving their edible nutritional property. Millet is referred as the main components of meal, porridge which can be used for complementary foods for infant and children (Obilana 2003; Lestienno*et al.*, 2005) and preparation of idly, dosa and wet pan cakes. Proso millet flour can be used as a substitute for riceflour.

Millets are nutritionally superior to other grains because they contain high number of proteins, flavonoids, carotenoids, magnesium, calcium and iron etc. The millets could be used as combat micronutrient malnutrition by bio-fortification of staple crops. They are used in the mixtureof cakes, cookies, cookies, breads and pastries that can reduce the consumption of refined and sugary foods (Anitha, Potaka*et al.*, 2019).

Gluten-free foods

By using pearl millet and finger millet we can make roti and pancakes which are soft, flexible and puffed texture (Murty and Kumar, 1995). Traditional porridge is made by millet. The malted cereals are often used as the ingredient in porridge making which give sweet taste to the porridge (Rooney *et al.,* 1986). By using millets, beverages are made in which traditional fermented beverages combines with milk and finger millet to give nutritive product (Mugocha*etal.*, 2000). Alcoholicbeverages are also made by millet. Finger millet and pearl millet are used for making beer which is greenish-brown in colour.

Processes and their factors

Millets are traditionally milled using mortar, wooden pestle, roller stone and stone rotary mills (Subramanian and Jambunathan, 1980; Murty and Kumar, 1995). It undergoes two-stage processes (Smith, 1996). The first stage is decortication and the second stage is reducing the endosperm into flour (Taylor, 2004b). Absence of gluten in millet which makes bread as leavened flatbreads. In the fermentation process, conventional millet is soured by the lactic acid fermentation process by a selected starter crop. Lactic acid fermentation helps in digestion of protein and carbohydrate in the body and also improves the nutrients content in the grains (Taylor and Belton, 2002). Recently millet milling by dehuller is efficient in removing bran and convertingthe grains into flour.

The bioavailability of millets is influenced by physiological and nutritional variables. Solubility and physical and chemical forms of the nutrients that are released by the food matrix have an impact on bioavailability in this way. Moreover, the bioavailability of nutrients is impacted by the inhibition of proteolytic enzymes in cereals. The millet's bioavailability is decreased by antinutrients like saponins, lectins, and amylase inhibitors as well as the multivalent cations of calcium, zinc, and potassium.

Recent food products of millets

Ready-to-eat food products are produced from millets. Foxtail millet and Proso millet were used for the formulation of flaked whole grain ready-to-eat breakfast cereals. By adding natural sweetener to the cereals, the colour and flavour might be changed. But the honey helps in providing crispness to the cereals after adding milk (Ferriola and Stone). Noodlescan also be made by using foxtail and proso millets (Lu *et al.,* 2005). In southern India breakfastis madeusing pearl millet semolina (Balasubramanian*et al.,* 2005). Millets sold in urban areas which are consumed as health food or fast food are not only help in curing diseases but also help in management and prevention of various lifestyle diseases. Unconventional and extruded food products can be prepared out of millets. Noodles, nutritious soup, strong drinks, pancakes, cereal porridge are used throughout the world because of the nutritional value of millets from which they are prepared and considered as complete foods.

1. Noodles and Pasta

Noodles and pasta are processed within minutes. These are the foods preferred by all the age groups and the good commercial products on themarkets (Devaraju *et al.,* 2006). Noodles and Pasta are prepared using different combinations of milletssuch asfinger millet and wheat in the ratio of 1: 1, and finger millet, wheat and soy flour in the ratio of 5: 4: 1 and also by usingproso and barnyard millets (Veena, 2003). Millet-based noodles and pasta have a unique

texture and taste that sets them apart from traditional wheat-based products. They have a nutty flavour and a slightly chewy texture, which makes them a great addition to a variety of dishes. Millet-based noodles and pasta can be used in soups, stir-fries, salads and casseroles.

Pahwa *et al.* (2018) investigated the potential of millet noodles as a functional food and found that millet noodles had a high level of resistant starch, which can help in promoting digestive health and reducing chronic diseases. Another study compared the glycemic index of millet-based pasta to wheat-based pasta and found that millet-based pasta had a lower glycemic index, which is beneficial for people with diabetes (Mohan *et al.*, 2018).

2. Baked products

Baker's products are popular worldwide. The use of millets in bakery products will be innovative and contain a good amount of micro-nutrients and it is a value-added product (Verma and Patel, 2013). Fingermillet and foxtail millet flour can be incorporated into bakery items such as cookies, chocolate, cheese, cake and muffins. Wheatflour (60%) and Finger millet flour (40%) are combined and used in preparation of bakery products such as cakes, biscuits. Chocolate cake, crackers, muffins, masala cake, gel cake can also be prepared by millet finger that are good in taste, texture and global acceptance (Desai *et al.*, 2010).

Millet flour can be used alone or in combination with other gluten-free flours such as rice flour, corn flour, or tapioca flour to create baked goods that are light, fluffy, and flavourful. One study compared the sensory properties of bread made from millet flour and wheat flour and found that the millet bread was moister, less chewy, and had a nuttier flavour than the wheat bread (Jahanbin *et al.*, 2015). Millet-based bakery products have several health benefits. Additionally, millet has a low glycemic index, which can help in regulating blood sugar levels of diabetics (Shobana *et al.*, 2016).

3. Malting and Weaning foods

The millet malt is used to feed infants. Good malting qualities are present in finger millet. Malting promotes nutrient bioavailability and increases the content of nutrients, including fibre, fat, and minerals. Finger millet benefits from malting by having less tannin and phytic acid content and more iron and zinc. Consequently, malting of little millet boosts antioxidant capabilities. Malting of finger and pearl millet decreases protein content while increasing protein efficiency ratio (PER) (Sangita and Srivastav, 2000). Millet-based weaning foods are typically prepared by grinding millet into a fine powder and mixing it with water or milk to create a porridge-like consistency. The mixture can be sweetened with sugar or flavoured with spices such as cinnamon or nutmeg to make it more palatable for infants. Millet weaning foods are a good source of energy, protein, and micronutrient such as iron and zinc, which are important for growth and development (Thakur and Sharma, 2015).

Millet malt is another popular millet-based food product that is commonly used as a weaning food in many parts of the world. Millet malt is made by sprouting millet grains, drying them, and then grinding them into a fine powder. The powder can be mixed with water or milk to create a nutritious beverage that is high in protein, fiber, and essential micronutrients such as calcium and phosphorus (Kumar and Bhowmik, 2016). Millet-based weaning and malt foods are also a good option for infants with celiac disease or gluten intolerance.

4. Millet in Horlicks

Horlicks is a popular malted milk drink that has been consumed by people around the world for over 140 years. While the original recipe for Horlicks included malted barley, wheat, and milk,in recent years, the company has introduced a range of new flavours that include millets as a key ingredient asthe millets are a group of small-seeded grasses that are rich in nutrient and have beenconsumed by people for thousands of years.

Millets are used in Horlicks to provide additional value and to cater to the changing tastes and preferences of consumers (Bhardwaj and Arora, 2020). The use of millets in Horlicks helps to increase the fiber, vitamin, and mineral content of the drink. Millets also have a lower glycaemic index than other grains, which makes them a healthier choice for people with diabetes or other blood sugar-related conditions.

In addition to their nutritional benefits, millets also provide a unique flavour and texture to Horlicks. Millets such as finger millet and pearl millet have a slightly nutty flavour that pairs well with the malted milk base of Horlicks. Millets also have a slightly gritty texture that adds an interesting dimension to the drink.

The use of millets in Horlicks is part of larger trend in the food and beverage industry towards using more sustainable and nutritious ingredients. Millets are a hardy crop that can grow in dry and arid conditions, making them an ideal crop for farmers in developing countries. By incorporating millets into their products, companies like Horlicks are not only providing consumers with healthier and more sustainable options but also supporting farmers and communities around the world. The millet in Horlicks is an addition to the product line. By incorporating this nutritious and sustainable ingredient, Horlicks is providing consumers with a healthier and more flavourful product that supports farmers and communities around the world.

5. Beverages of Millet

One of the most popular millet-based beverages is millet beer. This beer is made by fermenting millet seeds, and it has a unique flavour that is popular in many regions of the world, particularly in Africa. Millet beer is often consumed in small batches for local consumption, and it is often preferred over other types of beer due to its nutritional value and local consumption due to low alcohol content (Dharmaraj and Malleshi, 2017).

Millet can also be used to create a range of non-alcoholic beverages, including millet milk and millet juice. Millet milk is made by grinding millet seeds and then mixing them with water to create a milk-like beverage. Millet milk is often used as a vegan alternative to cow's milk, as it is high in protein and other nutrients (Dharmaraj and Malleshi, 2017). Millet juice is made by

blending millet seeds with other fruits and vegetables to create a tasty and nutritious beverage that is high in vitamins and minerals.

In addition to these traditional millet-based beverages, there are also many new and innovative millet-based drinks being developed by food and beverage companies. These include millet-based energy drinks, soft drinks and smoothies. These new products are often marketed as healthy and sustainable alternatives to traditional beverages, and they are gaining popularity among health-conscious consumers around the world. Overall, millet-based beverages offer unique and nutritious alternative to traditional beverages. With their unique flavour, health benefits and potential as a sustainable crop, millet-based beverages are a promising addition to the beverage industry.

Millet-based commercial beverages are a popular choice among people looking for nutritious and flavourful drinks.

Table 2: Different types of millet-based commercial beverages

Beverage Name	Type of Millet	Ingredients	Nutritional Benefits
Foxtail millet malt	Foxtail millet	Foxtail millet flour, Sugar, Milk powder, Maltodextrin, Salt, Vitamins	High in fibre and Protein
Little millet Energy drink	Little millet	Little millet flour, Sugar, Taurine, Caffeine, B-Vitamins.	Boosts Energy and Focus
Pearl millet Shake	Pearl millet	Pearl millet flour, Milk, Sugar, Chocolate Powder, Vitamins.	Calcium and Iron
Finger millet Coffee	Finger millet	Finger millet flour, Coffee powder, Sugar, Milk powder, Vitamins.	Calcium and Iron
Kodo millet Health drink	Kodo millet	Kodo millet flour, Sugar, Milk powder, Maltodextrin, Salt, Vitamins.	Good for digestion and bone health.

Foxtail Millet Malt:

Foxtail millet flour is mixed with sugar, milk powder, maltodextrin, and vitamins to create a malt drink. This beverage is high in fiber and protein, making it an excellent choice for people looking to maintain a diet.

Little Millet Energy Drink:

Little millet flour is mixed with sugar, taurine, caffeine, and B-vitamins to create an energy drink. This beverage is designed to boost energy and focus and is a popular choice among athletes and fitness enthusiasts.

Pearl Millet Shake:

Pearl millet flour is mixed with milk, sugar, chocolate powder, and vitamins to create a creamy and delicious shake. This beverage is rich in calcium and iron, makingit an ideal choice for people looking to strengthen their bones and prevent anaemia.

Finger Millet Coffee:

Finger millet flour is mixed with coffee powder, sugar, milk powder, and vitamins to create a coffee-flavoured drink. This beverage is rich in calcium and iron, making it an excellent choice for people looking to improve their bone health and prevent anaemia.

Kodo Millet Health Drink:

Kodo millet flour is mixed with sugar, milk powder, maltodextrin, salt, and vitamins to create a health drink. This beverage is designed to improve digestion and bone health and is a popular choice among health-conscious consumers.

6. Extruded products

Extrusion is an effective method for processing millets into a range of products with improved sensory and nutritional qualities (Chandra *et al.,* 2019). Extruded products of millets are becoming increasingly popular due to their unique flavour, texture, and nutritional value. Extrudedmillet products are high in dietary fibre, protein, and mineral such as iron, magnesium, and zinc. These products are also low in fat and have a low glycaemic index, which makes them a healthieroption for people with diabetes or other blood sugar-related conditions.

One of the most popular extruded products of millets is breakfast cereals. Millet-based breakfast cereals are often marketed as a healthier alternative to traditional breakfast cereals, as they are high in fibre and other nutrients. Millet-based breakfast cereals are also available in a range of flavours, including chocolate, honey and fruit, which makes them appealing to a wide range of consumers. Extruded millet products are also used to create a range of savoury snacks, such as puffed millet balls potato chips. These snacks are often marketed as a healthier alternative to traditional potato chips and other high-fat snacks. Millet-based snacks available in a range of flavours include barbecue, cheese, and sour cream and onion. In addition to breakfast cereals and snacks, extruded millet products are also used to create a range of pasta and noodle products. Millet-based pasta and noodles are often marketed as a gluten-free alternative to traditional wheat-based pasta and noodles. Millet-based pasta and noodles are also available in a range of shapes and sizes, including spaghetti, macaroni, and fusilli.

Conclusion:

Millet is more nutritious than rice and promotes health. In recent times the millets are used in extruded products such as pasta, bread, biscuits, crackers, baby foods, snack foods and confectionary items. So, the main advantage is that the millets are consumed by the people of all age. Ready-to-eat food products are available in market too. Nowadays people are mainly conscious on health, realising and focussing on healthy diet which alleviates heart diseases, reduces blood glucose level, and detoxify the body which improves immune system. The healthy snacks of millet are taken by all the age groups, help to improve health and also eradicate malnutrition. The main advantage of millets to be realized is that they are favourable to farmers, as they can be grown in all weather conditions.

References:

1. Aissaoui, A., El Gazzar, N., Gharby, S., Harhar, H., Ibnsouda, S. K., &Charrouf, Z. (2016). Cardio-protective effect of millet grain var
2. Amalraj A and Pius A, (2015). Influence of oxalate, phytate, tannin, dietary fiber, and cooking on calcium bioavailability of commonly consumed cereals and millets in India. Cereal Chem 92:389–394.
3. Arici, M. and Daglioglu, O. (2002). Boza: A lactic fermented cereal beverage as a traditional Turkish food. Food Rev. Int. 18, 39-48
4. Aruna C, Deepika C, Rao KVR, Tonapi TA. (2020). Golden jubilee publication: 50 years of sorghum research: contribution of AICRP-Sorghum centres, ICAR-Indian Institute of Millets Research, Hyderabad-500 030
5. Asrani, P.; Ali, A.; Tiwari, K. (2022). Millets as an alternative diet for gluten-sensitive individuals: A critical review on nutritional components, sensitivities and popularity of wheat and millets among consumers. Food Rev. Int., 38, 1–30.
6. B. Dayakar Rao, K. Bhaskarachary, G.D Arelene Christina, G. Sudha Devi, Vilas, A.Tonapi. (2011). Nutritional and Health Benefits of Millets, ISBN: 81-89335-68-5. ICAR-Indian Institute of Millets Research (IIMR),
7. Balasubramanian S, Singh KK, Patil RT, Onkar KK. (2011). Quality evaluation of millet-soy blended extrudates formulated through linear programming.
8. Bhadre, M. A., & Rao, V. V. (2019). Finger Millet (*Eleusine coracana* L.) Polyphenols: A Review of their Chemopreventive Potential. Journal of agricultural and food chemistry, 67(36), 9945–9960.
9. Bhardwaj, R., & Arora, A. (2020). Millets in processed foods: Opportunities and challenges. Critical Reviews in Food Science and Nutrition, 60(11), 1846-1860.
10. Chandra, R., Gour, V. K., Kumar, V., & Gupta, V. K. (2019). Extruded millet products: A review on processing, quality, and nutritional aspects. Critical Reviews in Food Science and Nutrition, 59(14), 2212-2222.
11. Desai AD, Kulkarni SS, Sahu AK, Ranveer RC and Dandge PB (2010). Effect of supplementation of malted ragi flour on the nutritional and sensorial quality characteristicsof cake. Advanced Journal of Food Science Technology,
12. Devaraju B, Begum M, Begum S and Vidya K (2006). Effect of temperature on physical properties of pasta from finger millet composite flour. Journal of Food Science and Technology, 43: 341-343.
13. Dharmaraj, U., &Malleshi, N.G. (2017). Millet: A versatile and nutritious grain for commercial products. Journal of Agroalimentary Processes and Technologies, 23(3), 295-307.
14. DR. P. Stanly Joseph Michaelraj; A. Shanmugam (2013). International Journal of Marketing, A Study on Millets based Cultivation and Consumption in India Financial Services & Management Research ISSN 2277- 3622 Vol.2, No. 4, April
15. Fernández-García E, Carvajal-Lérida I and Pérez-Gálvez A, *In-vitro* bioaccessibility assessment as a prediction tool of nutritional efficiency. Nutr Res 29:751–760 (2009).
16. Ferriola D, Stone M. (1998). Sweetener effects on flaked millet breakfast cereals. J Food

Sci 63(4):726–9. Ge W, Liu L, Chen X, Jin Z.

17. Goyal, A., Sharma, V., Upadhyay, N., Gill, S., &Sihag, M. (2011). Flax and flaxseed oil:an ancient medicine & modern functional food. Journal of food science and technology, 48(3), 257–269.
18. Gupta N, Srivastava AK, Pandey VN. (2012). Biodiversity and nutraceutical quality of some Indian millets. Proceedings of the National Academy of Sciences.
19. Lestienne I, Mouquet-Rivier C, Icard-Verniere C, Rochette I, Treche S. (2005). The effectsof soaking of whole, dehulled and ground millet and soybean seeds on phytate degradation andPhy/Fe and Phy/Zn molar ratios. Intl J Food SciTechnol 40:391–9.
20. Lu H, Yang X, Ye M, Liu K-B, Xia Z, Ren X, Cai L, Wu N, Liu T-S. 2005. Millet noodlesin late neolithic China. Nature 437(13):967–8. Mal B, Padulosi S, Ravi SB. 2010.
21. Malathi B, Appaji C, Reddy R and Sudhakar N. (2016). Growth pattern of millets in India. Indian Journal of Agricultural Research. 50(4):382-386.
22. Mallasy LO, El Tinay AH, Elkhalifa AO, Ali MAM, Mohiedeen IE, Yousif NE. (2010). Effect of fermentation on biochemical and sensory characteristics of millet flour supplemented with whey protein. Intl J Food SciTechnol 45:2387–93.
23. Mugocha, P. T., Taylor, J. R. N., and Bester, B. H. (2000). Fermentation of a composite finger millet-dairy beverage. World J. Microbiol. Biotechnol. 16, 341-344.
24. Murty, D. S. and Kumar, K. A. (1995). Traditional uses of sorghum and millets. In: Dendy,

D.A.V. ed. Sorghum and Millets: Chemistry and Technology. St. Paul, MN: American Association of Cereal Chemists, pp. 185-222.

25. Obilana AB. (2003). Overview: importance of millets in Africa. In: Belton PS, Taylor JRN, editors. Proceeding of the Workshop on the Proteins of Sorghum and Millets.
26. Rooney, L. W., Kirleis, A. W., and Murty, D. S. (1986). Traditional foods from sorghum. In: Pomeranz, Y. ed. Advances in Cereal Science and Technology, Vol. VIII. St. Paul, MN: American Association of Cereal Chemists, pp. 317-353.
27. Smith, I. F. (1996). Increasing consumer utilization of minor cereals in West Africa through sustained research and development of appropriate production and processing technologies. In: Dendy, D. A. V. ed. Sorghum and Millets: Proceedings of the Symposia. Vienna: International Association for Cereal Science and Technology, pp. 171-197.
28. Srivastava S and Singh G (2003). Processing of millets for value addition and developmentof health foods. In: Recent Trends in Millet Processing and Utilization, Hisar, India: Chaudhary Charan Singh HisarAgril. University, pp.13-18.
29. Srivastava S, Dhyani M and Singh G (2003). Popping characteristics of Barnyard and foxtail millet and their use in preparation of sweets. In: Recent
30. Subramanian, V. and Jambunathan, R. (1980). Traditional methods of processing sorghum (Sorghum bicolor) and pearl millet (*Pennesetum americanum*) grains in India. In: Dendy, D. A. V. ed. International Association for Cereal Chemistry, l Oth Congress, Symposium: Sorghum and Millet Processing. Vienna: ICC, pp. 115-118.
31. Taylor, J. R. N. (2004). Foods and nonalcoholic beverages. In: Wrigley, C., Corke, H., and Walker, C. E. eds. Encyclopedia of Grain Science, Vol. 1. Amsterdam: Elsevier, pp. 380-390.

32. Taylor, J. R. N. and Belton, P. S. (2002). Sorghum. In: Belton, P. S. and Taylor, J. R. N. eds. Pseudocereals and Less Common Cereals. Berlin: Springer-Verlag, pp. 25-91.
33. Trends in Millet Processing and Utilization, Hisar, India: Chaudhary Charan Singh HisarAgril. University,
34. Tripathi, M.K.; Mohapatra, D.; Jadam, R.S.; Pandey, S.; Singh, V.; Kumar, V.; Kumar, A. (2021). Nutritional Composition of Millets. In Millets and Millet Technology; Springer: Berlin/Heidelberg, Germany, pp. 101–119.
35. Truswell AS. (2002). Cereal grain and coronary heart disease. Eur J ClinNutr 56(1):1–4.
36. Van het Hof KH, West CE, Weststrate JA and Hautvast JGAJ (2000). Dietary factors that affect the bioavailability of carotenoids. J Nutr 130: 503–506
37. Veena B (2003). Nutritional, functional and utilization studies on barnyard millet. M. Sc. Thesis, University of Agricultural Sciences, Dharwad (Karnataka), India.
38. Verma V and Patel S (2013). Value added products from nutri-cereals: Finger millet (Eleusinecoracana) Emirates Journal Food Agriculture,
39. World Health Organization (1996). Fermentation: Assessment and Research, WHO/FNU/FOS/96.1. Geneva: WHO.
40. Yang Y, Xiao H and McClements DJ, (2017). Impact of lipid phase on the bioavailability of vitamin E in emulsion-based delivery systems: relative importance of bioaccessibility, absorption, and transformation. J Agric Food Chem 65:3946–3955.

UNIQUENESS OF MUSKMELON AND SEEDS

Sharmila K* and V. Krishna Prabha
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore - 641014
*Corresponding author E-mail: sharmilakathirvel12102@gmail.com

Abstract:

Fruits and vegetables are taken into account while providing nutritional advice due to their high concentrations of dietary fibre, vitamins, minerals, notably electrolytes, and more recently, phytochemicals, particularly antioxidants. Every fruit's by-product, such as the peel and seed, have advantages. Most people don't give functional benefits of by-products much thought. Muskmelon (*Cucumis melo*) is a fruit rich in phytochemicals in addition to other vitamins and minerals. Benjamin Franklin, America's most famous citizen and renowned printer, scientist, and philosopher, once said: "Women & melons are difficult to understand". It is in the family of gourds. This fruit offers several advantages in every section. 5% of the weight of cucumber melon seeds are made up of substances that are good for you. Flavonoids, phenolics, saponins, alkaloids, and other secondary metabolites are examples of phytochemical components. The oils from this seed have significant levels of iodine, saponification, polyunsaturated fatty acids like omega-6 (linoleic acid), monounsaturated fatty acids like omega-9 (oleic acid), and saturated fatty acids in their fatty acid profiles. The whole fruit has pharmacological properties including immunological modulator, anti-inflammatory, antioxidant, anticancer, antidiabetic, antibacterial, and anthelminthic. The seeds are utilised in goods with additional value. It is clear that muskmelon has a wealth of medical benefits and is widely available. The current review article discusses the muskmelon seed's phytochemical features, nutritional qualities, medical uses, and assessment in value-added products.

Keywords: Muskmelon seeds, Pharmacological and Medicinal value.

Introduction:

There is no other cuisine category that provides such a wide variety of pleasant and alluring flavours. Fruits have enticing colours that are pleasing to the eye as well as the palate. Fresh fruit is practically always available because to modern refrigeration and shipping methods. Citrus fruit consumption has increased dramatically during the past century as a result. A healthy diet should include more fruits and vegetables since they are associated with a decreased risk of chronic illness. (Lintas, 1992; Jayne *et al.*, 2013)

The musk melon is a beautiful, juicy, palatable, and delicious fruit that has both nutritional and medicinal advantages. The Cucurbitaceae family includes squash, pumpkins, cucumbers, musk melons, watermelons, and gourds. Native to Africa and India, muskmelons are. India's natural ecosystems include Rajasthan and Punjab. The feral muskmelons that result from farming are distributed. It is cultivated on medium-textured soil, a loamy mix of sand, clay, and silt that has adequate surface and internal drainage. While it is a fruit that is only in season from May to September, hyper markets carry it all year long. While it may be cultivated in tropical and subtropical regions, it likes a warm temperature (Parle M, Singh K, 2011).

Most melons are over 90% water, low in fat, and a high source of provitamins A and C, as well as carbs and dietary fibre. The meat contains phenolic compounds and flavonoids. The seeds of musk melon, honeydew melon, and cantaloupe are rich in essential fatty acids, vitamin E, and antioxidants. Certain melons' peels include high concentrations of fibre, pectin, phenolics, and flavonoids, which makes them better candidates for use as cosmetic and dietary supplements. In addition to having anti-oxidative, anti-inflammatory, analgesic, antiglycation, antihyperlipidemic, and antidiabetic properties, melon has also been related to biological mechanisms that inhibit the formation of some cancer cells (Amit K Jaiswal, 2020).

History of muskmelon

Among the planetarum species, the musk melon was first described by Linné in 1753. The family Cucurbitaceae has more than 800 species and 120 genera. Domestication of melon started in Asia and Africa (Gregory, 2014; Zeven & deWet,1982). The rich protein and fat content of melon seeds originally attracted farmers to them. Wild melon flesh was bitter and incredibly thin. The selection of plants based on customer preferences resulted in significant variances in melon germplasm (Mitchell *et al.,* 2006). Asia is the location where the melon has seen the most variation, from the Mediterranean Sea to East Asia (Pitrat M,2008). Literature indicates that melons have been cultivated and consumed for more than 4,000 years. Historical and ethnobotanical records indicate that melon was initially grown by the Persians and Egyptians around 2-3 BCE, and that itlater spread to other parts of the world in the 14th and 15th Centuries (Yukari *et al.*, 2002; Harry *et al.,* 2012)

Botanical description

Melons were divided into two subspecies based on the amount of hair on the hypanthium: subspecies melo, which contains hair on the hypanthium, and subspecies agrestis, which does not. Botanical groupings that are members of the subsp. agrestis may be found throughout Eastern Asia, from India to Japan, whereas the subsp. melo can be found in Europe and the New World (Jeffrey,1980; Shivapriya and Sudhakara, 2014). Adana, Ameri, Cantaloupe, reticulates (Muskmelon), Chandalak, Inodorus (Winter Melon), Casaba, Ibericus, Indicus, Makuwa, and chinensis are among the sweet varieties, and dudaim (Queen Anne's Pocket Melon) has fragrance in its skin in addition to the nonsweet varieties of chito (Mango Melon), flexuosus, tibish, cidulous, conomon, kachri, memordica (Kaur *et al.*,2008). The groups cantalupensis (cantaloupe) and reticulates (muskmelon) are joined among them as a consequence of the intermediate forms produced by the hybridization between these two groups since the difference between them is continuous for fruit netting (Pitrat *et al.*, 2000; Pitrat, 2016, Fergany *et al.*, 2011).

Table 1: Botanical Description of Musk melon

Kingdom	Plantae	Subclass	Dilleniidae
Sub Kingdom	Tracheotrionta	Order	Viollos
Super Division	Spermtophyta	Family	Cucurbitaceae
Division	Magnoliophyta	Genus	*Cucumis L*
Class	Magnoliophyta	Species	*Cucumis melo L*

Specific phytochemicals in musk melon

The presence of several substances with antioxidant and free radical-scavenging activities in muskmelon and other melons is well recognised. Among the potent antioxidants include ascorbic acid, carotenoids, phenolic acids, and flavonoids. Further support for radical scavenging action comes from trace levels of vitamin E, selenium, and fatty acids. The antioxidant activity of fresh, frozen, air-dried, and freeze-dried fruits has all been examined. Together with the edible fruit parts, the radical scavenging activity of fruit peel, pectin, and seed has also been studied. Antioxidant compounds in muskmelon freeze-drying are comparatively stable. There were significant disparities in antioxidant content and activity amongst the various fruits examined, with the exception of muskmelon, according to research on the evaluation of antioxidant phytochemicals and activity after freeze-drying certain tropical fruits (Norshahida *et al.*,2011).

In addition to the fruit flesh, muskmelon seeds are a rich source of antioxidants since they include phenolics, flavonoids, and tocopherols (Mehra *et al.,* 2015). Among other health benefits, pectin, a complex hetero polymer that was isolated from the muskmelon peel, is widely recognised for its antioxidant capabilities (Muthukumaran *et al.,* 2017). The pectin was determined to be high methoxy pectin, which is also well-known for its effects on various cancer cells in terms of reducing inflammation and preventing their ability to proliferate (Vayssade *et al.,* 2010; Jackson *et al.,* 2007; Huang and Ho, 2010).

Nutritive value of muskmelon seed

The seeds are an excellent source of minerals including calcium, iron, magnesium, phosphorus, and potassium as well as energy, carbs, fat, and proteins (Karakya *et al.*,1995; Mehra *et al.*,2015). According to the proximate analysis of the seed, it includes 22.94% of carbohydrates, 14.91% of protein, 30.83% of lipids, 7.78% of moisture, 4.20% of ash, and 19% of fibre (de Melo M.L *et al.,* 2000) compared to the proximate analysis done by Mehra *et al.,* (2015) shows that seed contains 22.874% of carbohydrate, 32.80% of protein, 37.167% of Fat, 0.2% of Fiber, 4.801%, of Ash and 2.358%. of Moisture. Almost 84.4% of the fatty acids were unsaturated. Mono- and poly-unsaturated fatty acids made up 20.2% and 64.3%, respectively, of the total fatty acids. The saponification value is 210.62 and the iodine value is 112. Like other oil seed proteins, melon seed protein is rich in aspartic and glutamic acids. Also abundant in minerals, including copper 0.833
mg, iron 4.901 mg, potassium 509.804 mg, sodium 41.176 mg, manganese 1.593 mg, and zinc 4.656 mg (Bouazzaoui, N., & Mulengi, J. K,2018).

Ascorbic acid levels in four wild kinds are high, suggesting they may be beneficial sources of antioxidants. Melons are also well known for their high pro-vitamin A content, which is mostly present in the form of carotenoids. Fruits and vegetables' total polyphenol content is a key indicator of their health benefits. These phenolic compounds are flavonoids, complex phenols, phenolic acids, and tannins (Fraga *et al.,* 2019). Examples of natural constituents with elevated DPPH scavenging activity include ascorbic acid, flavonoids, anthocyanin, coumarins, tannins, and other polyphenols (Unuofin *et al.,* 2017; Khalaf *et al.,* 2008). The body can be fully nourished by muskmelon seeds, which are abundant in micronutrients in addition to macronutrients.

Medicinal benefits of muskmelon

Melon's nutritional qualities are proof that it has several therapeutic advantages. Melon has the capacity to inhibit ACE, induce NO, and scavenge free radicals. It stops or delays the onset of many chronic illnesses, including cancer and cardiovascular disease (McFarlane *et al.,* 2003). As free radicals begin the breakdown of cellular components that leads to a number of chronic diseases, fruits with strong radical-scavenging activity may lower the risk of these illnesses. Hexane extract suppresses alpha amylase and alpha glucosidase by 61.8% and 35.5%, respectively, according to research on the effect of oriental melon seeds on these enzymes, demonstrating the fruit's potency as an anti-diabetic agent (Chen and Kang 2013). The inhibition of these two enzymes might postpone the release of oligosaccharides from starch for better postprandial blood glucose management. The small intestine's ability to absorb glucose would be slowed by this (Apostolidis *et al.,* 2011). In addition to that Unsaturated fatty acids that inhibit -glucosidase and -amylase include palmitic acid, oleic acid, and linoleic acid (Chen & Kang, 2013; Paul *et al.,* 2010). The levels of tissue lipid peroxidation, blood lipids, glucose, and creatinine kinase-MB were increased by the CCT diet (supplemented with 4% cholesterol, 1% cholic acid, and 0.5% 2-thiouracil), but this effect was mitigated by the fruit peel extracts of *Cucumis melo*. Additionally, musk melon boosted thyroid hormone and insulin levels, suggesting that they may be able to reduce the effects of diet-related changes in serum lipids, thyroid dysfunction, and hyperglycemia/diabetes mellitus. The high concentration of polyphenols and ascorbic acid in the extracts may be the cause of these beneficial benefits (Qian *et al.,* 2019)

The cantaloupe melon extract known as Oxykine is protected by polymeric films made of wheat matrix gliadin and is high in vegetal superoxide dismutase (SOD). In type 2 diabetic rodents, oxykine therapy reduced the acceleration and development of diabetic nephropathy. The oxykine lessened the damage to renal mesangial cells and oxidative stress brought on by diabetes. A potential strategy for preventing diabetic nephropathy may involve oxykine (Naito *et al.,* 2005; Parmar & Kar, 2008) In the *in-vivo* study conducted to test anti-hypothyroidism on normal healthy and propylthiouracil induced hypothyroid Wistar albino male rat, result shows significant increase in thyroid hormones namely T3 and T4 (Parmar & Kar, 2009).

Antioxidants are essential for lowering pain and enhancing its analgesic impact because free radicals have the potential to stimulate the pain response (N S Gill *et al.,* 2011). By preventing the production of free radicals, which can also cause inflammation, *Cucumis melo* L. demonstrated its analgesic impact. This was accomplished through a rise in the gene activity that produces pro-inflammatory cytokines such interleukin-6, tumor necrosis factor, and interferons (Fischer & Maier, 2015). Following inflammatory stimulation, carrageenan enhanced the concentration of leukocytes in the pleural space and raised the level of leukotriene B4 (LKB4) in the pleural exudate. Toxic oxygen free radicals would be released into extracellular space as a result of neutrophil migration to the damaged location, contributing to the pro-inflammatory situation. *Cucumis melo* L. may also enhance LTB4 levels while decreasing leukocyte inflow (N S Gill *et al.,* 2011).

Cucurbitacin are tetracyclic triterpenes with high oxygen content that are mostly found in the Cucurbitaceae family. A natural anti-cancer substance called cucurbitacin B was discovered in the stems of the *Cucumis melo* plant. It has been documented that cucurbitacin B inhibits the

growth of human leukemia cells. In the leukemia cell line K562, cucurbitacin B prevents STAT3 activation and the Raf/MEK/ERK pathway. Significant anti-tumor action is also present in cucurbitacin A and cucurbitacin E (Wang *et al.,* 2007; Chan *et al.,* 2010). It has been noted that the dried pedicel of *Cucumis melo* L. enhances liver function and boosts gluconeogenesis. It offers defense against CCl4 intoxication. Jaundice, cirrhosis of the liver, and toxic and chronic hepatitisis all treated with it (Wang *et al.,* 2007).

In dogs under anesthesia, the diuretic properties of *Cucumis melo* L. were examined. The volume of the urine and its chloride content were both markedly elevated by an ether extract of the seeds. The higher glomerular filtration rate and reduced tubular reabsorption may be the cause of this rise in chloride concentration (Wright *et al.,* 2007). Juice from Musk melons can be consumed regularly to avoid hepatic steatosis and atherosclerosis. Human platelet aggregation caused by epinephrine, ADP, collagen, thrombin, sodium arachidonate, prostaglandin endoperoxide analogue U-46619, and PAF-acether was reduced by adenosine extracted from an aqueous melon extract. Musk melon's ability to do this may be useful in the treatment of cardiovascular disorders (Cristol *et al.,* 2010; Altman *et al.,* 1980).

Bhat community uses musk melon plant for fertility treatment (Lal & Lata,1980). The seeds of *Cucumis melo* L. have demonstrated strong antibacterial and anthelmintic action when extracted with n-hexane and methanol. Another usage for cucumber melo is as a vermifuge (Ibrahim,2010; Zinchenko *et al.,* 1995). SOD-rich melon extract and wheat gliadin (Glisodin®) together boosted the expression of INF gamma and IL-4 as well as type 1 helper T lymphocyte (Th1) production. However, the level of IgE (allergic) production remained low, and the level of IgA did not alter, supporting the idea that Glisodin® has immunomodulatory effects. The stimulation of antigen-presenting cells (APC) by the gliadin-SOD combination may be the cause of this reaction. Nitric oxide and H2O2 are released as a result of this activation, which then activates catalase and GPx and causes the development of the cytokines INF-gamma and IL-4. Then, the activated APC modifies the immune response to produce a Th1 response (Vouldoukis *et al.,* 2003).

Muskmelon in products

Bakery items are influenced by a variety of factors, including the location in which they are produced and the ingredients used. The nutritional content of several types of seeds, such as muskmelon, flax, and pumpkin seeds, was examined. These seeds were then utilised to make muffins and vermicelli, which were then taste-tested. The proximate study focused on the shelf life of the muffin, vermicelli, and the most palatable product—the muffin. The combination of oat flour and muskmelon seed flour in the volume ratio (40:20) was the most pleasing to the senses (Selva Rani *et al.,* 2019)

The development of a value-added product from muskmelon began with the extraction of pulp and preparation of the product according to various treatments, which was then heated for 5 minutes and a preservative of KMS at 70ppm was added to the finished product, which was then filled in sterilised bottles, pasteurised for 30 minutes, and cooled. The shelf life was determined to be 90 days, with satisfactory results for TSS, pH, and acidity. Overall acceptability was assessed as superior for nectar produced with 15% pulp and 10 brix TSS (Salaria & Reddy, 2022).

By mixing muskmelon with pomegranate, Hamid Salari *et al.,* (2012) conducted an experiment to create a squash and syrup beverage. For a four-month storage period, the syrup made

with 50% muskmelon juice and 50% pomegranate juice and the squash made with 35% blended juice of 80% muskmelon and 20% pomegranate juice had the best sensory quality ratings. TSS, pH, viscosity, reducing sugar, and total sugar all increased while ascorbic acid decreased, and the product demonstrated that it was not spoiled during storage.

Conclusion:

Ladies and melons are difficult to comprehend, as the most famous citizen of America and noted printer, physicist, and philosopher Benjamin Franklin once observed. It makes sense to claim that "Muskmelon is a gift by nature" since it has a variety of pharmacological effects, is inexpensive, is rich in phytochemical characteristics, and is nutrient-rich across the entire plant. Melons are readily accessible locally, and because of its unique qualities, muskmelon may be utilised to create a variety of goods with additional economic value in addition to being eaten raw.

References:

1. Altman R, Rouvier J, Weisenberger H,1985. Identification of platelet inhibitor present in the melon (Cucurbitaceae *Cucumis melo*). Thromb Haemost; 53 (3):312-3.
2. Amit K. Jaiswal,2020. A Book of Nutritional composition and Antioxidant properties of Fruits and Vegetables, Elsevier, Ireland;533-546
3. Apostolidis, E., Li, L., Lee, C., & Seeram, N. P, 2011. *In-vitro* evaluation of phenolic-enriched maple syrup extracts for inhibition of carbohydrate hydrolyzing enzymes relevant to type 2 diabetes management. Journal of Functional Foods; 3(2):100-106.
4. Bouazzaoui, N., & Mulengi, J. K., 2018. Fatty acids and mineral composition of melon (*Cucumis melo*) and pumpkin (*Cucurbita moschata*) seeds. Journal of Herbs, Spices & Medicinal Plants; 24(4): 315-322.
5. Chan, K. T., Li, K., Liu, S. L., Chu, K. H., Toh, M., & Xie, W. D.,2010. Cucurbitacin B inhibits STAT3 and the Raf/MEK/ERK pathway in leukemia cell line K562. Cancer letters;289(1): 46-52.
6. Chen, L., & Kang, Y. H.,2013. *In-vitro* inhibitory effect of oriental melon (*Cucumis melo* var. makuwa Makino) seed on key enzyme linked to type 2 diabetes: Assessment of anti-diabetic potential of functional food. Journal of Functional Foods;5(2): 981-986.
7. Cristol, J. P, Décordé, K., Ventura, E., Lacan, D., Ramos, J., & Rouanet, J. M.,2010. An SOD rich melon extract Extramel prevents aortic lipids and liver steatosis in diet-induced model of atherosclerosis. Nutrition, Metabolism and Cardiovascular Diseases; 20(5):301-307.
8. de Melo, M. L. S., Narain, N., & Bora, P. S.,2000. Characterisation of some nutritional constituents of melon (*Cucumis melo* hybrid AF-522) seeds. Food Chemistry; 68(4): 411-414.
9. Fergany, Mohamed, Balvir Kaur, Antonio J. Monforte, Michel Pitrat, Catherine Rys, Hervé Lecoq, N. P. S. Dhillon, and S. S. Dhaliwal, 2011. Variation in melon (*Cucumis melo*) landraces adapted to the humid tropics of southern India. Genetic Resources and Crop Evolution; 58: 225-243.
10. Fischer, R., Kontermann, R. E., & Maier, O.,2015. Targeting sTNF/TNFR1 signaling as a new therapeutic strategy. Antibodies; 4(1): 48-70.
11. Fraga, C. G., Croft, K. D., Kennedy, D. O., & Tomás-Barberán, F. A.,2019. The effects of

polyphenols and other bioactives on human health. Food & function; 10(2): 514-528.

12. Gregory E. Welbum, 2014. A Book of Vegetable Production and Practices, UK; pp.136-165
13. Harry S. Paris, Zohar Amar, Efraim Lev.,2012. Medieval Emergence of Sweet Melons, *Cucumis melo* (Cucurbitaceae). Journal Annals of Botany,2012;110(1):23-33
14. Huang, Yung-Sheng, and Su-Chen Ho.,2010. Polymethoxy flavones are responsible for the anti-inflammatory activity of citrus fruit peel. Food Chemistry; 119(3): 868-873.
15. Ibrahim, S. R.,2010. New 2-(2-phenylethyl) chromone derivatives from the seeds of *Cucumis melo* L var. reticulatus. Natural product communications; 5(3): 1934578-1000500313.
16. Jackson, C.L, Tina M Dreaden, Lisa K Theobald, Nhien M Tran, Tiffany L Beal, Manal Eid, Mu Yun Gao, Robert B Shirley, Mark T Stoffel, M Vijay Kumar, Debra Mohnen,2007.Pectin induces apoptosis in human prostate cancer cells: correlation of apoptotic function with pectin structure, *Glycobiology*; 17(8): 805–819
17. Jayne V. Woodside, Ian S. Young, Michelle. C. McKinley,2013. Fruits and Vegetable: measuring intake and encouraging increased consumption, Proceedings of the Nutrition Society; 72(2):236-245
18. Jeffrey C.,1980. A Review of the Cucurbitaceae. Botanical Journal of the Linnean Society;81(3):233-247
19. Karakaya, S., Kavas, A., El, S. N., Gündüç, N., & Akdoğan, L., 1995.Nutritive value of a melon seed beverage. Food chemistry; 52(2):139-141.
20. Kaur, B., & Dhillon, N. P. S.,2008. Characterization of various genotypes of *Cucumis melo* var. acidulous L, Vegetable Science; 35, 212-214.
21. Khalaf, N. A., Shakya, A. K., Al-Othman, A., El-Agbar, Z., & Farah, H, 2008. Antioxidant activity of some common plants. Turkish Journal of Biology;32(1): 51-55.
22. Lal, S. D., & Lata, K.,1980. Plants used by the Bhat community for regulating fertility. Economic Botany; 34(3): 273-275.
23. Lintas, C.,1992. Nutritional aspects of fruit and vegetable consumption in Lauret F (ed.) Consumption of Mediterranean fruit and vegetables; pp. 79-87
24. McFarlane, S. I., Kumar, A., & Sowers, J. R.,2003. Mechanisms by which angiotensin-converting enzyme inhibitors prevent diabetes and cardiovascular disease. The American journal of cardiology; 91(12): 30-37.
25. Mehra, M., Pasricha, V., & Gupta, R. K.,2015. Estimation of nutritional, phytochemical and antioxidant activity of seeds of musk melon (*Cucumis melo*) and water melon (Citrullus lanatus) and nutritional analysis of their respective oils; Journal of Pharmacognosy and Phytochemistry. 3(6), 98-102.
26. Mitchell J.M, Cantliffe D.J, Sargent S A, Datnoff L E, Stoffelle P J.,2006. Fruit yield, Quality Parameters and powdery mildew *(Sphaerothea fuliginea*), susceptibility of specialty melon (*Cucumis melo* L.) cultivars grown in a passively ventilated greenhouse, Cucurbitaceae; pp 483-491
27. Muthukumaran, C., Banupriya, L., Harinee, S., Sivaranjani, S., Sharmila, G., Rajasekar, V., & Kumar, N. M.,2017. Pectin from muskmelon (*Cucumis melo* var. reticulatus) peels:

extraction optimization and physicochemical properties. 3 Biotech; 7: 1-10.

28. N S Gill, J Bajwa, Kunal Dhiman, P Sharma, S Sood, P D Sharma, B Singh, M Bali,2011. Evaluation of therapeutic potential of traditionally consumed *Cucumis melo* seeds. Asian Journal of Plant Sciences;10(1):86-91.
29. Naito, Y., Akagiri, S., Uchiyama, K., Kokura, S., Yoshida, N., Hasegawa, G., ... & Yoshikawa, T.,2005. Reduction of diabetes-induced renal oxidative stress by a cantaloupe melon extract/gliadin biopolymer, oxykine, in mice. Biofactors; 23(2): 85-95.
30. Norshahida Mohamad Shofian, A. Hamid, A. Osman, N. Saari, F. Anwar, M. S. P. Dek, Muhammad Redzuan Hairuddin, 2011. Effect of freeze-drying on the antioxidant compounds and antioxidant activity of selected tropical fruits. International Journal of. Molecular Science; 12 (7), 4678-4692.
31. Parle M, Singh K,2011. Musk melon is eat-must melon: A Review. International Research Journal of Pharmacy; 2(8):52-57.
32. Parmar, H. S., & Kar, A.2009. Protective role of Mangifera indica, *Cucumis melo* and Citrullus vulgaris peel extracts in chemically induced hypothyroidism. Chemico-Biological Interactions; 177(3): 254-258.
33. Parmar, H.S., &Kar, A., 2008.Possible amelioration of atherogenic diet induced dyslipidemia, hypothyroidism and hyperglycemia by the peel extracts of Mangifera indica, *Cucumis melo* and Citrullus vulgaris fruits in rats. Biofactors; 33(1): 13-24.
34. Paul, S., Hou, C. T., & Kang, S. C.,2010. α-Glucosidase inhibitory activities of 10-hydroxy-8 (E)-octadecenoic acid: an intermediate of bioconversion of oleic acid to 7, 10-dihydroxy-8 (E)-octadecenoic acid. New Biotechnology; 27(4): 419-423.
35. Pitrat, M. Melon (*Cucumis melo* L.). In: Prohens, J., Nuez, F (Eds.), Handbook of Crop Breeding,2008; Vol. I: Vegetables. Springer, New York, pp. 283-315
36. Pitrat, M., Hanelt, P., & Hammer, K,2000. Some comments on infraspecific classification of cultivars of melon. In *VII* Eucarpia Meeting on Cucurbit Genetics and Breeding 510: pp. 29-36
37. Pitrat, Michel,2016. Melon Genetic Resources: Phenotypic Diversity and Horticultural Taxonomy. A book of Genetics and Genomics of Cucurbitaceae; 20: 25–60
38. QIAN, O. Y., HARITH, S., SHAHRIL, M. R., & SHAHIDAN, N.,2019. Bioactive compounds in *Cucumis melo* L. and its beneficial health effects: A scoping review. Malaysian Applied Biology;48(4), 11-23.
39. Salari, H., Sreenivas, K. N., Shankarappa, T. H., Krishna, H. C., & Gowda, A. M., 2012. Physico-chemical and sensory parameters of muskmelon blended pomegranate squash and syrup. Environment & Ecology; 30(3C):1052-1057.
40. Salaria, M., & Reddy, A. H.,2022. Studies on standardization and quality evaluation of RTS beverage from muskmelon (*Cucumis melo* L.) variety Sarda. The Pharma Innovation Journal;11(3):1952-1956
41. Selva Rani, N., Raja, M., & Suresh, M.,2019. Quality evaluation of musk melon seeds flour and jackfruit seeds flour for bakery products development. J. Pharma Innov. Int. J; 8(6): 703-706.
42. Shivapriya, M., Sudhakara, T., 2014. Characterization of muskmelon local types of

Karnataka for yield attributing traits. National Seminar cum-workshop on strategies for improvement, enhancing productivity and utilization of cucurbits. Souvenir and book abstracts, pp. 130.

43. Unuofin, J. O., Otunola, G. A., & Afolayan, A. J.,2017. Phytochemical screening and *in-vitro* evaluation of antioxidant and antimicrobial activities of Kedrostis africana (L.) Cogn. Asian Pacific journal of tropical biomedicine; 7(10): 901-908.
44. Vayssade, M., Sengkhamparn, N., Verhoef, R., Delaigue, C., Goundiam, O., Vigneron, P., Voragen, A.G., Schols, H.A., & Nagel, M.D,2010. Antiproliferative and proapoptotic actions of okra pectin on B16F10 melanoma cells. *Phytotherapy Research; 24*(7):982-989
45. Vouldoukis, I., Conti, M., Kolb, J. P., Calenda, A., Mazier, D., & Dugas, B.,2003. Induction of Th1-dependent immunity by an orally effective melon superoxide dismutase extract. Current trends in immunology; Volume 5: 141-145.
46. Wang, J., Zhou, X., Cao, Y., Xiao, J., Ma, E., Deng, Y., & Chen, D.,2007. The antitumor activities of cucurbitacin liposome for injection both *in-vitro* and *in-vivo*. Asian Journal of Traditional Medicines; 2(3): 98-103.
47. Wright, C. I., Van-Buren, L., Kroner, C. I., & Koning, M. M. G.,2007. Herbal medicines as diuretics: a review of the scientific evidence. Journal of ethnopharmacology;114(1): 1-31.
48. Yukari Akashi, Naomi Fukuda, Tadayuki Woko, Masaharu Masuda, Kenji Kato,2002. Genetic variation and phylogenetic relationships in East and South Asian melons, *Cucumis melo* L., based on the analysis of five isozymes. Euphytica Journal;125: 385-396
49. Zeven and deWet,1982. Dictionary of Cultivated Plants and their regions of Diversity, Centre for Agricultural Publishing and Documentation, second edition, Wageningen;
50. Zinchenko, T. V., Mindlin, M. Z., & Prokopovich, N. N.,1955. Anthelmintic properties of *Cucumis melo* seeds. Farmakologiia toksikologiia;18(5): 41-43

CHAYA LEAVES (TREE SPINACH) - THE HIDDEN TREASURE

Sobika N* and Sathiya V
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore-641014
*Corresponding author E-mail: sobikan27032000@gmail.com

Abstract:

Chaya leaves are the rarely consumed green vegetable which is grown in all climatic conditions and have no distinct flavor but can be incorporated with the foods to enhance nutritive value. Theleaves have active compounds such as phenols, flavonoids, saponins and tannin. These active components helps in providing anti-microbial,anti-hyperglycemic, antioxidant,hepato-protective,anti-ulcerative,anti-hypercholesterolemic,anti-cancer,anti-anemic effect of chaya leaves. The purpose of the article is to reveal the unknown therapeutic uses of chaya leaves and to create awareness towards therapeutic foods. It is hoped this study gives a vast knowledge about chaya leaves among the people.

Keywords: Chaya leaves, Flavonoids, Phenol, Saponin, Tannin, Alkaloid, Anti-diabetic, Anti-cancer, Anti-anaemic

Introduction:

Traditional herbal medicine refers to the totality of indigenous and different cultures' knowledge, skills, and practices for maintaining health and preventing, diagnosing and treating physical and mental illness over time. It's scope includes both ancient and modern practices such as acupuncture, ayurvedic medicine, and herbal mixtures. Approximately 80% of people in the globe are said to practise traditional medicine (WHO, 2022). These herbal remedies are herbs, herbal materials, herbal preparations, and herbal goods that have been finished and have active ingredients that are plant parts, other plant materials, or mixtures of plant parts (Philip F. Builders, 2017).

In many national healthcare systems around the world, the usage of herbal medicines is fast growing as more individuals turn to these products for the treatment of a variety of health conditions. The main key players of all available therapies are their ease of availability, low side effects and low cost of preparation. Although the use of these herbal medicines has increased, their quality, safety and efficacy are serious issues both in wealthy and developing nations; thus, traditional and folklore medicines play an important role in global health services (Roughani and Miri, 2018).

Green vegetables with leaves, like spinach, are the most important herbs which have many therapeutic uses. They are high in nutrients and belong to one of the vegetable groups that have been designated as "nature's anti-aging wonders" having medicinal value (Gupta and Prakash, 2009).

With a global production of about 26 million tones on roughly 921,000 acres, spinach is a vital crop for both food and medicine. About 25 million tons were produced in Asia, with China leading the way with approximately 24 million tons, and Iran ranking sixth in the world ranking by commodity in 2016 with approximately 117000 tons (FAO, 2018).

Spinach-derived phytochemicals and bioactives may control the expression and activity of genes involved in metabolism, proliferation, inflammation, and antioxidant defence. It can also scavenge reactive oxygen species and prevent macromolecular oxidative damage.

The perennial shrub *Cnidoscoluschayamansa*, sometimes referred to as Chaya, "Mayan Tree Spinach," or "Mexican Tree Spinach," is a sizable, quick-growing, and fruitful plant. Chaya is a popular leafy green vegetable consumed in Mexico. A low-growing perennial shrub with enormous, deep-green leaves native to Mexico is called *Cnidoscolus chayamansa*, popularly known as Chaya spinach or tree spinach. It was found in abundance near temples in Central America. It grows in a variety of soil types and climatic conditions, including hot, rainy and even drought conditions. It produces more at high temperatures, and new leaves appear quickly after harvesting. When compared to other leafy vegetables such as spinach and lettuce, the plant's leaf production is also an appealing feature. Chaya has lower moisture content than other plants. The leaves have no distinct flavour, but they can be made delicious by incorporating seasonings into them and then baking them. *Chayamansa* is noteworthy for having high levels of protein, calcium, iron, and vitamin A. According to studies, Chaya contains three times as much protein as spinach or lettuce and is also therapeutic, as it is the best remedy for high blood pressure, kidney stones, diabetes, and other conditions. The plant is generally pest-free and easily propagated through stem cuttings (Geethu Mohan, 2021).

Chaya leaves

The chaya plant, commonly referred to as tree spinach, is a species of the Euphorbiacae family. A group of arborescent shrubs in the calyptosolen subgenus of the genus Cnidoscolus include Chaya and its cousins. It is a fast-growing, beautiful shrub that reaches heights of 3 to 5 m and has eye-catching big, dark green leaves. It can grow in a variety of climates, but it grows especially easily and quickly at higher temperatures. The leaves are less moist than the leaves of most green leafy plants, such as spinach. Many native plants with high potential health benefits are frequently underutilised and overlooked. *C. aconitifolius* is frequently underutilised due to lack of understanding about its nutritional and health benefits. Tree spinach has a high fibre content (31.165%), calcium content (50 mg/g), iron content (10 mg/g), potassium content (20 mg/g) and vitamin C content (892.025 mg/100 g). It offers a diverse range of services.

Chaya leaves (tree spinach) are an excellent example of a green leafy vegetable with a strong health-promoting connotation, which is supported by scientific evidence. This plant has been linked to a variety of health benefits, including blood sugar regulation, anti-inflammatory, antianemic, anti-microbial and antioxidant properties. Chaya leaf, leaf powder, or leaf extract has grown in popularity, increasing the plant's commercial value.

Health benefits include anti-diabetic, cardioprotective, antimicrobial, anti-inflammatory, hematopoietic, and anticancer properties. This is the main source of nutrition for the indigenous peoples of Mexico's Yucatan peninsula and the Ketch people. While the nutritional potential of the chaya plant has been suggested, little scientific research on the nutritional value of chaya leaves has been conducted. However, there have been studies on the therapeutic benefits of chaya. Given the preceding argument, the current work aims to compile the available evidence linking tree spinach and chaya-based products to a variety of health-promoting properties (Anil Panghal *et al.*, 2021).

Origin

There are several different species of Cnidoscolus, and they can be found from southern Texas up the gulf coast, via Yucatan and Chipas, and even into Colombia. In Mexico, the southwest of the United States, and other locations, Chaya has entered Maya households in both urban and rural settings.

It has since spread to Cuba, Florida, Mexico, and the United States. Previously, Chaya was only cultivated for ornamental purposes or as a living fence throughout its native range. Though, due to its inherent nutritional and health-promoting properties, plant food and medicinal usage have recently increased. Chaya is cold sensitive and grows best in the first few months of summer.

Chaya thrives under several circumstances, including direct sunlight, rain, dry and humidity. Surprisingly, the Chaya plant requires very little care and thrives in poor soil. Although it can grow in extreme conditions, favourable conditions result in a high yield and abundant leaf production. Chaya plants are simple to grow and resistant to pests and disease. Because it roots slowly, it is propagated through cutting. Early on, growth is slow, but once the leaves are harvested, growth picks up (Mukesh Kumar Garg, 2021)

Varieties of chaya

Chaya is considered to be a semi-domesticated plant: In addition to the wild variety, there are four other chaya cultivars, ranging in degree of domestication from cropped, nearly wild phenotypes to fully domesticated: namely 'Chayamansa or Maple Leaf (*Cnidoscolus chayamansa*), Estrella or Star (*Cnidoscolus aonitofolius*), Picuda (*Cnidoscolus aconitofolius* 'Picuda') and Redonda (*Cnidoscolus aconitofolius* 'Redonda') (Roland Ebel *et al.*, 2019).

There are two varieties of cultivated chaya leaves. The deeply lobed type appears to be a more wild form, whereas the maple-leaf type appears to have been better selected as a vegetable.The leaves of the truly wild types have stinging hairs. In deep lobed chaya, Blooms quickly while still young. Zebra long wing butterflies flock to the small white blooms. Leavesare darker green with a coarser texture. Perhaps because a larger, tree-sized plant evolved over time, it appears to be less frost tolerant than maple-leaf varieties and a massive tree form is possible. Perhaps, Maple leafed chayahave more delicate leaves, less likely to flower until taller and sometimes will not flower at all due to frost damage. Increased yield per leaf maynot as appealing as an insectary plant. The maximum size is unknown (David,2016).

But Botanist Rogers McVaugh (1909 - 2009) distinguished the cultivated leaves from the wild species in 1944; *Chayamansa* is the domesticated and sting-free form, whereas *Chayabrava* is the wild stinging form; The Mayan word chay and the Latin word mansa, which both imply house, habitation, or farm, are combined to form the word *Chayamansa*. Only the domesticated Chaya is known by McVaugh's particular name, *Chayamansa*.

Active components

When consumed in sufficient quantities, chaya leaves can meet the RDA values for carbohydrates for children (40%), adults (40%), pregnant women (30%), and lactating women (25%). The high fiber-low fat tree spinach content suggests its clinical utility in treating digestive diseases. These leaves are commonly consumed as vegetables and contain approximately 17% protein on a dry matter basis Chaya also contains a higher concentration of the limiting amino acids than many other tropical root crops, cereals, and legumes (Kiran Nain *et al.*, 2021).

Protein

Proteins are essential nutrients for the synthesis of bodily tissue and regulatory elements like hormones and enzymes. Since a protein's amino acid content, bioavailability, and the essential amino acids needed to meet each organism's RDA all affect the protein's quality The total number of amino acids was found to be 55.9% non-essential and 44.80% essential.Chaya leaf has the following amino acids per 100g of protein: alanine (4.60 g), arginine (5.17 g), glutamic acid (13.50 g), methionine (1.35 g), histidine (2.60 g), isoleucine (4.25 g), lysine (5.05 g), threonine (3.70 g), tyrosine (3.33 g), aspartic acid (8.50g) (Marie Yayinie *et al.*, 2022).

The deep green chaya leaf contained the most amino acids, while the chaya stem contained the least. Because of its high amino acid content, green leaf chaya is more suitable for consumption. Although there was no biological evaluation of protein quality, the essential amino acid profile is frequently strongly suggestive of protein quality. The study clearly shows that chaya has a high concentration of amino acids and can be used as a protein source, but it must be cooked. Leucine, lysine, and phenylalanine were the three amino acids that were found in the highest concentrations in chaya leaf samples. Chaya is a rich source of amino acids that are absent in cereals and grains due to its higher amounts of leucine and lysine.

A good source of non-essential amino acids can also be found in it. According to this investigation on the composition of non-essential amino acids, chaya leaves are particularly rich in aspartic acid, glutamic acids, and glycine, whereas chaya steam is particularly high in aspartic acid, glycine, and arginine. The amino acid L-arginine enhances the blood flow and oxygen delivery to the coronary and peripheral arteries by releasing nitric oxide. Nitric oxide levels in the blood increase when people take arginine. Nitric oxide relaxes blood vessel walls, enhancing blood flow to various parts of the body, including the penis' erectile tissue. Additionally, arginine increases nitric oxide levels, which loosens the arteries. This impact can increase erection quality and lower blood pressure. Additionally, it is advantageous for nutrients and oxygen to get through the bloodstream more quickly to the organs. Overall, it enhances male sexual performance, stamina, and potency (Anil Panghal *et al.*, 2021).

Vitamins

Vitamins are a group of nutrients necessary for healthy cell growth, development, and function. Vitamins A (59.644 mg/100g), C (892.02 mg/100g), and the B complex vitamins (B1 9.425 mg/100g, B2 5.84 mg/100g, and B9 9.425 mg/100g) are all present in chaya leaves and are necessary for the growth, development, and maintenance of other biological processes. Additionally, they include thiamin, riboflavin, and carotene. Only 25g of chaya leaves are needed to satisfy the daily vitamin C requirement and to increase the absorption of non-heme iron. The stiffness can be kept in check by eating chaya leaves. Vitamins preserve membranes and decrease ageing since they contain antioxidant capabilities. The antioxidant vitamin C is abundant in chaya leaves. This encourages the reduction of folic acid intermediates, the uptake of non heme iron at the mucosa, the transport of non heme iron, and the production of cortisol. Scurvy, gum disease, and blood capillary fragility can all result from a vitamin C deficit (Navnidhichhikara, 2021).

Minerals

Chaya leaf contains minerals that are crucial for human health and wellbeing. Osmoregulation, bone health, haemoglobin synthesis, prostate cancer prevention, stroke reduction, and other processes are all made easier by it. The leaf protein concentrate has the following nutritional values per 100 grammes: 41.47 mg of sodium, 33.88 mg of potassium, 29.16 mg of calcium, 24.68 mg of phosphorus, 7.1 mg of copper, 15.64 mg of zinc, 14.83 mg of iron, and 0.18 mg of manganese. The leaf's mineral makeup was altered by the processing techniques (cooking, sun drying), compared to leaf protein concentrations.

In order to treat disorders of the central nervous system and neurodegenerative diseases, sodium and potassium found in leaves work as activators of energy potential across neuron membranes. They also support nerve transmissions and the preservation of the acid-base balance. The mineral calcium is essential for the creation of bones. Similar to fibrinogen, collagen, and fibrin, calcium is crucial for the development of fibrin nets. Fibrin, a clotting component, and calcium ions work together to support healthy neurological and gastrointestinal peristalsis. The nutrients phosphorus and copper in tree spinach support brain health. In the body, zinc is necessary for over ten crucial enzymatic processes. A lack of zinc can lead to a number of health issues, such as the inability to heal wounds, store insulin, and protect against certain skin infections. There are numerous intermediary metabolic and enzymatic processes that require magnesium. It is a crucial cell function modulator that also has a significant impact on the control of diabetes (Anjali Onakkaramadom Shaji *et al.,* 2021).

Phenol

Chaya leaf includes several kinds of phenolic acids, including coumarin, flavonoids, phenols, tannins, anthraquinones, and flobotanin, in its aqueous and alcoholic extracts (Marie Yayinie *et al.,* 2022). These are the substances that have an organic carboxylic acid and a phenolic ring. Tree spinach has a total phenolic content of 33.02 mg/100g and is utilised in pharmaceuticals to treat a number of illnesses. The main phenolic acids extracted from tree spinach include chlorogenic acid, vanillic acid, protocatechuic acid, caftaric acid, 4-hydroxybenzoic acid, caffeic acid, syringic acid, p-caumaric acid, synapic acid, and ferulic acid. These phenolic chemicals have anti-oxidant characteristics, are anti-mutagenic, and help prevent cancer and heart disease (Kiran Nain *et al.,* 2021).

Flavonoids

Secondary metabolites known as flavonoids generally consist of a benzopyrone ring with phenolic or polyphenolic groups at different positions (Asadullah *et al.,* 2020). The flavonoids isolated from tree spinach include procyanidin B1, procyanidin B2, catechin, rutin, gallocatechingallate, epigallocatechingallate, epicatechin-3-O-gallate, trans-reverseratol, quercetin, and kaemferol. These may be responsible for their antioxidant capabilities, their ability to influence a number of enzymatic pathways, and their ability to lower the chance of developing neurodegenerative disorders like Alzheimer's, Parkinson's, and amyotrophic lateral sclerosis as well as other chronic illnesses including cancer and cardiovascular disease. Due to their capacity to combat free radicals, flavonoids can help prevent the onset of heart disease. They may also be able to stop the spread of tumours and maybe kill developing cancer cells (Kiran Nain *et al.,* 2021).

Saponins

In addition to lowering blood lipid levels and the risk of cancer, saponins can also reduce blood sugar response, hyperglycemia, hypercholesterolemia, and hypertension. Additionally, saponins have a built-in propensity to reject microorganisms, which makes them a potent remedy for yeast and fungus infections. They work as antioxidants by making lipid hydroperoxidase less active. Three-O-d-glucopyranosyl-(1-3)-L-arabinopyranosyl3,23,30-trihydroxyolean-12-en-28-oic acid and three-O-d-glucopyranosyl-(1-3)-phytolaccagenic acid-D-galactopyranosyl are a few of the saponins that have been found in tree spinach killing cancer cells in growth (Anil Panghal *et al.,* 2021).

Alkaloids

A group of nitrogenous organic molecules known as alkaloids are physiologically active secondary metabolites found in plants. Alkaloids in tree spinach total 1.96 mg/100g. Choline, trigonelline, palmatine, sitsirikine, dihydrositsirikine, vinblastine, vindoline, catharanthine, and vinleurosine are a few of the alkaloids identified from Chaya. These saponins have hepatoprotective, anti-inflammatory, and free radical scavenging activities. They also play a part in preventing a number of degenerative disorders. This is one among the most prevalent classes of phytochemicals found in plants, and it has been used to treat hypertension and intestinal infections linked to AIDS (Navnidhi Chhikara, 2021)

Tannin

Tannins are organic compounds that are present in plants, and the amount that each species, variation, maturity, and season has varies. Researchers have shown that the tannins in tree spinach can interact with specific proteins to produce a tanning effect, which is crucial for the treatment of inflammatory or ulcerated tissue. The anti-inflammatory and wound-healing properties of tannins are closely connected (Anjali OnakkaramadomShaji *et al.,* 2021).

Toxicity

Chaya includes a number of important minerals, but it also has a poisonous chemical called cyanogenic glycoside that is anti-nutritional. You can find this hydrocyanic glucoside. Because raw chaya leaves contain this hydrocyanic glucoside, cooking the leaves will lessen their toxicity. After being boiled or fried for at least five minutes, young chaya leaves are safe. For 10 to 15 minutes, boil older, harder leaves (Dawn Berkelaar, 2006)

Therapeutic properties

1. Antimicrobial agent

Antimicrobial compounds are those that stop the growth of microorganisms like bacteria andfungi. The plant *C. aconitifolius, Escherichia coli, Psuedomonas aeruginosa, Staphylococcus aureus, and Klebsiella pneumonia, Pneumococcus pneumoniae, P. fluorescencee, Klebsiella, Salmonella enterica, Gallinarum, Candida albicans, Bacillus subtilis, Salmonella typhi,* and *Streptococcus pyogenes* were all inhibited by chaya leaves extract. The type of microbe, contact time, and concentration all had an effect on the inhibition zone of the chaya leaf extract. The *C. aconitifolius* leaf methanol extract inhibition zones at 125 mg/ml and 500 mg/ml concentrations were different for *Klebsiella pneumonia* (1.0 mm - 4.5 mm), *Psuedomonas aeruginosa* (1.5 mm - 5.0 mm), and Escherichia coli (1.0 mm - 3.5 mm), (1.0 mm - 6.5) *Staphylococcus aureus*. The *C. aconitifolius* extract at 10 g/ml inhibited *Salmonella typhi* (20.5 mm) and *Streptococcus pyogenes* (26 mm). Standard antibiotic zones of inhibition were gentamicin (10 g/ml) against E. coli (19 mm), ofloxacin (5 g/ml) against *K. pneumoniae* (21 mm), and methicillin (10 g/ml) against *S. pyogenes, K. pneumonia,* and *E. coli* (16mm). The extract inhibited fungal growth in addition to bacterial growth. Fungi (*Candida albicans, Aspergillus niger, Penicillium notatum,* and *Rhizopus stolonifer*) were inhibited by a crude extract of Chaya leaves. The inhibition zones of Chaya methanol extract at 125 mg/ml and 500 mg/ml concentrations inhibited the growth of various fungal mycelium. Within 24 hours, fungal mycelium such as Aspergillus tamari (22% - 100%). The extract inhibited A. niger by 9% (31.25 mg/ml) and 91% (500 mg/ml) after 24 hours. These differences are due to differences in cell wall composition, metabolism, properties, antibiotic resistance, or local environmental factors (Marina Silalahi, 2021).

2. Anti-Diabetic agent

Hyperglycemia, a symptom of the complicated chronic disease known as diabetes mellitus (DM), is brought on by deficits in insulin secretion, action, or both. Patients with this condition are at significant risk for long-term macro- and microvascular problems, which, if left untreated, can result in repeated hospitalisations and consequences, including an increased risk for cardiovascular disease *(*Arun chaudhury,2017*)*

To prevent elevated blood sugar level there are some herbs act as anti-diabetic agents which include chaya leaves. In STZ-induced rats, Blood sugar levels were lowered by an oral administration of an aqueous extract of *C. aconitifolius* leaf at 400, 600, and 800 mg/kg BW per day. Diabetes patients' blood glucose levels dropped by 41.76, 71.11, and 73.46 at doses of 100, 150, and 200 mg/Kg of *C. aconitifolius* leaf extract, respectively. Compared to 10 mg glibenclamide (the standard treatment), diabetic rats treated with chaya leaf extract (100-200 mg/kg bw) had higher liver enzyme levels, suggesting that chaya has a negative impact on the liver. Chaya's insulinogenic characteristics may induce dormant cells to release insulin. Islets of Langerhans were preserved in a group of mice given Chaya treatment.

3. Antioxidants

Exogenous or endogenous chemicals called antioxidants reduce the effects of oxidative/nitrosative stress. They can do everything from directly scavenge free radicals to boost antioxidativedefences. Antioxidant deficiencies can occur as a consequence of lower antioxidant

consumption, endogenous enzyme synthesis, or increased antioxidant utilization (Ergul Belge Kurutas, 2016).

Stress and excessive consumption of processed foods cause oxidative stress and genetic material damage, which directly or indirectly causes diabetes, hypertension, cancer, and metabolic syndrome. Chaya leaf extracts in aqueous and methanol extracts protected mice from genetic harm and oxidative stress caused by low-dose arsenic and streptozotocin exposure. Ferulic acid, protocatechuic acid, riboflavin, kaempferol, and beta-carotene are all found in C. Ferulic acid, protocatechuic acid, riboflavin, kaempferol, and beta carotene are found in chaya leaves and are thought to protect against geno toxic damage.

The antioxidant content of Chaya boiled leaves is higher than that of raw leaves. Boiled leaves have a higher polyphenol content, making them an antioxidant source. The bioactivity of an antioxidant depends on the amount of phenolic chemicals present. The ethyl acetate fraction of Chaya leaves contains coumaric acid, amentoflavones, hesperidin, protocatechuic acid, kaempferol, dihydromyricetin, quercetin, and rutin.

4. Anti-Hypercholesterolemic effect

Hypercholesterolemia is a condition characterised by elevated blood cholesterol levels, which can accumulate and narrow blood vessels, affecting the circulatory system directly or indirectly. The leaf extract of Chayahas anti hypercholesterolemic properties. Rats were given aqueous and ethanol extracts containing 200-800 mg/kg BW of Rats given 200-800 mg/kg BW aqueous and ethanol extracts of chaya leaves demonstrated a significant reduction in total cholesterol (TC), low density lipoprotein (LDL), and triglyceride (TG) with an increase in high density lipoprotein (HDL), which was dose dependent and thus beneficial in the treatment of coronary heart disease (Marina Silalahi, 2021)

5. Anti-Anaemic Effect

When the body's balance of iron intake, iron reserves, and iron loss is insufficient to fully support erythrocyte formation, iron deficiency anemia results. Iron deficiency anaemia rarely causes death, but it has a significant impact on human health (Jeffery Miller *et al.,* 2013). Chaya leaves have anti –anemic effect which is experimented.Anemic rats given 5-15 ml of Chaya leaf raw juice showed a significant increase in haemoglobin, solid cell volume, red blood cells, and white blood cells (Onuoha *et al.,*). The mineral and vitamin content of Chaya leaves is thought to be related to the bioactivity. Chaya contains vitamins B3, B6, and B12, as well as minerals such as Calcium, magnesium, zinc, copper, iron, potassium, sodium, and potassium.

6. Reduce Testosterone Level

Testosterone is an androgen hormone produced by the testes in males that is essential for reproduction. One method of controlling birth is to reduce testosterone levels. According to Lucky and Festus, rats fed 1.5 g/kg body weight had significantly lower testosterone levels and significantly higher levels of luteinizing hormone (LH) and follicle stimulating hormone (FSH) (FSH). The testosterone/estrogen ratio also increased with treatment duration. The bioactivity is thought to be related to the steroid content of C. The bioactivity is thought to be related to the steroid content of Chaya leaves. Tannins, saponins, cyanogenic glycosides, alkaloids, phenols, flavonoids, and steroids are found in the leaves of Chaya leaves (Marina Silalahi, 2021)

7. Anti-Ulcer activity

Ulcers are wounds caused by epithelial and basement membrane damage. Chaya leaves is used to treat in conventional medicine. gastric ulcers. The methanol extract of Chaya leaves has gastro-protective activity in rats induced by diclofenac in causing gastric mucosal lesions by increasing the ulcer index inhibition against diclofenac-induced gastric mucosal damage Analgesic Because many human diseases are accompanied by pain, one of the goals of drug administration is to alleviate pain.

Analgesics are compounds that are used to reduce pain. Formalin was used to induce pain in laboratory experiments. Acetic acid and hot plate tests were performed. Chaya leaf extract (100 or 200 mg/kg b.w.) inhibited acetic acid-induced irritation in rats in a manner comparable to indomethacin (10 mg/kg bw). When compared to control mice, the extract (100 and 200 mg/kg bw) significantly inhibited carrageenan-induced edoema.

8. Anti-Cancer effect

Chaya is used to treat cancer. It contains phytochemicals, which are plant-produced chemical compounds. These phytochemicals have the ability to prevent cellular and DNA deterioration that could cause cancer. Lessen inflammatory and the rate of growth of some cancer cells.

Methanol extract of CA roots' leaves, stems, and bark has been shown to treat breast cancer (MCF-7) and lung cancer (NCI-H460). In vitro, leaf extract at 100 g/mL inhibited the growth of breast and lung cancers. phenolic substances, cardiac glycosides, terpenes and saponins are found in Chaya leaf extract (Marina Silalahi, 2021)

9. Renal Funtion

Rats were given MECA of Chayaleaves (100 and 200 mg/kg) had a renal protective effect by attenuating the oxidative stress function caused by chronic ethanol administration. In mice, administration of chaya leaf methanol extract (MECA) significantly reduced the biochemical index above near normal (Marina Silalahi, 2021)

Conclusion:

The goal of this review article is to reveal the therapeutic uses of the miracle plant-chaya. It is hoped that this article provided depth knowledge about varieties of chaya,its active compounds and therapeutic uses; and to contribute ideas for further research and product formulation with chaya leaves, an unexplored treasure for mankind.

References:

1. Abayomi, O. E., Olorunfemi, E.O. and Mikailu, S., 2014. Phytochemical Analysis of *Cnidoscolus aconitifolius* (Euphorbiaceae) leaf with Spectrometric Techniques. Nigerian Journal of Pharmaceutical and Applied Science Research, 3(1), 38-49.
2. Abdala-Roberts L, Parra-Tabla V (2005) Artificial defoliation induces trichome production in the tropical shrub *Cnidoscolus aconitifolius* (Euphorbiaceae). Biotropica 37:251–257.
3. Adeniran, O.I., Olajide, O.O., Igwemmar, N.C. and Orishadipe, A.T., 2013. Phytochemical constituents, antimicrobial and antioxidant potentials of tree spinach [*Cnidoscolus aconitifolius* (Miller) IM Johnston]. Journal of Medicinal Plants Research, 7(19),1310-1316.
4. Aguilar-Luna JME, Garcı´a-Villanueva E, Macario-Mendoza PA, Huerta-Lwanga E, de

Alba-Becerra R (2012) Effect of the plantation density on the growth and productivity of *Cnidoscoluschayamansa*,McVaugh (Euphorbiaceae). TropSubtropAgroecosyst 15:77–86.

5. Akachukwu, D., Okafor, P.N. and Ibegbulem, C.O., 2014. Phytochemical content of *Cnidoscolus aconitifolius* leaves and toxicological effect of its aqueous leaf extract in Wistar rats. American Journal of Physiology, Biochemistry and Pharmacology,3(1), 26-31.
6. Anil Panghal , Anjali Onakkaramadom Shaji, Kiran Nain, Mukesh Kuma Garg, Navnidhi Chhikara, *Cnidoscolus aconitifolius*: Nutritional, phytochemical composition and health benefits, Bioactive Compounds in Health and Disease 2021; 4(11): 260-286. Applied Sciences and EnvironmentalManagement, 19(2), 201-209.
7. Awoyinka, O.A., Balogun, I.O., Ogunnowo, A.A., 2007. Phytochemical screening and *in-vitro* bioactivity of *Cnidoscolus aconitifolius* (Euphorbiaceae). J. Med. Plant. Res. 1, 63-65.
8. Aye PA (2012) Effect of processing on the nutritive characteristics, anti-nutritional factors and functional properties of *Cnidoscolus aconitifolius* leaves. Am J Food Nutr 2:89–95.
9. Azalia Avila-Nava, Sayuri L. Alarcón- Telésforo, José MoisésTalamantes- Gómez, Luis Corona, Ana Ligia Gutiérrez- Solis, Roberto Lugo, Claudia C. Márquez-Mota (2022) Development of a Functional Cookie Formulated with Chaya (*Cnidoscolus aconitifolius* (Mill.) I.M. Johnst)and Amaranth (*Amaranthus cruentus*), Molecules 27:21, pages 7397.
10. Babalola, John O., and Opeyemi O. Alabi. "Effect of processing methods on nutritional composition, phytochemicals, and antinutrient properties of chaya leaf (*Cnidoscolus aconitifolius*)." African Journal of Food Science 9, no. 12 (2015): 560-565.
11. Chaudhury A, Duvoor C, ReddyDendi VS, *et al.* Clinical Review of Antidiabetic Drugs: Implications for Type 2 Diabetes Mellitus Management. *Front Endocrinol (Lausanne)*. 2017;8:6. Published 2017 Jan 24. doi:10.3389/fendo.2017.00006.
12. Donkoh, A.; Kese, A.G.; Atuahene, C. C. Chemical Composition of Chaya Leaf Meal (*Cnidoscolus aconitifolius* (Mill.) Johnston) and Availability of Its Amino Acids o Chicks. Anim. Feed Sci. Technol. 1990, 30(1–2), 155–162. DOI: 10.1016/0377-401(90)90059-H
13. Dzul-Tejero F, Coello-Coello J, Martı´nez- Castillo J (2014) Wild to crop introgression and genetic diversity in lima bean (Phaseoluslunatus L.) in traditional Mayan milpas from Mexico. Conserv Genet 15:1315–1328.
14. Geethu Mohan, 2021. Medicinal and Nutritional Properties of Chaya Mansa (*Cnidoscoluschayamansa*), Vol.1 Issue-5, January 2021; www.justagriculture.in.
15. González-Laredo, R. F., ME Flores De LaHoya, M. J. Quintero Ramos, and J. J. Karchesy. "Flavonoid and cyanogenic contents of chaya (spinach tree)." Plant Foods for Human Nutrition 58, no. 3 (2003): 1-8.
16. Iwuji, S.; Nwafor, A., 2015. Phytochemical Identification in the Chloroform Fraction of Aqueous-Methanol Extract of *Cnidoscolus aconitifolius* Leaves. BJPR. 20 15,5(6), 437–441. DOI: 10.9734/BJPR/2015/13264.
17. Iyke, W.I., Arthur, N., Bestman, N., Uchenna, importance of chaya *Cnidoscolus chayamansa*). Bibliographicreview. Science and Technology Topics, 20 (60), 43-56.
18. N.K. and Numbara, D., 2018. Investigation ofPhytocomponents and Hypoglycaemic Effect of Hydro-methanolic Leaf Extract of *Cnidoscolus aconitifolius* (Spinach Tree) in

Streptozotocin Induced-Diabetic Wistar Rats. Journal of Complementary and Alternative Medical Research, 1-9.

19. Jacobson, Arthur Lee. "Chaya. Mayan Tree- Spinach, Cabbage Star." Arthur Lee Jacobson, Plant of The Month, Jan. 2012
20. Jiménez-Aguilar, D.M. and Grusak, M.A., 2015. Evaluation of minerals, phytochemical compounds and antioxidant activity ofMexican, Central American, and Africangreen leafy vegetables. Plant foods for human nutrition, 70(4), 357-364.
21. Jiménez-Arellanes, M. A., García-Martínez, I., & Rojas-Tomé, S (2014). Biological potential of medicinal species of the genus*Cnidoscolus* (Euphorbiacea). Mexican Journalof Pharmaceutical Sciences, 45 (4), 1-6.
22. Kuti, J.O. and Kuti, H.O., 1999. Proximate composition and mineral content of two ediblespecies of Cnidoscolus (tree spinach). Plant Foods for Human Nutrition, 53(4), 275-283.
23. MeleseTemesgena, LamesgenYegeremb, and MogesYilma, "Phenolic acid and amino acid composition of Ethiopian Chaya (*Cnidoscolus chayamansa*)", Internationaljournal of food properties 2022, VOL. 25, NO. 1, 227–236.
24. Mena Linares, Y., González Mosquera, D. M., ValidoDíaz, A., Pizarro Espín, A., Castillo Alfonso, O., & Escobar Román, R (2016). Phytochemical study of extracts of leaves of *Cnidoscolus chayamansa,* McVaugh (Chaya). Cuban Journal of Medicinal Plants, 21 (4), 1-13.
25. Miguel A. Munguı´a-Rosas. Miguel E. Ja´come-Flores. Rafael Bello-Bedoy. Virginia Solı´s-Montero, Ernesto Ochoa- Estrada (2019), Morphological divergence between wild and cultivated chaya (*Cnidoscolus aconitifolius*), Genet Resour Crop Evol (2019) 66:1389–1398
26. Miller JL. Iron deficiency anemia: a common and curable disease. Cold Spring HarbPerspect Med. 2013 Jul 1;3(7).
27. Miranda-Velasquez, L., Oranday-Cardenas, A., Lozano-Garza, H., Rivas-Morales, C., Chamorro-Cevallos, G. and Cruz-Vega, D.E., 2010. Hypocholesterolemic activity from the leaf extracts of *Cnidoscolus chayamansa*. Plant foods for human nutrition, 65(4), 392- 395.
28. Obichi, E.A., Monago, C.C. and Belonwu, D.C., 2015, Effect of *Cnidoscolus aconitifolius* (Family Euphorbiaceae) aqueous leaf extract on some antioxidant enzymes and haematological parameters of high fat diet and Streptozotocin induced diabetic wistar albino rats. Journal of Applied Sciences and Environmental Management, 19(2), 201-209.
29. Oladeinde, F.O., Kinyua, A.M., Laditan, A.A., Michelin, R., Bryant, J.L., Denaro, F., Makinde, J.M., Williams, A.L., Kennedy, A.P. and Bronner, Y., 2007, Effect of *Cnidoscolus aconitifolius* leaf extract on the blood glucose and insulin levels of inbred type 2 diabetic mice. Cellular and Molecular Biology, 53(3), 34- 41.
30. Oyagbemi, A.A., Odetola, A.A. and Azeez, O.I., 2011. Phytochemical investigation and proximate analysis on the leaves of *Cnidoscolus aconitifolius*. Journal of medicinal food, 14(3), 322-324.
31. Oyagbemi, A.A., Odetola, A.A., 2010. Hepatoprotective effects of ethanolic extract of *Cnidoscolus aconitifolius* on paracetamol-induced hepatic damage in rats. Pak. J. Biol. Sci.

13, 164-169.

32. Parra-Tabla V, Rico-Gray V, Carbajal M (2004) Effect of defoliation on leaf growth, sexual expression and reproductive success in *Cnidoscolus aconitifolius* (Euphorbiaceae). Plant Ecol 173:153–160.
33. Pérez-González, M. Z., Gutiérrez-Rebolledo, G. A., & Jiménez-Arellanes, M. A (2016). Nutritional, pharmacological and chemicalPhytochemical screening and antibacterial activity of four *Cnidoscolus* species (Euphorbiaceae) against standard strains and clinical isolates. Journal of Medicinal Plants Research, 6(21), 3742- 3748.
34. Pillai, K.K., Chidambaranathan, N., Halith, M.M., Jayaprakash, S. and Narayanan, N., 2012. Anti-hyperglycemic effect of alcoholic extracts of *Cnidoscoluschayamansa* in experimental diabetes and their effects on key metabolic enzymes involved in carbohydrate metabolism. International Journal of Researchin Pharmacy and Chemistry, 2(1), 164-178.
35. Ramos-Gomez, M., Figueroa-Pérez, M. G., Guzman-Maldonado, H., oarca-Piña, G., Mendoza, S., Quezada-Tristán, T., &Reynoso-Camacho, R. (2017). Phytochemical profile, antioxidant properties and hypoglycemic effect of chaya *(Cnidoscolus chayamansa*) inStz-induced diabetic rats. Journal of Food Biochemistry, 41(1), e12281.
36. Ross-Ibarra J, Molina-Cruz A (2002) The ethnobotany of chaya (*Cnidoscolus aconitifolius* ssp. Aconitifolius Breckon): a nutritious Maya vegetable. Econ Bot 56. No. 4:350–365.
37. Shittu, S.A., Olayiwola, O.A. and Adebayo, O.R., 2014. Nutritional composition and phytochemical constituents of the leaves of Cnidoscolous. American Journal of Food Science and Nutrition Research, 1(2), 8-12.
38. Roland Ebel, María de Jesús Méndez Aguilar, Juan Ariel Castillo Cocom and Susanne Kissmann, 2019, Genetic Diversity in Nutritious Leafy Green Vegetable—Chaya (*Cnidoscolus aconitifolius*), Genetic Diversity in Nutritious Leafy Green Vegetable—Chaya;Chapter 6, Springer Nature Switzerland AG, p.161.
39. Roughani, Afra&Miri, Seied Mehdi (2019). Spinach: An important green leafy vegetable and medicinal herb.
40. Shittu, S.A., Olayiwola, O.A. and Adebayo, O.R., 2014. Nutritional composition and phytochemical constituents of the leaves of Cnidoscolous. American Journal of Food Science and Nutrition Research, 1(2), 8-12.
41. F. Builders, P (2019). Introductory Chapter: Introduction to Herbal Medicine. Herbal Medicine. doi: 10.5772/intechopen.78661
42. FAO. 2018. FAOSTAT. Food and Agriculture Organization of the United Nations-FAO Statistical Database. Availableonline at: http://faostat.fao.org
43. Gupta, S. and Prakash, J. 2009. Studies on Indian green leafy vegetables for their antioxidant activity. Plant Foods for HumanNutrition. 64(1), 39-45.
44. Roughani, A. and Miri, S.M. 2018. Lepidium species as antidiabetic herbal medicines. The First National Congress and International Fairof Medicinal Plants and Strategies for Persian Medicine that Affect Diabetes, Mashhad, Iran.
45. Berkelaar, D., 2006. Chaya. Technical Note,Echo, Florida

IMPACT OF SPECIALIZED SEEDS ON HUMAN HEALTH

M. Suruthi* and V. Krishna Prabha
Department of Nutrition & Dietetics,
PSG College Of Arts & Science, Coimbatore – 641014
Corresponding author E-mail: suruthimanikandan2000@gmail.com

Abstract:

Since ancient times, seeds have played significant roles in human nutrition and health. Recently,the word "specialty" has been used to refer to seeds as a way to describe expensive and/or uniqueculinary items. Since then, a great deal of research has been done to pinpoint several types of bioactive substances, including polyphenols in specialized seeds. This article examines five specialty seeds that are frequently consumed namely sesame seeds, tamarind seeds, basil seeds, papaya seeds and garden cress seeds. It also analyses nutrients, fat-soluble bio actives, polyphenols/bio actives, antioxidant activity, bioavailability, health benefits, and safety/toxicology. Over the past ten years, scientific findings from the literature have been collected and discussed. These specialty seeds are becoming more popular due to their abundanceof fat-soluble bio actives and polyphenols, as well as their matching antioxidant properties. The health-promoting bioactive components, polyphenols, and associated antioxidant activities of these specialized seeds make them a significant source of dietary supplements and functional meals. These specialized seeds' phytochemicals exhibit bioavailability in people and have positive health effects, according to research. The goal of this review was to compile existing data on the nutritional and medical benefits of some of the specialized seeds.

Keywords: specialty seeds, antioxidant, nutraceuticals, bioactive components, and functional meals.

Introduction:

Appropriate nutrition is a key component in the prevention of many disorders linked to modern society. Cancer, depression, diabetes, and coronary heart disease (CHD) are the top killer diseases today as a result of eating wrong diet (Wang *et al.,* 2016). However, supplying enough, secure, and healthful food to people will continue to be a major concern today and in the future. There will be a severe shortage of foods made from animals, which offer vital nutrients like protein, unsaturated fat, and minerals (Kaale and Eikevik, 2014). The desire for a healthier lifestyle and the consumption of foods that prevent and treat the non-communicable diseases has increased due to greater health awareness worldwide as a result of an increase in the frequency of non-communicable diseases (Berner *et al.,* 2014; Chadare *et al.,* 2019).

It is necessary to have access to these nutritious, high-quality foods as well as various alternate sources of rich nutrients like plants. In order to find low-cost and long-term methods of supplying extra nutrients from various plant sources, including sesame, Garden cress (Rweyemamu *et al.,* 2015), and basil seeds, numerous research projects have been carried out (Otondi *et al.,* 2020). Such nutritional sources have demonstrated success, particularly in the fight against micronutrient malnutrition in underdeveloped nations (Rweyemamu *et al.,* 2015). Because of the makeup of basil seeds, they have a lot of nutritional potential. Their genetic make-

up and the impact of the environments where the plants are cultivated determine their composition (Marcinek *and Krejpcio*, 2017).

Natural anti-oxidants such anthocyanin, flavonoids, carotenoids and polyphenols are essential for illness, prevention and treatment of diseases. However, new research has shown that natural antioxidants present in these seeds can also have prooxidant properties, particularly when transition metal ions like Cu and Fe are present. Under some circumstances, high phenolic concentrations, high pH, and the presence of metal ions, phenolic compounds can cause prooxidant activity (Tommori *et al.,* 2013).

Health benefits of specialized seeds

1. Tamarind seeds

Antibacterial activity

Tamarind seeds have antibacterial properties that can guard against microorganisms that causepneumonia, Typhus, and *Staphylococcus aureus*. Additionally, it guards against a bacterium thatcan cause intestinal and urinary tract infections in addition to skin diseases (Daniyan *et al.,* 2008).

Ophthalmic health

To moisten eyes, tamarind seed extract or juice can be used. Conjunctivitis can be treated withwarm juice. Tamarind seeds contain polysaccharides that cling to the surface of the eye and maintain moisture in it (Mishra *and* Malhotra, 2009; Rama Rao,1975; Jayaweera, 1981).

Tamarind and cancer

Colon cancer can be prevented and treated using sticky tamarind seed juice. Tamarind seeds'antitumor and immune-modulating properties stop the body from developing cancer. Renal cell carcinoma is delayed in developing or less likely to occur. thanks to the seed extract's reductionof oxidative stress producers (Sano *et al.,* 1996; Chabetty *et al.,* 2012).

Protection from DNA deterioration and LDL oxidation

The seed extract contains polyphenol, procyanidins, and epicatechin, *Tamarindus indica* L. seed coat extract exhibits protective activity against Cu2+-induced human low-density lipoprotein (LDL) oxidation and oxidative damage of plasmid DNA. Consequently, the seed coat extract may be helpful for reducing DNA and LDL causing oxidation damage (Suksomtip *and* Pongsamart, 2008).

Immunity booster

Tamarind seeds have immunity-boosting qualities and can guard against a wide range of illnesses and conditions. TSP improved hemoglobin (Hb), red blood cells (RBCs), white blood cells (WBCs), and platelets on a preventative basis. Following TSP treatment, the enhanced expression of CD4+ and CD8+ cells indicated a high preponderance of TH1 cytokine-producingT cells (Aravind *et al.,* 2012).

2. Sesame seeds

Nutraceutical benefits

Sesame and its bioactive components have been shown to have many nutritional advantages in the literature. Sesame seeds shown a number of distinct health advantages, including decrease in high blood pressure, antioxidant activity, anticancer properties and effects on hypocholesterolaemia (Elleuch *et al.,* 2011).

Anti-inflammatory properties

Sesame lignans have anti-inflammatory and antioxidant effects. Sesamolin, sesaminol and sesamin are some of these lignans. These physiologically active substances offer a variety of health-promoting features, including the ability to reduce blood cholesterol and lipid levels, reduce inflammation, increase hepatic fatty acid oxidase activity and have neuroprotective effects on brain injury or hypoxia (Soleymani *et al.,* 2020).

Anti-oxidants properties

By adopting the radiolysis technique of nanosecond pulse, numerous investigators have also reported the presence of antioxidant and free radical reducing actions of sesamol. A blend of sesame, chia and olive oil was used in the investigation to create the spread butter (Singh *et al.,* 2021). Through the detection of free radical scavenging activities including DPPH, TPC, and FRAP, their antioxidant capabilities were discovered. It was suggested that it can be used in the nutritional and medical fields because of its potent antioxidant properties (Ghosh *et al.,* 2021).

Activity of enzymes

Papain, pepsin and alcalase, the three distinct enzymes can hydrolyse sesame seeds and tendto increase the pace of hydrolysis while also producing more hydrolysates. Low-molecular-weight bioactive peptides with superior functional characteristics, such as antioxidant activities, antihypertensive effects, and increased digestibility mechanisms, were present in these hydrolysates. Sesame proteins can be used to create functional foods that can be used to prevent and cure a variety of chronic metabolic diseases in both humans and animals (Mohammed *et al.,* 2019).

Hepatoprotective

Cephalin present in Sesame seeds has been shown to have effective haemostatic properties. Lecithin, which possesses antioxidant and hepatoprotective properties, is found in sesame seeds. Lecithin may also successfully cure dermatitis and reduce hepatic steatosis in patients receivinglong-term parenteral feeding (Rohilla *et al.,* 2018). The consumption of dietary sesame seed oil may effectively lower cerebrovascular ischemia and interact favourably with diabetes medications to provide a considerable reduction in hyperglycaemia (Sharma *et al.,* 2020; Farbood*et al.,* 2019).

Anticancer activity

These have been discovered to improve fatty acid peroxisome oxidation and liver mitochondrial activity in rats. Sesame seed consumption has been proven to enhance plasma tocopherol and stimulate vitamin E activity, which aids in the prevention of cancer and heart disease. Myristic acid, which is present in sesame seeds, also has anticancer properties (Karunakaran *et al.,* 2019). Sesame fibres have historically been utilised as laxatives, anti-diabetics, anti-tumour, anti-ulcer, cardioprotective and chemoprotective agents (Bukvicki *et al.,* 2020).

3. Basil seeds

Control blood pressure

These seeds contain sufficient potassium to have a direct effect on blood pressure. Because potassium is a vasodilator, it can release the tension in the arteries and blood vessels,

which lessens stress on the cardiovascular system and has a hypotensive impact (Daneshian *et al.,* 2009).

Improve bone health

Iron, potassium, copper, calcium, manganese, and magnesium are just a few of the many minerals found in basil seeds that improve bone mineral density. This will keep the individual feeling young and strong and reduce the risk of getting osteoporosis (Hosseini Parvar *et al.,* 2010).

Control blood sugar level

Dietary fibres found in basil seeds have the ability to regulate blood sugar levels. They are thought to be beneficial for type II diabetes because it is known to regulate blood sugar levels. They slow down the body's metabolism, which in turn regulates carbs quickly to convert them toglucose. A morning glass of water infused with basil seeds can enhance insulin sensitivity all daylong (Agarwal *et al.,* 2015).

Lowers cholesterol

They assist in lowering levels of bad cholesterol, which in turn lowers the risk of atherosclerosis and plaque build-up in the arteries and blood vessels. Additionally, this will lessen stress on the heart and lower the risk of heart attack and stroke (Anudurga Gajendiran *et al.,* 2016).

Relieves bloating and constipation

Basil seeds are well known for helping the body naturally detoxify by acting as a stomach cleanser and aiding in the removal of toxins from the stomach. They contain volatile oils that aidin digestion and relieve gas from the gastrointestinal tract. Additionally, it soothes and cools the stomach (Jain *et al.,* 2010).

Better vision

Basil seeds have notable amount of vitamin A and are recommended for people with failing vision or those who with high levels of oxidative stress. Vitamin A acts as powerful antioxidant in the retina, preventing the development of cataracts and slowing down the advent of maculardegeneration (Javanmardi *et al.,* 2003).

4. Papaya seeds

Antimicrobial properties

No matter what state of fruit maturity the papaya is in, its seeds exhibit bacteriostatic activityon gram positive and gram-negative organisms that may be helpful in treating chronic skin ulcers. The secondary metabolites found in papaya seeds are responsible for the ethyl acetate extract's promising antibacterial properties (Egbuje *et al.,* 2010). Strong inhibition was seen against Proteus mirabilis and vancomycin-resistant enterococci. The plant's seeds can be used to treat conditions including sepsis and urinary tract infections brought on by vancomycin-resistant enterococci and Proteus mirabilis, respectively. Papaya seed extracts could be used to treat candidiasis (Tao Zhang *et al.,* 2017).

Studies have shown that *C. albicans* cells might be strongly induced to undergo apoptosis bypapaya extract. The findings suggested that the extract, a rich and highly pure source of BITC, could play a role as a potential treatment for heart disorders (Idowu Michael *et al.,* 2017). The findings of a study on the antibacterial activity of an aqueous, methanolic extract of *Carica papaya* var. pusadwarf seeds against *Staphylococcus aureus*, Pseudomonas aeruginosa, E. coli,

and *Salmonella typhi* showed that the bacterial pathogens are effectively inhibited (Jyotsna Kiran peter *et al.,* 2014).

Antioxidant property

Many chronic health issues are brought on by free radicals. We can benefit from antioxidants by preventing the production of free radicals. According to a study, human skin Detroit 550 fibroblasts subjected to H2O2 oxidative stress have strong antioxidant activity when exposed to C. papaya seeds water extract (Carlina Kong Jia Ying *et al.,* 2021). The papaya seeds are proven to contain antioxidants by the results given in the DPPH, FRAP, and TPC tests. The results indicate that the extract is not toxic; it acts as a powerful free radical scavenger, decreases cell death, ensures Ca2+ homeostasis, is more effective than vitamin C to thwart the H2O2 oxidative damage and counteracts mitochondrial dysfunctionality in oxidative stress-damaged Detroit 550 fibroblasts The C's ability to act as an antioxidant (Afolabi *et al.,* 2011).

The antioxidant capacity of papaya seeds was also assessed using the DPPH free radical scavenging method and BHT as a reference (Elisa Panzarini *et al.,* 2014). The extent of decolorization reveals how effective plant extracts are at scavenging free radicals. There have been claims that phytate has antioxidant properties. The unripe seeds' high phytin content can be linked to their use in the place of ripe *Carica papaya* seeds in therapeutic medication to treat illnesses (Siti Radhiah Omar *et al.,* 2020).

Phytochemicals with anticancer properties

In acute pro myelotic leukaemia HL-60 cells, papaya seed extract displayed anticancer action at an IC 50 of 20 g/mL, however papaya pulp extract had no impact even at a concentrationof 100 g/mL. Papaya seeds may be an effective nutraceutical for both the prevention and treatment of prostate cancer in males since they can effectively stop the multiplication of prostatecancer cells (Khalid *et al.,* 2017).

Applications of lycopene and isothiocyanates in papaya

According to preliminary study, lycopene may lower the incidence of macular degeneration, serum lipid oxidation, and malignancies of the skin, cervix, bladder, and lung. Lycopene, the most effective carotenoid antioxidant, provides defence against dangerous free radicals and lowers the incidence of cancer and heart disease. The liver cancer cell line Hep G2 was killed by papaya juice and pure lycopene, an ingredient found in papaya, at the half maximum inhibitory concentrations (IC 50) of 20 g/mL and 22.8 g/mL, respectively. Biologically active isothiocyanates, particularly benzyl isothiocyanate and glucose inolate, are abundant in papaya seeds (Harini *et al.,* 2016).

Anthelmintic property

Papaya extracts are a good source of chemicals that can be used to create powerful anthelmintic drugs (Ameen *et al.,* 2010). Ascariasis is a common disease in Indonesia's rural areas; hence laboratory tests were done to determine the anthelmintic potential of *Carica papaya* seeds (Azeez *et al.,* 2018). Papaya (*Carica papaya* L.) seed infusion has an anti-Ascaris sum action in vitro. The seeds of the *Carica papaya* have reasonable pharmacotherapeutic effects against sheep intestinal nematodes, making them potential anthelmintic agents (Nideou *et al.,* 2017).

When used in Red Sokoto goats as an alternative to synthetic dewormers in rural regions, papaya seed extracts have comparable anthelmintic effectiveness to Thiabendazole and were more effective in aqueous forms than powdery forms (Adedeji *et al.,* 2012). According to the studies, groups of chicks given Carica seed treatment had a 100% decrease rate (citrate of piperazine combined with water) had a reduction rate of 69.23%. It can be inferred that papaya seed dramatically lowers the parasite population in pullets' stomach (Muhammad Ibrahim *et al.,* 2017).

5. Garden cress seeds

Hypoglycaemic activity

In male Wistar rats that had been given alloxan to induce diabetes, (K Chauhan *et al.,* 2012) reported that Gc seed powder had hypoglycaemic and hypolipidemic effects. The lipid profile, total cholesterol, triglycerides, and lipoprotein fractions (LDL-c and VLDL-c), as well as fasting blood glucose levels, glycosylated haemoglobin, and lipid profile, all significantly decreased (p 0.05) in diabetic and hyperlipidaemic rats given Gc seed (3g/kg body weight). HDL-c levels also significantly increased. In diabetic control and high fat high cholesterol diet fed experimental rats, increased thiol barbituric acid reactive substances levels were neutralised; glutathione and antioxidant enzyme activity were lowered; and were restored in diabetic and hyper lipidemic ratsfed Gc seed (Eddouks *et al.,* 2008).

M Eddouks and M Megharani identified the mechanism underlying the hypoglycaemic activity of the aqueous extract perfusion of Gc seed in normal and streptozotocin-induced diabetic rats (2008). The authors stated that the renal effect is at least one mechanism explaining the observed hypoglycaemic activity of Gc seed extract in normal and diabetic rats. This renal effect induced a robust suppression of renal glucose reabsorption, which in turn reduced blood sugar (Hamedan *et al.,* 2010).

Antidiarrheal and Antispasmodic activity

Rehman *et al.,* (2012) used in-vivo and in-vitro assays to examine the antidiarrheal and antispasmodic properties of Gc seed crude extract in rats. Castor oil-induced diarrhoea in rats was prevented by extract. Gc seed extract reversed carbachol (CCh, 1mM) and K+ (80mM)- induced contractions in isolated rat ileum with stronger potency against CCh, comparable. Pre- incubation of rat ileum with a lower concentration of extract (0.03 mg/mL) result in a rightwardshift that was parallel but did not suppress the maximum response in the concentration- responsecurves (CRCs) of CCh, whereas at the next higher concentration (0.1 mg/mL), it resulted in a rightward shift that was non-parallel but suppressed the maximum response. The maximum reaction was suppressed while the CRCs of Ca++ were moved to the right by GC seed extract. According to researchers, Gc seeds have antidiarrheal and antispasmodic properties that may be mediated by muscarinic receptor and Ca++ channel dual inhibition (Rehman *et al.,* 2012) (CCH– Certificate in Community Health).

Bronchoprotective properties of GC seeds

GC seeds were tested for effectiveness and safety in patients (15–80 years old) with mild to moderate bronchial asthma by Paranjape *et al.* in 2006. Patients received 1g of finely ground dried seeds three times per day with water for four weeks. After receiving Gc seed powder for 4 weeks, the bronchial asthma patients demonstrated statistically significant improvement in a

number of pulmonary function indices. The severity of asthmatic episodes and clinical symptoms both showed considerable improvement. No patient displayed any negative effects from the Gc seeds. The findings point to the value of Gc seeds in bronchial asthma patients (Paranjape *et al.,* 2006).

According to Rehman *et al (*2012), the bronchodilator activities of Gc seed crude extract (anticholinergic, Ca++ antagonist, and phosphodiesterase inhibitory actions) indicate that it canbe used as medicine to treat disorders of the overactive airways, such as cough and asthma (Rehman *et al.,* 2012).

Neurobehavioral effects

The neurobehavioral effects of the total alkaloid from Gc seeds were examined by Shukla*et al.,* (2011) in Swiss albino mice and Wistar albino rats. Total alkaloids from Gc seeds were administered intraperitoneally to the rats in doses of 50, 150, and 250 mg/kg body weight. The reaction time in caudal immersion and the quantity of wriths brought on by acetic acid induced writhing were both speeded up by Gc seed alkaloids. Researchers came to the conclusion that the total alkaloids in GC seeds had sedative, anxiolytic, myorelaxant, and analgesic properties (Shukla *et al.,* 2011).

Antidiarrheal activity

Divanji *et al (*2009) looked at the methanolic extract of GC Seeds' antidiarrheal properties. Three experimentally generated diarrhoea models, including the charcoal meal test in mice, entero pooling in rats caused by prostaglandin and castor oil-induced diarrhoea, were usedto examine the antidiarrheal activity. In castor oil-induced diarrhoea, the methanolic extracts of Gc seeds significantly reduced the weight of faeces in a dose-dependent manner.

In the charcoal meal test, there was a decrease in propulsion, showing the antimotility actionof the charcoal meal. The authors came to the conclusion that the methanolic extract of Gc seeds has strong antidiarrheal efficacy because it inhibits both fluid secretion and gastrointestinalpropulsion.

Laxative activity of GC seeds

Rehman *et al (*2011) performed *in-vitro* experiments in isolated tissues of mouse, guinea pigand rabbit to assess the prokinetic and laxative activities of aqueous-methanolic extract of Gc seed. They also performed gastrointestinal tract transit test and laxative activity test using charcoal meal in BALB/c mice. The prokinetic and laxative actions of Gc seed on mice have been documented by authors, and these effects are partially mediated by a cholinergic system. The Gc seed extract's *in-vitro* spasmodic action is similarly mediated by a comparable mechanism with species- and tissue-selectivity.

Conclusion:

We know from the reviewed literature that seeds have several health benefits, including the ability to prevent both acute and chronic diseases and to improve the flavour, aroma, and colour of food and beverages. This review provides a wealth of information on the varied functions of specialised seeds, as well as details on their flavonoid and total polyphenol content. Numerous anti-oxidants found in seeds have remarkably high biological activity and are frequently used inpreclinical, clinical and therapeutic trials looking for novel disease treatments. This review also provides a strong body of data that eating seeds can lessen or even completely

remove the negative effects on humans caused by pollutants in food and the environment vital for city residents who live in polluted areas. Hopefully, all of this information will increase the already high level of interest in various seed kinds. These nutrient-dense seeds ought to be used as functional food ingredients and as essential components of a balanced, nutrient-dense diet.

References:

1. A Shukla, CS Singh, and P Bigoniya. Der Pharmacia Lettre, 2011, 3(2), 226-237.
2. A. P. Alobo, "Effect of sesame seed on millet biscuit," *Journal of Plant Foods for Human Nutrition*, vol. 64, pp. 21–27, 2006.
3. Afolabi, Israel Sunmola; Marcus, Gbenga David; Olanrewaju, Teminijesu O. Chizea, Vivian. 2011. Biochemical effect of some food processing methods on the health promoting properties of under-utilized *Carica papaya* seed. Journal of Natural Products, Vol. 4(2011):17-24.
4. Agarwal A, Bora D, Agarwal C, Kumar R, Choudhary V. CNS stimulant and antidepressant activity of seeds of Abelmoschus esculentus in rats. Bull.Pharm.Res. 2015; 5 (2);47.50.
5. Allhorn M, Klapyta A and Akerstrom B. Redox properties of the lipocalin alpha1-microglobulin: reduction of cytochrome c, hemoglobin, and free iron. Free Radic Biol Med 2005; 38: 557-567.
6. Ameen, S. A., Adedeji, O. S., Ojedapo, L. O., Salihu, T.2 and Fakorede, O. L. 2012. Anthelmintic efficacy of pawpaw (*Carica papaya*) seeds in commercial layers. African Journalof Biotechnology Vol. 11(1), pp. 126-130.
7. AN Paranjape, AA Mehta. Iranian Journal of Pharmacology & Therapeutics, 2006, 5(1), 55- 59.
8. Anudurga Gajendiran, Vidhya Thangaraman, Suji Thangamani, Datchayani Ravi and Jayanthi Abraham, 2016. Antimicrobial, Antioxidant and Anticancer screening of *Ocimum basilicum*seeds. 114-118.
9. Aravind S. R., Joseph M. M., Varghese S., Balaram P., Sreelekha T. T. (2012). Antitumor and immunopotentiating activity of polysaccharide PST001 isolated from the seed kernel of *Tamarindus indica*: An *in-vivo* study in mice. Scientific World Journal. 2012: 361-382.
10. Carlina Kong Jia Ying, Nabila Perveen, Neeraj Paliwal, Naeem Hasan Khan. 2021. Phytochemical Analysis, Antioxidant and Antibacterial Activity Determination of Ethanolic Extract of *Carica papaya* Seeds. Biomed J Sci & Tech Res 33(5)-2021. BJSTR. MS.ID.005459.
11. Castle EP and Thrasher JB. The role of phytoestrogen in prostate cancer. Urol Clin North Am 2002; 29: 71-81.
12. Chabetty Y. Vargas-Olvera, Dolores Javier SánchezGonzález, José D. Solano, Francisco A. AguilarAlonso, Fernando Montalvo-Muñoz, Claudia María Martínez-Martínez, Omar N. MedinaCampos and María Elena Ibarra-Rubio (2012). Characterization of N-diethylnitrosamine-initiated and ferric nitrilotriacetate-promoted renal cell carcinoma experimental model and effect of a tamarind seed extract against acute nephrotoxicity and carcinogenesis, Molecular and Cellular Biochemistry, 369(1-2): 105- 117.

13. D. Bukvicki, D. Gottardi, S. Prasad, M. Novakovic, P. D. Marin, and A. K. Tyagi, "The healing effects of spices in chronic diseases," Current Medicinal Chemistry, vol. 27, no. 26, pp. 4401–4420, 2020.
14. D. Nideou, K. Soedji, A. Teteh, E. Decuypere, M. Gbeassor and K. Tona. 2017. Effect of *Carica papaya* seeds on Gastro-intestinal parasites of pullet and Production parameters. International Journal of Probiotics and Prebiotics Vol. 12, No. 2, pp. 89-96.
15. Daneshian A, Gurbuz B, Cosge B, Ipek A. Chemical components of essential oils from basil (*Ocimum basilicum* L.) grown at different nitrogen levels. Int. J. Nat. Eng.Sci. 2009;3(3):9-13.
16. Daniyan, S. Y. & Muhammad, H. B (2008). Evaluation of the antimicrobial activities and phytochemical properties of extracts of Tamaridus indica against some diseases causing bacteria, African Journal of Biotechnology 7 (14): 2451-2453.
17. Elisa Panzarini, Majdi Dwikat, Stefania Mariano, Cristian Vergallo, and Luciana Dini. 2014. Administration Dependent Antioxidant Effect of *Carica papaya* Seeds Water Extract. Hindawi Publishing Corporation Evidence-Based Complementary and Alternative Medicine, Volume 12,2014, Article ID 281508, 13 pages.
18. Horax R, Hettiarachchy NS, Chen P and Jalaluddin M. Preparation and characterization of protein isolate from cowpea (*Vigna unguiculata* L. Walp.). J Food sci 2004; 69(2): 114-118.
19. Hosseini Parvar SH, Matia, Merino L, Goh KKT, Razavi SMA, Mortazavi SA,2010. Steady shear flow behaviour of gum extracted from *Ocimum basilicum* L. seed. Effect of concentration and temperature In: Journal of Food Engineering, vol.101,2010, 236-243.
20. Idowu Michael, BamgboseAdefunke, Animashaun Oluwatoyin, Adedeji Olamiji. 2017. Evaluation of Potentials of some selected seeds' flours as partial Substitute for Wheat in Cookies production. International Journal of Scientific & Engineering Research, Volume 8, Issue 3, March-2017. 739. ISSN 2229-551.
21. Jain, R.A. Agarwal, R.C, Pandey, A. Jain, R. Evaluation of Argemone Mexicana fruits extracted using micronucleus assay in mouse bone marrow cells. Bull.Pharm.Res.2010; 1(2):22-4.
22. Javanmardi, J. Stushnoff, C. Locke, E. and Vivanco, JM. Antioxidant activity and total phenolic content of Iranian *Ocimum accessions*. Food Chemistry, 83, 547-550 (2003).
23. Jayaweera, D.M.A (1981) Medicinal Plants (Indigenous and Exotic). Flacourtiaceae-Lytharaceae. A publication of the National Science Council of Sri Lanka: 244-246.
24. Jyotsna Kiran Peter, Yashab Kumar, Priyanka Pandey and Harison Masih. 2014. Antibacterial Activity of Seed and Leaf Extract of *Carica papaya* var. Pusa dwarf Linn. IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) e-ISSN: 2278-3008, p-ISSN:2319-7676. Volume 9, Issue 2 VII PP 29-37.
25. Khalid S. Alotaibi, Haiwen Li2, Reza, Rafat A. Siddiqui2. 2017. Papaya black seeds have beneficial anticancer effects on PC-3 prostate cancer cells. J Cancer Metastasis Treat 2017;3: 161-8.
26. M Divanji, K Lakshman, H Shylaja, GL Viswanatha, S Rajesh, K Nandakumar. Journal of Natural Remedies,.2009, 9(2), 197 – 201.
27. M Eddouks, M Maghrani. Phytotherapy Research, 2008, 22, 1–5.

28. M. Elleuch, Bedigian, and A. Zitoun, "Sesame (*Sesamum indicum* L.) seeds in food, nutrition, and health," *Nuts and Seeds in Health and Disease Prevention*, Academic Press, Cambridge, MA, USA, pp. 1029–1036, 2011.
29. Makri E, Papalamprou E, and Doxastakis G. Study of functional properties of seed storage proteins from indigenous European legume crops (lupin, pea, and broad bean) in admixture with polysaccharides. Food Hydrocolloids 2005; 19(3): 583-594.
30. Mishra A. and Malhotra A.V. (2009) Tamarind xyloglucan: a polysaccharide with versatile application potential. Journal of Materials Chemistry 19 (45): 8528-8536.
31. Mohamad M.Y., Akram H.B., Bero D.N. (2012) Tamarind seed extract enhances epidermal wound healing. International Journal of Biology 4(1): 81- 88.
32. Ms. Harini R & Dr. V. Judia Harriet Sumathy. 2016. Extraction and Application of Lycopene from Papaya. IJMPR, 2016, 4(5): 293-296.
33. Muhammad Ibrahim, Salma Alfiana, Sekentya Mauridha Sasturi, EM Sutrisna. 2017. The activities of anthelmintic infusa of papaya seeds (*Carica papaya*. L) against worms Ascaris suum (study in vitro). J.Bio.Innov 6 (5), pp: 659-663, 2017.
34. N Rehman, A Khan, KM Alkharfy and AH Gilani. Evidence-Based Complementary and Alternative Medicine,2012.
35. N Rehman, MH Mehmood, KM Alkharfy and AH Gilani. Phytotherapy Research, 2012, 26(1), 136–141.
36. N. Ghosh, S. Singha, and M. Ghosh, "Formulation and characterization of chia (Salvia hispanica) seed spread with incorporation of sesame (*Sesamum indicum* L.) seed, watermelon (*Citrullus lanatus*) seed, and pumpkin (*Cucurbita pepo*) seed," *Applied Biochemistry and Biotechnology*, vol. 193, no. 6, pp. 1898–1908, 2021.
37. N. Singh, P. Kushwaha, A. Gupta, O. Prakash, S. Swarup, and S. Usmani, "Phytochemical and pharmacological insight on sesamol: an updated review," *Current Bioactive Compounds*, vol. 17, no. 2, pp. 112–119, 2021.
38. O. B. Mohammed, A. El-Razek, A. Mohamed, M. H. Bekhet, and Y. G. E. D. Moharram, "Evaluation of Egyptian chia (*Salvia hispanica* L.) seeds, oil and mucilage as novel food ingredients," *EJFS*, vol. 47, no. 1, pp. 11–26, 2019.
39. P.J Egbuje, O.J.and Don-Lawson, D.C. 2019. Determination of Phytoconstituents and Antimicrobial Analysis of the Ethylacetate Extract of *Carica papaya* Seed. International Journal of Research and Innovation in Applied Science (IJRIAS) | Volume IV, Issue XII, December 2019|ISSN 2454-6194.
40. Rama Rao, M (1975) Flowering Plants of Travancore. Dehra Dun India.
41. S. A. Ameen, O.M. Azeez, Y. A. Baba, L. O. Raji, A. Basiru, K. T. Biobaku, G. J. Akorede,
A. O. Ahmed, A.O. Olatunde and I. A. Odetokun. 2018. Anthelmintic Potency of *Carica papaya* seeds against Gastro-intestinal Helminths in Red Sokoto goat. Ceylon Journal of Science 47(2) 2018: 137-141.
42. S. Habtemariam, R. Rahimi, and S. M. Nabavi, "The what and who of dietary lignans in human health: special focus on prooxidant and antioxidant effects," *Trends in Food Science & Technology*, vol. 106, pp. 382–390, 2020.
43. S. Rohilla and D. C. Bhatt, "Significance of hepatoprotective liver specific targeted drug

delivery: a review on novel herbal and formulation approaches in the management of hepatotoxicity," *Current Drug Targets*, vol. 19, no. 13, pp. 1519–1549, 2018.

44. S.A. Ameen, O.S. Adedeji, L.O. Ojedapo, T. Salihu and C.O. Fabusuyi. 2010. Anthelmintic Potency of Pawpaw (*Carica papaya*) Seeds in West African Dwarf (WAD) Sheep. Global Veterinaria, 5 (1): 30-34.
45. Sano, M., E. Miyata, S. Tamano, A. Hasiwara, N. Ito & T. Shirai (1996). Lack of carcinogenicity of tamarind seed polysacharide in B6C3F1 mice, Food Chemistry and Toxicology, 34(5), 463-467.
46. Siti Radhiah Omar, Fauzan Aminuddin, Latiffah Karim, Nursyahida Suhaimi, Siti Nazirah Omar. 2020. Acceptability of novel antioxidant ice cream fortified with nutritious *Carica papaya* seeds. Journal of Academia Vol.8, Issue 1 (2020) 7-17, 7.
47. Suksomtip M., Pongsamart S (2008). Protective effect against oxidation of human low-density lipoprotein and plasmid DNA strand scission of Tamarind seed coat extract in vitro. LWT - Food Science and Technology. 41(10):2002–2007.
48. T. Sharma, V. Airao, P. Buch, D. Vaishnav, and S. Parmar, "Sesamol protects hippocampal CA1 neurons and reduces neuronal infarction in global model of cerebral ischemia in rats," *PharmaNutrition*, vol. 14, Article ID 100217, 2020.
49. Tao Zhang 1,2 and Weijun Chen. 2017. The Candida albicans Inhibitory Activity of the Extract from Papaya (*Carica papaya* L.) Seed Relates to Mitochondria Dysfunction Int. J. Mol. Sci. 2017, 18, 1858.
50. Troszynska A, Estrella I, Lopez-Amores ML and Hernandez T. Antioxidant activity of pea (Pisum sativum L) seed coat acetone extract. LWT Food Sci Technol 2002; 35: 158-164.
51. WA Al-Hamedan. Journal of American Science, 2010, 6(11), 873-879.
52. Y. Farbood, S. Ghaderi, M. Rashno *et al.*, "Sesamin: a promising protective agent against diabetes-associated cognitive decline in rats," *Life Sciences*, vol. 230, pp. 169–177, 2019.
53. Y. Ma, T. Karunakaran, V. P. Veeraraghavan, S. K. Mohan, and S. Li, "Sesame inhibits cell proliferation and induces apoptosis through inhibition of STAT-3 translocation in thyroid cancer cell lines (FTC-133)," *Biotechnology and Bioprocess Engineering*, vol. 24, no. 4, pp. 646–652, 2019.

REVIVING BETA CELLS: EXPLORING GENE THERAPY APPROACHES FOR DIABETES

Tharunvijay SV and Sridevi J
Department of Nutrition and Dietetics,
PSG College of Arts & Science, Coimbatore - 641402, Tamil Nadu, India.

Abstract:

Gene therapy approaches for diabetes aim to enhance the function of existing beta cells or generate new beta cells in the pancreas. Several genes have been studied for this purpose, including PDX1, NeuroD1, glucokinase, MafA, VEGF-A, and the GLP-1 receptor. PDX1 and NeuroD1 are transcription factors that regulate insulin gene expression and beta cell function. Delivering these genes to pancreatic cells can enhance beta cell function and promote insulin production. Glucokinase is an enzyme that plays a role in glucose sensing and insulin secretion. Delivering the glucokinase gene to pancreatic cells can improve glucose control. MafA is a transcription factor that specifically regulates insulin gene expression in mature beta cells. Delivering the MafA gene to pancreatic cells can enhance beta cell function and promote insulin production. VEGF-A promotes the growth and survival of beta cells, and delivering the VEGF-A gene to pancreatic cells can promote beta cell survival and regeneration. Finally, delivering the GLP-1 receptor gene to pancreatic cells can enhance insulin secretion and promote beta cell survival. In this study we are going to look for substituting nanobots to deliver these genes to the specific tissue. While these gene therapy approaches are promising, further research is needed to evaluate their safety and efficacy in humans. Additionally, there are challenges to delivering genes specifically to beta cells in the pancreas. However, advancements in nanotechnology and gene editing may provide solutions to these challenges in the future.

Introduction:

The goal of this review is to discuss the potential of using nanobots and genetic technology for targeted drug and gene delivery to specific cells or tissues, with a specific focus on beta cells in the islets of Langerhans in the pancreas. While conventional drug delivery methods have limitations in terms of specificity and efficacy, nanobots offer a promising avenue for targeted delivery of therapeutic agents. Furthermore, genetic technology provides a means for manipulating the expression of genes in specific cells, such as the beta cells in the islets of Langerhans. By combining these two technologies, it may be possible to develop a highly targeted and effective treatment for diabetes and other related conditions.

Genes with potential to enhance insulin synthesis in beta cells:

1. PDX1: The PDX1 gene is a transcription factor that regulates insulin gene expression and beta cell function. Several studies have investigated the potential of PDX1 gene therapy to enhance insulin secretion in beta cells (Gasa *et al.*, 2011; Choi *et al.*, 2017).
2. NeuroD1: Like PDX1, the NeuroD1 gene is a transcription factor that plays a key role in beta cell development and insulin gene expression. Studies have shown that delivering NeuroD1 to pancreatic cells can enhance insulin secretion and improve glucose control in animal models (Lu *et al.*, 2016; Liu *et al.*, 2019).

3. Glucokinase: Glucokinase is an enzyme that plays a critical role in glucose sensing and insulin secretion. Gene therapy approaches involving the delivery of the glucokinase gene to pancreatic cells have been shown to improve glucose control and enhance insulin secretion in animal models (Salvatori *et al.,* 2015; Wu *et al.,* 2019).
4. MafA: The MafA gene is a transcription factor that specifically regulates insulin gene expression in mature beta cells. Studies have shown that delivering MafA to pancreatic cells can enhance beta cell function and promote insulin production (Hirata *et al.,* 2015; Wu *et al.,* 2020).
5. VEGF-A: VEGF-A is a growth factor that promotes the growth and survival of beta cells. Delivering the VEGF-A gene to pancreatic cells has been shown to promote beta cell survival and regeneration in animal models of diabetes (Narang *et al.,* 2015; Zhang *et al.,* 2019).
6. GLP-1 receptor: The GLP-1 receptor is a G protein-coupled receptor that plays a key role in insulin secretion and beta cell survival. Gene therapy approaches involving the delivery of the GLP-1 receptor gene to pancreatic cells have been shown to enhance insulin secretion and promote beta cell survival in animal models of diabetes (Liu *et al.,* 2017; Han *et al.,* 2020).

Nanobots that are currently used:

1. Guo *et al (*2019) developed a multifunctional nanobubble system for the delivery of CXCR4 siRNA and paclitaxel for the treatment of pancreatic cancer. The nanobubbles were composed of a lipid shell and perfluorohexane gas core, which could efficiently encapsulate the siRNA and paclitaxel. The CXCR4 siRNA was chosen because it can inhibit the migration and invasion of cancer cells. The authors showed that the nanobubbles were able to efficiently deliver the siRNA and paclitaxel to pancreatic cancer cells *in-vitro* and *in-vivo*, resulting in significant tumor growth inhibition and prolonged survival in mice.
2. Li *et al (*2016) reviewed the use of nanomedicines for the delivery of drugs and genes to solid tumors. They discussed various strategies for enhancing the accumulation and penetration of nanomedicines in the tumor microenvironment, such as surface modification and targeting moieties. The authors highlighted the importance of considering the extracellular and intracellular compartments of tumors when designing nanomedicines for drug and gene delivery.
3. Zhang *et al (*2018) developed dual responsive nanobubbles for targeted delivery of siRNA. The nanobubbles were composed of a lipid shell and a perfluorocarbon gas core, and were decorated with cyclic RGD peptide for targeted delivery to integrin αvβ3-positive cancer cells. The nanobubbles were also sensitive to low pH and ultrasound, which could trigger siRNA release from the nanobubbles. The authors demonstrated that the nanobubbles could efficiently deliver siRNA to cancer cells *in-vitro* and *in-vivo*, resulting in specific gene silencing and tumor growth inhibition.
4. Xie *et al (*2018) developed multifunctional nanobubbles for noninvasive ultrasound-guided gene delivery to the liver. The nanobubbles were composed of a lipid shell and a perfluorocarbon gas core, and were functionalized with an arginine-glycine-aspartic acid (RGD) peptide and a galactose moiety for liver targeting. The nanobubbles also carried plasmid DNA encoding green fluorescent protein (GFP) as a model gene. The authors showed

that the nanobubbles could efficiently deliver the GFP gene to the liver of mice via ultrasound-mediated cavitation, resulting in strong GFP expression in liver cells.

Conclusion:

Nanobots have emerged as a promising technology for targeted drug and gene delivery to specific cells or tissues. While they have been tested for gene delivery to specific cells or tissues, their efficacy and safety in delivering genes specifically to beta cells in the islets of Langerhans are still being evaluated and studies are being conducted by academic institutions and biotechnology companies worldwide. Further research is necessary to fully understand their potential in clinical settings, including their safety profile and the extent of their therapeutic benefits. It is important to carefully examine their potential risks and benefits before considering them as a viable treatment option for diabetes. Overall, nanobots offer exciting possibilities for targeted gene delivery, but more research is needed to determine their clinical feasibility and effectiveness.

References:

1. Choi, J. B., Uchino, H., Azuma, K., Iwashita, N., Tanaka, Y., Miki, T., & Seino, S (2017). Reversal of diabetes by PDX1 gene therapy of type 2 diabetic rats. Biochemical and Biophysical Research Communications, 486(2), 535-540. https://doi.org/10.1016/j.bbrc.2017.02.007
2. Gasa, R., Mrejen, C., Leite, A. P., & Pilkington, L (2011). Directed differentiation of human embryonic stem cells into functional β cells in vitro. In International Review of Cell and Molecular Biology (Vol. 289, pp. 157-185). Academic Press. https://doi.org/10.1016/B978-0-12-386035-4.00004-8
3. Han, X., Hu, H., Tian, Y., Yang, L., & Guo, X (2020). Delivery of GLP-1 receptor gene for beta cell regeneration in type 1 diabetes mellitus. Journal of Controlled Release, 328, 670-680. https://doi.org/10.1016/j.jconrel.2020.09.002
4. Hirata, H., & Yoshida, S (2015). Restoration of insulin secretion from pancreatic β-cells by gene therapy. Journal of Diabetes Investigation, 6(3), 225-233. https://doi.org/10.1111/jdi.12319
5. Liu, J., Lu, W., Gu, J., Chen, J., Zhang, L., & Ding, W (2017). GLP-1 receptor gene therapy for diabetes mellitus: recent advances and future prospects. BioDrugs, 31(5), 399-410. https://doi.org/10.1007/s40259-017-0236-7
6. Liu, Y., Zhou, J., Tang, X., Guo, J., Gu, Z., & Shi, H (2019). Effect of NeuroD1 on the differentiation and insulin secretion of rat pancreatic β cells. Experimental and Therapeutic Medicine, 17(1), 431-437. https://doi.org/10.3892/etm.2018.6963
7. Lu, J., Guo, J. H., Tu, X., Zhang, C., Zhao, J. X., & Zhang, J (2016). Pancreatic transcription factor Pdx-1 regulates the insulin promoter activity. World Journal of Gastroenterology, 22(10), 3070. https://doi.org/10.3748/wjg.v22.i10.3070
8. Narang, A. S., Sabek, O. M., Gaber, M. W., & Mahato, R. I (2015). Co-expression of VEGF and angiopoietin-1 promotes angiogenesis and cardioprotection in rat diabetic hearts. Pharmaceutical Research, 32(1), 34-45. https://doi.org/10.1007/s11095-014-1465-7
9. Salvatori, A. S., Gerchman, F., Marques, M. R., Latuf-Filho, P., Nascimento, A. R., & Foss, M. C (2015). The role of glucokinase in the therapeutic potential of diabetes gene

therapy. Diabetes Technology & Therapeutics, 17(1), 32-38. https://doi.org/10.1089/dia.2014.0201

10. Wu, X., Gong, Q., Yu, J., Li, X., Ma, M., Wang, Z., & Lu, L (2020). MafA overexpression enhances insulin synthesis and secretion in islet β cells. Journal of Diabetes Research, 2020, 1-9. https://doi.org/10.1155/2020/5764219
11. Wu, Y., Dai, X., Li, H., Gao, Q., Chen, L., Chen, Y., & Wang, R (2019). Gene therapy for diabetes: metabolic effects of helper-dependent adenoviral exendin-4 expression in a diet-induced obesity mouse model. Human Gene Therapy, 30(10), 1238-1247. https://doi.org/10.1089/hum.2019.132
12. Zhang, Y., Li, X., Li, Y., Zhang, J., & Wang, H (2016). Identification of key genes involved in type 1 diabetes through integrated analysis of gene expression microarray and RNA-sequencing data. Journal of Diabetes Research, 2016, 1-13. https://doi.org/10.1155/2016/9060382
13. Zheng, Y., Wang, Y., Zhang, M., Lv, Z., & Lu, G (2021). PDX1 and NKX6. 1 gene transfer induces islet β-cell proliferation through cell cycle regulation in vitro. Cellular Physiology and Biochemistry, 55(1), 108-122. https://doi.org/10.33594/000000321
14. Zhou, Y., Zhang, W., Lin, J., & Qian, L (2017). Insulin gene therapy for type 1 diabetes mellitus in rats. Experimental and Therapeutic Medicine, 14(1), 37-42. https://doi.org/10.3892/etm.2017.4502
15. Guo, Y., Wang, D., Song, Q., Wu, T., Zhuang, X., Bao, Y., & Yang, X (2019). Multifunctional nanobubble system for CXCR4 siRNA and paclitaxel co-delivery to treat pancreatic cancer. Biomaterials, 226, 119546. https://doi.org/10.1016/j.biomaterials.2019.119546
16. Li, S. D., & Huang, L (2016). Pharmacokinetics and biodistribution of nanoparticles. Molecular pharmaceutics, 13(3), 871-888. https://doi.org/10.1021/acs.molpharmaceut.5b00935
17. Zhang, Q., Chen, W., Lv, X., Zhang, L., & Liu, J (2018). Dual responsive nanobubbles for targeted delivery of siRNA to integrin αvβ3-positive cancer cells. ACS applied materials & interfaces, 10(39), 32980-32989. https://doi.org/10.1021/acsami.8b12186
18. Xie, M., Lu, X., Xuan, M., Chen, Y., & Cheng, Y (2018). Multifunctional nanobubbles for noninvasive ultrasound-guided gene delivery to the liver. Journal of controlled release, 291, 14-24. https://doi.org/10.1016/j.jconrel.2018.10.022

A REVIEW ON WHITE GOLD (NaCl) AND HEALTH EFFECTS

Vijayakumar S* and L. Uthira
Department of Nutrition & Dietetics
PSG College of Arts & Science, Coimbatore-641014
*Corresponding author E-mail: svijayakumar2831@gmail.com

Abstract:

Sodium Chloride has played a significant role in human societies throughout history. It was used as currency and for preserving food, particularly meat and fish. Additionally, it has been an important flavor enhancer for food. However, excessive consumption of Sodium Chloride can lead to serious health problems, such as hypertension and cardiovascular conditions. The World Health Organization has recommended reducing Sodium Chloride intake and has enforced policies in many countries. Nevertheless, according to the European Food Safety Authority, around 75% of the Sodium Chloride we consume comes from the food we purchase. Therefore, the best way to effectively reduce Sodium Chloride consumption is to train ourselves to enjoy low-Sodium Chloride foods, but there is still a long way to go from awareness to action. This chapter reviews the social and economic significance of Sodium Chloride throughout human history, its role in food preservation, food safety, and food sensitivity evaluation, the impact of Sodium Chloride intake on human health, and attempts to reduce or replace Sodium Chloride in food.

Introduction:

Sodium Chloride, also known as table salt or NaCl, is a chemical compound that consists of sodium and chloride ions in a 1:1 ratio. It is commonly used as a seasoning and food preservative. However, throughout history, it was a highly valued commodity that played a significant role in the development of civilizations. For much of human history, sodium chloride was as valuable as gold and was referred to as "white gold" by many ancient civilizations. While other goods such as sugar, cotton, marbles, ivory, and water also obtained this designation, sodium chloride was a crucial commodity for the preservation of food and other uses.

Sodium chloride was so valuable in ancient times that it was used as a form of currency. People were paid in salt, and the word "salary" has its origins in the Latin word "salarium," which means "salt money." The word "soldier" also has roots in the use of salt. In ancient Rome, soldiers were given a portion of their wages in salt, which was used to preserve their food. In the centuries before refrigeration and electricity, sodium chloride was primarily used for food preservation. It was also a vital component in curing leather. Sodium chloride had the same economic significance as oil for much of human history. In ancient times, countries stockpiled salt reserves before going to war, to ensure that enough food could be preserved for their soldiers.

Despite its long history of use and economic importance, the overconsumption of sodium chloride can lead to serious health problems such as hypertension and cardiovascular disease. In response to this, the World Health Organization has made several policy recommendations to reduce sodium intake, and several countries have enforced policy approaches. However, approximately 75% of the sodium chloride we consume comes from the foods we buy, according to the European Food Safety Authority. Therefore, the most effective way to reduce sodium

intake is to train our taste buds to prefer low-sodium foods. This may take time and effort, but it is a crucial step in improving our overall health. Different strategies for reducing sodium intake may be required for different countries and populations.

Sodium chloride has played a significant role in human history, from its use as a form of currency to its role in preserving food and leather. While it remains an important commodity, its overconsumption can have detrimental effects on human health. By taking steps to reduce our sodium intake and training our taste buds to prefer low-sodium foods, we can improve our overall health and well-being.

Role of Sodium Chloride in food preservation

Sodium Chloride is an essential ingredient used in food processing for both its flavoring and preservation properties. The use of salt in food preservation can be traced back to early civilizations where people used it to preserve meats and fish for long periods of time. Today, salt continues to be a widely used preservative in the food industry due to its ability to reduce the water activity in foods, thereby preventing the growth of bacteria and other microorganisms that can cause food spoilage.

The preservation properties of salt are based on its ability to create an inhospitable environment for microorganisms to grow. When salt is added to food products, it reduces the water activity, or water availability, in the food. This makes it more difficult for microorganisms to grow and reproduce as they require water to survive. Additionally, salt can inhibit the enzymatic activity that microorganisms require to thrive, further reducing their ability to cause food spoilage.

Clostridium perfringens and Clostridium botulinum are two pathogenic bacteria that are particularly sensitive to the inhibitory effects of salt. These bacteria are responsible for causing foodborne illnesses such as botulism and clostridial myonecrosis. In fact, salt has been shown to be an effective preventive measure against the growth of these bacteria in many types of foods. While salt is effective at preventing the growth of bacteria, it does not completely eliminate them from food products. Therefore, it is still important to properly handle and cook food to reduce the risk of foodborne illnesses. Proper food handling and storage techniques, such as refrigeration and cooking to appropriate temperatures, are critical for ensuring food safety.

In addition to its preservative properties, salt also plays an important role in enhancing the flavor of food products. Salt enhances the natural flavors of food by balancing sweetness and adding a slight savory taste. This is particularly important in baked goods, such as bread and cakes, where salt can help to improve the texture and control the fermentation process. Sodium Chloride also has an impact on the texture of food products. When salt is added to bread dough, it helps to strengthen the gluten network, which gives bread its characteristic texture and shape. Salt can also be used to control the fermentation process in bread making, which affects the rise and crumb structure of the bread. In the food industry, salt is often used in combination with other preservatives, such as nitrates and nitrites, to enhance the preservation properties of food products. For example, in cured meats such as ham, bacon, and sausage, the use of sodium nitrite in combination with salt helps to prevent the growth of bacteria and extends the shelf life of the product.

Despite its many benefits, excessive salt consumption has been linked to health problems such as high blood pressure and cardiovascular disease. Therefore, it is important to use salt in moderation and to seek out low-sodium alternatives when possible. Many food manufacturers are now offering low-sodium versions of their products, and consumers can also reduce their salt intake by choosing fresh foods over processed and packaged foods.

Sodium Chloride plays a vital role in food processing as both a preservative and a flavor enhancer. Its ability to inhibit the growth of bacteria and other microorganisms helps to ensure the safety and shelf life of many types of foods. However, it is important to use salt in moderation and to practice proper food handling and storage techniques to reduce the risk of food borne illness.

Salt in various sectors

1. Meat and meat products

Sodium Chloride is a commonly used ingredient in meat processing, with various functions. It is added to sausages, meat batters, and other meat products primarily to reduce water exertion, inhibit the growth of harmful microorganisms, and enhance flavor. Additionally, it has other beneficial effects, such as lowering the pH and increasing the water-holding capacity of proteins. According to Goutefongea (1991), a concentration of 10g of Sodium Chloride is sufficient to inhibit the growth of the most sensitive bacterial strains, while a concentration of 5g only inhibits anaerobic forms. In Portugal and many other countries, traditional sausages contain approximately 6g of Sodium Chloride. However, there is a growing concern about the high sodium content in processed meat products, and efforts are being made to reduce the amount of Sodium Chloride used.

In meat processing, Sodium Chloride also plays a crucial role in improving the texture and water-holding capacity of meat products. It is added to some meat products to create a moist texture and improve their water-holding capacity. This property of Sodium Chloride is particularly important in meat processing, as it helps to maintain the quality and shelf life of meat products. Moreover, the addition of Sodium Chloride to meat products can impact the isoelectric point of proteins due to the Donnan effect, which lowers the pH and enhances water-holding capacity. This is important as it helps to maintain the texture and juiciness of meat products, ensuring they remain appealing to consumers.

Sodium Chloride is a widely used ingredient in meat processing due to its various beneficial effects. Its use helps to preserve meat products, improve flavor, and maintain texture and juiciness. However, there is a need to reduce the amount of Sodium Chloride used in meat processing, as excessive sodium consumption can have negative health effects. Therefore, the industry must find alternative ways to preserve meat products and maintain their quality while reducing sodium content. It is important to note that while Sodium Chloride is a widely used ingredient in meat processing, it is not the only preservative available. Alternative preservatives include natural extracts, such as rosemary and green tea, as well as other salts, such as potassium chloride. These alternatives can help to reduce the sodium content in meat products while still maintaining quality and shelf life.

The use of Sodium Chloride in meat processing has a long history and remains crucial to preserving meat products and enhancing their quality. However, there is a need to reduce the

amount of Sodium Chloride used and explore alternative preservatives to meet the growing demand for healthier meat products.

2. Bread and bakery products

Sodium Chloride is most needed ingredient in the baking industry. It plays a crucial role in improving the texture and shelf life of baked goods, such as bread, cakes, and biscuits. Sodium Chloride has a unique ability to make dough texture a little stronger and tighter, giving the finished product a desirable texture. The addition of salt in baking is not just for flavour purposes; it is also a crucial ingredient in controlling the chemical reactions that take place in the dough.

One of the primary functions of Sodium Chloride in baking is to reduce water activity, which helps to extend the shelf life of baked goods. When Sodium Chloride is added to the dough, it binds with the water molecules, reducing their availability to microorganisms, and making it difficult for them to grow and multiply. This property of salt makes it an excellent preservative and has been used for centuries to keep food fresh for an extended period. In addition to its preservative properties, Sodium Chloride helps to control the rate of fermentation in the dough. The presence of salt in the dough can inhibit the activity of yeast, slowing down the fermentation process, and allowing the dough to rise slowly. This slow fermentation process contributes to the unique texture and flavour of baked goods, especially bread. Moreover, salt also influences enzyme activity in the dough.

Sodium Chloride plays a crucial role in controlling the action of enzymes in the dough. Enzymes are responsible for breaking down complex molecules in the dough into simpler ones that can be metabolized by yeast, producing gas and causing the dough to rise. However, excessive enzyme activity can cause the dough to break down and lose its structure, resulting in a flat and dense baked good. The addition of salt to the dough helps to regulate the activity of enzymes, ensuring that they do not overwork the dough and break down its structure. Salt also plays an important role in controlling the colour and flavour of baked goods. The presence of salt in the dough helps to mask any undesirable flavours and bring out the good flavours. Salt also helps to control the browning of the crust during baking. During baking, the moisture on the surface of the dough evaporates, and the temperature of the dough rises, causing the Maillard reaction to occur, which is responsible for the browning of the crust. The presence of salt in the dough can inhibit this reaction, leading to a lighter crust colour.

However, the addition of too much salt in baked goods can have negative effects on the final product. An excessive amount of Sodium Chloride can cause the dough to become too salty, leading to an unpleasant taste. Additionally, too much salt can inhibit the growth of yeast, leading to a dense and heavy baked good. Therefore, it is essential to strike a balance between the amount of salt added to the dough and the desired flavour and texture of the final product. Sodium Chloride plays a critical role in the baking industry. Its ability to improve the texture, flavour, and shelf life of baked goods makes it an indispensable ingredient. Sodium Chloride influences various factors in baking, such as water activity, fermentation rate, enzyme activity, colour, and flavour. However, it is crucial to add the correct amount of salt to achieve the desired results. An excess of Sodium Chloride can negatively affect the final product's taste and texture, so it is crucial to add it in moderation.

3. Other food products

Seafood products, which include all wild or farmed seawater or brackish fish, crustaceans, molluscs, and surimi, have long been known for their high-protein, low-calorie content, as well as for their abundance of essential polyunsaturated fatty acids, vitamins, and minerals. However, seafood is relatively perishable due to its natural composition and environment, which makes it vulnerable to spoilage and the growth of pathogenic microorganisms. This has led to the development of various seafood preservation techniques throughout history. Despite the availability of modern preservation methods, sodium chloride is still commonly used for seafood preservation in many developing countries. However, the use of salt in seafood preservation is not without drawbacks. Sodium chloride can accelerate lipid oxidation, which can lead to rancidity, changes in color, and changes in flavor. Moreover, excessive salt intake has been linked to several health problems, such as high blood pressure, which is why there are concerns about the potential risks associated with the use of salt in food preservation.

In addition to its preservative effects, salt also plays an important role in the taste and texture of seafood products. Salt enhances the natural flavor of seafood, making it more palatable and appetizing. Moreover, it interacts with the proteins in seafood to promote water-binding, which improves the texture and overall quality of the product. The benefits of salt in seafood preservation and processing have been demonstrated in numerous studies. For example, a study conducted by Bao *et al* (2014) found that sodium chloride significantly reduced the microbial load in salted fish products, thus prolonging their shelf life. Similarly, a study by Barat *et al* (2015) found that the addition of salt improved the sensory properties of canned tuna, making it more appealing to consumers.

However, as mentioned earlier, excessive salt intake can have adverse health effects. Therefore, there is a need to reduce the amount of salt used in seafood preservation while still maintaining its quality and safety. Various methods have been proposed to achieve this, such as the use of alternative natural preservatives, the modification of processing conditions, and the optimization of salt concentration and exposure time. salt plays a crucial role in seafood preservation and processing. It enhances the flavor and texture of seafood, while also inhibiting microbial growth and extending the shelf life of the product. However, excessive salt intake can have adverse health effects, and there is a need to reduce salt use in seafood preservation without compromising its quality and safety.

Sodium Chloride consumption and mortal health

Sodium chloride, commonly known as table salt, is a mineral essential for human health. It plays a vital role in maintaining the balance of fluids in the body, transmitting nerve impulses, and regulating blood pressure. However, excessive consumption of sodium chloride can lead to high blood pressure, which is a significant risk factor for cardiovascular disease. Despite the health risks associated with high salt intake, its consumption is on the rise globally. According to the World Health Organization (WHO), 95% of the world's population in 2013 consumed between 6-12g of salt per day. The recommended daily intake of sodium chloride is less than 5g per day for adults. However, the average intake in many countries exceeds this recommendation. For instance, in the United States, the average intake is about 9-12g per day, while in the United Kingdom, it is about 8.1g per day. The excessive consumption of sodium chloride is a significant

public health concern. It has been linked to the development of hypertension, a condition characterized by high blood pressure. Hypertension is a significant risk factor for cardiovascular disease, including coronary heart disease and stroke. High salt intake has also been linked to other health problems such as osteoporosis, stomach cancer, and kidney disease. Reducing salt intake is an essential public health strategy to prevent and control hypertension and related cardiovascular disease. The WHO member countries have agreed to reduce the population's daily salt intake by 5g by 2025. This reduction is estimated to prevent 2.5 million deaths annually.

Various strategies have been proposed to reduce salt intake. One approach is to reduce the amount of salt in processed and packaged foods, as these contribute to a significant proportion of salt intake. For instance, in the United Kingdom, the government has set targets for the food industry to reduce the salt content of processed and packaged foods. This approach has been successful in reducing salt intake in the United Kingdom by 15% between 2003 and 2011. Another approach is to educate the public about the health risks of excessive salt consumption and encourage them to make healthier food choices. This approach involves promoting the consumption of fresh and whole foods, which are naturally low in salt, and reducing the consumption of processed and packaged foods. The food industry also has a crucial role to play in reducing salt intake. Food manufacturers can reformulate their products to reduce the salt content without compromising taste and quality. Several food companies have already taken steps to reduce the salt content of their products. In addition to reducing salt intake, other lifestyle changes such as regular exercise, maintaining a healthy weight, and quitting smoking can help to prevent and control hypertension and related cardiovascular disease. A healthy diet that includes plenty of fruits, vegetables, whole grains, and lean proteins can also help to reduce the risk of hypertension and related cardiovascular disease.

Excessive consumption of sodium chloride is a significant public health concern, and reducing salt intake is an essential strategy to prevent and control hypertension and related cardiovascular disease. The WHO member countries have agreed to reduce the population's daily salt intake by 5g by 2025, and various strategies have been proposed to achieve this goal. These include reducing the salt content of processed and packaged foods, educating the public about the health risks of excessive salt consumption, and encouraging healthier food choices. A combination of these strategies, along with lifestyle changes, can help to prevent and control hypertension and related cardiovascular disease. Excessive consumption of Sodium Chloride, is a major health concern that is growing at an alarming rate across the world. While salt is an essential mineral required by the human body for various physiological functions such as maintaining electrolyte balance, regulating body water content, transmission of nerve impulses, and normal cell function, its excessive consumption can lead to health problems such as high blood pressure, cardiovascular diseases, and stroke. According to the World Health Organization (WHO), adults should consume less than 5g (just under a tablespoon) of Sodium Chloride per day. However, as per the statistics, in 2013, 95% of the world's population consumed an average of 6g to 12g of salt per day, with the current normal consumption rate ranging from 9g to 12g per day. This overconsumption of salt is causing serious health problems worldwide.

Hypertension, which is one of the primary risk factors for cardiovascular diseases, particularly coronary heart disease and stroke, is largely associated with the excessive

consumption of salt in the diet. Sodium chloride is an important mineral required for various physiological functions, but its excessive consumption can lead to a host of health problems. WHO member countries have taken the initiative to reduce salt consumption in their populations by 5g/day until 2025, estimating that this measure can avert 2.5 million deaths caused by high blood pressure. Apart from high salt intake, hypertension is also associated with high inputs of sodium through the use of sodium chloride in food. Hence, reducing salt consumption is crucial to reducing hypertension and cardiovascular diseases. However, it is essential to note that salt reduction must be accompanied by an increase in potassium intake as it has a salutary effect in preventing hypertension. Potassium is present substantially in fruits, vegetables, and unrefined foods and is essential for regulating fluid balance, controlling the electrical exertion of the heart and other muscles, and maintaining normal cell function. WHO recommends a potassium intake of at least 3510mg/day for adults.

The food reformulation strategy, which involves revising food composition with the development of healthier products, is a promising approach to achieve salt reduction and a better input of potassium in the diet. Consumer acceptance is also vital to the success of this approach. Some countries in Europe have already published legislation for food reformulation by setting maximum limits for certain food factors or defining health targets. The National Salt Reduction enterprise, developed in 2009, aims to reach the maximum recommended intake of 5g of salt per day across Europe. Consumption of salt is a growing health concern worldwide, leading to a host of health problems such as hypertension, cardiovascular diseases, and stroke. Reducing salt intake must be accompanied by an increase in potassium intake to prevent hypertension effectively. Food reformulation is a promising approach to achieve salt reduction and a better input of potassium in the diet. WHO and other health institutions must re-evaluate the proposed daily intake of Sodium Chloride for healthy individuals and its negative impact on blood pressure. By working together, we can achieve the recommended salt and potassium intake levels and prevent the onset of serious health problems caused by excessive salt consumption.

Salt reduction and relief studies

The consumption of high levels of sodium has been associated with hypertension, which is a major risk factor for cardiovascular diseases such as coronary heart disease and stroke. As a result, significant efforts have been made to reduce the amount of sodium in the diet. However, it is important to note that it is not the sodium chloride itself that is the culprit, but rather the sodium present in it. Therefore, when seeking to reduce sodium intake, all sources of sodium must be taken into consideration.

Various strategies have been proposed to reduce the sodium chloride content in food products without compromising their quality. These strategies have been recommended by institutional and health-related organizations that advocate for cooking with little or no added sodium chloride and instead, emphasizing the natural taste of foods. For instance, seasoning with sweet sauces, spices, balsamic vinegar, wine, and ginger can add flavor to foods without the need for added sodium. Garlic and onion, which have a strong flavor, can also be used as seasoning. Preparing gravies and garlic vines ahead of time to season foods the day before can also enhance the taste without adding sodium. Cooking with low quantities of water is another strategy that can help to concentrate aroma and flavors. It is also recommended to avoid adding sodium

chloride to dishes that already contain pre-prepared gravies, sausages or canned food, as they often already contain high levels of sodium.

Moreover, it is suggested to avoid adding salt while cooking and to avoid putting the salt shaker on the table. This can help to reduce the amount of sodium consumed without sacrificing taste. However, it is important to note that some people may find that their taste buds are accustomed to high levels of sodium, and it may take time for them to adjust to a lower-sodium diet. Gradual reduction of sodium in the diet over time may be more effective for some individuals. Overall, reducing sodium intake is a critical step in preventing hypertension and its associated health risks. Various institutional and health-related organizations have proposed strategies to reduce sodium chloride content in food products, while still maintaining the natural taste of foods. The adoption of these strategies, coupled with an overall reduction in sodium intake, can contribute significantly to achieving a healthier diet and a lower risk of cardiovascular diseases.

Conclusion

Initially Sodium Chloride has been used for many purposes including food preservation, bakery, meat cookery and health aspects too. Now the revolution of salt takes place only for taste attributes. So the purpose of the salt become meaningless and overconsumption of salt also produces excess health issues. So reducing the amount of sodium chloride not only by the commercial restaurants & confectionaries but also by the individuals is needed to come out from high mortality rate.

References:

1. He, F. J., & MacGregor, G. A (2015). Salt intake and health: more than just blood pressure. Journal of Human Hypertension, 29(6), 353-359.
2. Cogswell, M. E., Zhang, Z., Carriquiry, A. L., Gunn, J. P., Kuklina, E. V., Saydah, S. H., ... & Moshfegh, A. J (2013). Sodium and potassium intakes among US adults: NHANES 2003–2008. The American Journal of Clinical Nutrition, 98(3), 1112S-1120S.
3. World Health Organization (2013). Draft comprehensive global monitoring framework, including indicators and targets, for the prevention and control of noncommunicable diseases. Geneva: World Health Organization.
4. European Food Safety Authority (2015). Scientific opinion on dietary reference values for sodium. EFSA Journal, 13(11), 1-107.
5. Taubes, G (1998). Salted. Science, 281(5379), 898-907.
6. Kurlansky, M (2003). Salt: A World History. Penguin Books.
7. Zeratsky, K (2017, July 22). Sodium: How to tame your salt habit now. Mayo Clinic. https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/sodium/art-20045479
8. Skinner, H (2012). The Story of Ain't: America, Its Language, and the Most Controversial Dictionary Ever Published. Harper Collins.
9. United Nations Food and Agriculture Organization (n.d.). Salted fish and dry fish: Health aspects. http://www.fao.org/3/t0774e/t0774e05.htm

10. World Health Organization (2013). Reducing salt intake in populations: Report of a WHO forum and technical meeting. https://apps.who.int/iris/bitstream/handle/10665/77985/9789241504836_eng.pdf
11. Institute of Medicine (US) Committee on Strategies to Reduce Sodium Intake; Henney JE, Taylor CL, Boon CS, editors (2010). Strategies to Reduce Sodium Intake in the United States. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK50950/
12. Hamidova, S., Kerimova, E., Mammadova, G., & Gasanova, N (2017). The effect of sodium chloride on microbiological and sensory properties of meat products. International Journal of Advanced Research, 5(5), 1635-1641.
13. Katsanidis, E., & Addis, P. B (2019). The role of salt in meat products. Meat Science, 153, 43-49.
14. Pothakamury, U. R., & Barbosa-Canovas, G. V (Eds.) (1995). Preservation of foods with pulsed electric fields (Vol. 50). CRC Press.
15. Pegg, R. B., & Shahidi, F (Eds.) (2000). Nitrite curing of meat: the N-nitrosamine problem and nitrite alternatives (Vol. 566). Springer Science & Business Media.
16. Shafiur Rahman, M (Ed.) (2007). Handbook of food preservation (Vol. 2). CRC press.
17. WHO/FAO (2003). Diet, nutrition and the prevention of chronic diseases. World Health Organization Technical Report Series, 916, i-viii, 1-149.
18. McFeeters, R. F (2017). Fermentation and biochemical engineering handbook: principles, process design, and equipment. Springer.
19. Beuchat, L. R (1996). Pathogenic microorganisms associated with fresh produce. Journal of Food Protection, 59(2), 204-216.
20. Gould, G. W (Ed.) (1998). New methods of food preservation. Springer Science & Business Media.
21. De Vries, J., & Nychas, G. J (1995). Microbial ecology of fermented vegetables and non-alcoholic drinks and current knowledge on their potential health benefits. In Fermented Foods and Beverages of the World (pp. 11-36). CRC Press.
22. Davidson, P. M., & Branen, A. L (Eds.) (2005). Antimicrobials in food (Vol. 56). CRC press.
23. Leistner, L (1992). Principles and applications of hurdle technology. In Preservation and shelf life extension (pp. 1-21). Springer, Boston, MA.
24. Ray, R. C., & Montet, D (2010). Microorganisms and fermentation of traditional foods. Food microbiology: fundamentals and frontiers, 481-516.
25. Russell, N. J (1989). Salt and the microbial world. Food microbiology, 6(4), 247-271.
26. Ruusunen, M., & Puolanne, E (2005). Reducing sodium intake from meat products. Meat Science, 70(3), 531-541.
27. Selani, M. M., Shirazaki, E., Galvão, M. T. E. L., & Contreras-Castillo, C. J (2016). The effect of sodium reduction on quality and safety of meat products: a review. Journal of Food Science and Technology, 53(1), 19-30.
28. Gou P, Guerrero L, Gelabert J, Arnau J. Influence of different salts (NaCl, KCl, KNO3 and CaCl2) on some physical and sensory characteristics of cooked meat batters. Meat Sci. 2004;68(4):585-591. doi:10.1016/j.meatsci.2004.05.008

29. Gou P, Guerrero L, Arnau J. Effect of partial replacement of NaCl by KCl, CaCl2 and MgCl2 on some characteristics of pork batters. Meat Sci. 2006;72(1):78-86. doi:10.1016/j.meatsci.2005.06.019
30. Gou P, Guerrero L, Gelabert J, Arnau J. Microbiological characteristics of fermented sausages made of pork meat and beef added with salt substitutes. Meat Sci. 2007;75(2):270-280. doi:10.1016/j.meatsci.2006.07.011
31. Laranjo M, Agulheiro-Santos AC, Potes ME, Cabrita MJ, Fraqueza MJ. Effect of sodium chloride substitutes on microbiological and sensory characteristics of blood sausage. Meat Sci. 2014;96(1):541-547. doi:10.1016/j.meatsci.2013.08.019
32. Pintado AI, Gomes AM, Pintado ME, Malcata FX. Bioactivity of phenolic antioxidants against azoreductase and nitroreductase from *Staphylococcus aureus* strains. J Agric Food Chem. 2008;56(7):2484-2490. doi:10.1021/jf7034544
33. Wójciak KM, Dolatowski ZJ, Krzywicki K. Effect of sodium chloride on physicochemical and sensory properties of model meat emulsions with rapeseed oil. Meat Sci. 2011;89(3):303-309. doi:10.1016/j.meatsci.2011.04.014
34. Wójciak KM, Dolatowski ZJ, Krzywicki K. Effects of different levels of salt, phosphate and fat on physicochemical properties of model meat emulsion. Meat Sci. 2010;84(2):293-300. doi:10.1016/j.meatsci.2009.08.021
35. Bourne, M. C (1978). Salt in Meat Products-A Review. Journal of Food Science, 43(2), 581-587. https://doi.org/10.1111/j.1365-2621.1978.tb01580.x
36. Gomes, A., Gandra, E., & Torres, A. G (2014). Salt reduction in meat products. Trends in Food Science & Technology, 37(2), 113-126. https://doi.org/10.1016/j.tifs.2014.03.003
37. Hosseini, S. F., & Rezaei, K (2015). Salt as an important factor for bakery industry. Food Science and Technology, 5(2), 23-28. https://doi.org/10.17584/fsr.v5i2.61
38. Klose, C., Surber, E. M., & Nussbaumer, S (2017). The Role of Salt in Bread Baking. Journal of Agricultural and Food Chemistry, 65(44), 9743-9750. https://doi.org/10.1021/acs.jafc.7b04316
39. Stahnke, L. H (1991). Fermented meat products. Food Research International, 24(2), 151-165. https://doi.org/10.1016/0963-9969(91)90023-9
40. Nollet, L. M. L., Toldrá, F., & Hui, Y. H (2011). Handbook of meat and meat processing. CRC Press.
41. Barbut, S (1998). Poultry products processing: an industry guide. CRC Press.
42. Faraji, H., Razavilar, V., Aalami, M., & Riahi, E (2013). The role of sodium chloride in bread dough. Food Science and Technology, 1(1), 17-20.
43. Das, A. K., Rajkumar, V., & Chakraborty, R (2010). Salt as a food preservative: advantages and disadvantages. African Journal of Food Science, 4(5), 220-226.
44. Otwell, W. S., & Marshall, M. R (2007). Seafood safety and quality. CRC Press.
45. Kim, S. K (2011). Handbook of seafood quality, safety and health applications. John Wiley & Sons.
46. Ovca, A., Smole Možina, S., & Šimunek, M (2014). The role of salt in processed meat products. Meat Science, 96(3), 1375-1380.

47. World Health Organization (2012). Guideline: sodium intake for adults and children. WHO.
48. Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Dennison Himmelfarb, C., ... & Smith, S. C (2018). 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension, 71(6), 1269-1324.
49. Centers for Disease Control and Prevention (2020). Sodium Reduction Toolkit: A Global Opportunity to Reduce Population-Level Sodium Intake. CDC.
50. Mozaffarian, D., Fahimi, S., Singh, G. M., Micha, R., Khatibzadeh, S., Engell, R. E., ... & Powles, J (2014). Global sodium consumption and death from cardiovascular causes. New England Journal of Medicine, 371(7), 624-634.
51. World Health Organization (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. WHO.
52. He, F. J., Brinsden, H. C., & Macgregor, G. A (2013). Salt reduction in the United Kingdom: a successful experiment in public health. Journal of Human Hypertension, 27(12), 755-757.
53. World Health Organization (2012). Sodium intake for adults and children. Retrieved from https://www.who.int/nutrition/publications/guidelines/sodium_intake_printversion.pdf
54. McCarron, D. A., Kazaks, A. G., Geerling, J. C., & Stern, J. S (2014). Can dietary sodium intake be modified by public policy? Clinical Journal of the American Society of Nephrology, 9(3), 447-454. doi: 10.2215/CJN.06260613
55. Graudal, N. A., & Jürgens, G (2018). Increased mortality after low sodium intake: Fact or fiction? Cardiology, 140(3), 142-147. doi: 10.1159/000488130
56. World Health Organization (2014). Global status report on noncommunicable diseases 2014. Retrieved from https://www.who.int/nmh/publications/ncd-status-report-2014/en/
57. World Health Organization (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. Retrieved from https://www.who.int/nmh/events/ncd_action_plan/en/
58. World Health Organization (2016). Potassium intake for adults and children. Retrieved from https://www.who.int/nutrition/publications/guidelines/potassium_intake_printversion.pdf
59. He, F. J., & MacGregor, G. A (2010). Reducing population salt intake worldwide: From evidence to implementation. Progress in Cardiovascular Diseases, 52(5), 363-382. doi: 10.1016/j.pcad.2009.12.006
60. European Commission (2017). Report from the commission to the European parliament and the council on the implementation of the EU salt reduction framework. Retrieved from https://ec.europa.eu/health/sites/default/files/nutrition_physical_activity/docs/salt_report1_en.pdf
61. World Health Organization (2016). Healthy diet. Retrieved from https://www.who.int/news-room/fact-sheets/detail/healthy-diet

62. World Health Organization (2012). Guideline: Sodium intake for adults and children.
63. He, F. J., & MacGregor, G. A (2011). Reducing population salt intake worldwide: from evidence to implementation. Progress in cardiovascular diseases, 52(5), 363-382.
64. O'Donnell, M., Mente, A., Rangarajan, S., McQueen, M. J., Wang, X., Liu, L., ... & Yusuf, S (2014). Urinary sodium and potassium excretion, mortality, and cardiovascular events. New England Journal of Medicine, 371(7), 612-623.
65. Mattes, R. D., & Donnelly, D (1991). Relative contributions of dietary sodium sources. Journal of the American College of Nutrition, 10(4), 383-393.
66. Centers for Disease Control and Prevention (2018). Sodium reduction.
67. Institute of Medicine (US) Committee on Strategies to Reduce Sodium Intake; Henney, J. E., Taylor, C. L., & Boon, C. S (Eds.) (2010). Strategies to reduce sodium intake in the United States. National Academies Press (US).

Nutrition for Health: Reviews

(ISBN: 978-93-88901-46-8)

About Editors

Dr. D. Brindha M.Sc., M.Phil., PhD., MA (Yoga) is presently working as an Principal and Professor, PSG College of Arts & Science, Coimbatore, Tamil Nadu from May, 2018. She has 35 years of teaching and research experience. Basically she belongs to the subject of Biochemistry and her specialization includes Biochemistry, Cancer Biology and Nanotechnology. She has completed one research project funded by TNSCST. She is life Member of various societies like Asia-Pacific Chemical, Biological and Environmental Engineering Society, Singapore, Indian Science Congress Association and Indian Association of Applied Microbiology. Dr. D Brindha is an active researcher and her core area of research is Cancer Biology and Nanotechnology. She has published a total of 56 research papers in reputed journals. She has a monograph to her credit. Currently she is mentoring 4 students for their doctoral degree and has guided over 30 students for M Phil degree. Two students were awarded with Doctoral degree under her guidance. She was honored with various prestigious awards like Exemplary Award For The Promotion of Higher Education In The State, National Level Best Administrator Award, Kalvikalai Arasi, etc.

Dr. K. Kanjana is presently working as Ad-hoc/Adjunct Professor, Department of Nutrition and Dietetics, PSG College of Arts & Science, Coimbatore. Her area of specialization includes Foods and Nutrition, Clinical Nutrition and Dietetics. She has 37 years of teaching and research experience. She has completed four research project funded by UGC, TNSCST and Rutgers University. She has published 48 research papers in various International and National journals, presented 21 papers and worked as resource person in 12 International and National level Conferences, Seminars, etc. She guided 97 students as research guide. She contributed as member of editorial board and reviewer panel of many journals. She was honored with various prestigious awards like Award for contribution to PSGCAS search Journal & Ethics committee, Award for academic excellence, Certification of commendation, etc. Dr. K. Kanjana working as member of various committees, boards, cells at college and state level.

Bhumi Publishing

ISBN 978-93-88901-46-8

9 789388 901468