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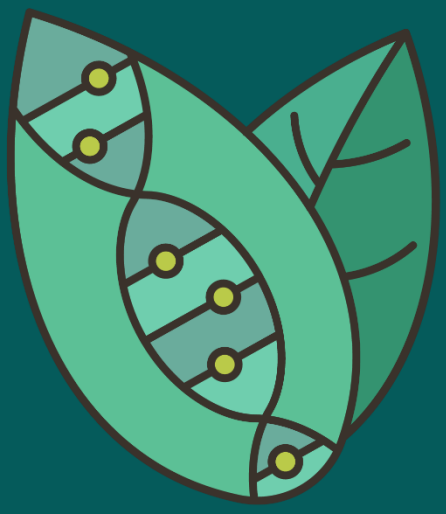

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PREFACE

In the vast expanse of the scientific realm, the field of Life Science stands as a beacon of curiosity, continually illuminating the mysteries of existence. As we embark on a journey through the pages of "Research Trends in Life Science," we find ourselves in the midst of a dynamic and ever-evolving landscape, where the boundaries of what we know are constantly pushed, reshaped, and expanded.

This compilation serves as a testament to the relentless pursuit of knowledge within the Life Sciences—a multidisciplinary domain that spans from the microscopic intricacies of cellular processes to the grand tapestry of ecosystems. Our exploration delves into the forefront of scientific inquiry, where researchers, scholars, and visionaries collaborate to unravel the complexities of life itself.

Within these pages, you will encounter a diverse tapestry of research trends, each thread weaving a narrative of discovery and innovation. From cutting-edge advancements in genomics and biotechnology to profound insights into ecological dynamics, this book encapsulates the pulse of contemporary Life Science research.

As we navigate through the chapters, we invite you to witness the convergence of traditional wisdom and modern methodologies, where technology and tradition dance in harmony to reveal the secrets of the living world. The preface sets the stage for a compelling odyssey, inviting readers to engage with the unfolding stories of breakthroughs, challenges, and the relentless pursuit of understanding life in all its forms.

Embark with us on this intellectual expedition, where the boundaries between the known and the unknown blur, and the pursuit of knowledge becomes a shared endeavor that transcends disciplinary confines. "Research Trends in Life Science" beckons you to join the exploration of the frontiers of life, where every discovery is a stepping stone toward a more profound comprehension of the intricate web of existence.

Editors

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DIVERSITY OF CYANOBACTERIA AND PROXIMATE ANALYSIS OF *ANABAENA VARIABILIS* NTSS17 ISOLATED FROM PADDY FIELD OF SOORIYUR, TIRUCHIRAPPALLI DISTRICT

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Abstract:

The composition, distribution and biodiversity of cyanobacteria isolated from rice field situated in Sooriyur in Tiruchirappalli district. Members belonging to Cyanophyceae, and Cholorophyceae were occurred. The Cyanophyceaean genera include *Oscillatoria princeps*, *Chroococcus turgidus*, *Spirulina subsalsa* and Cholorophycean such as *Cosmarium sp.*, *Pediastrum sp.* and *Scenedesmus dimorphous* were dominant in their distribution. *Anabaena* is a genus of filamentous cyanobacteria that exists as plankton. *Anabaena variabilis* NTSS17 was isolated and identified morphologically by using Light Microscopic and Confocal Laser Scanning Electron Microscopic (CLSM). Biochemical analysis of *Anabaena variabilis* NTSS17 was analyzed and quantified highest concentration showed carbohydrate, protein, lipids and amino acids. *Anabaena variabilis* NTSS17 potent ecofriendly environmental purpose.

Keywords: Paddy field, Biodiversity, *Anabaena* variabilis, NTSS17, Proximate composition

Introduction:

Cyanobacteria are notable ecosystem engineers with an evolutionary history stretching back at least 2.15 billion years [1, 2]. They are often referred to as ‘miniature factories’ of the biological world and represent an alternative resource of a variety of bioactive compounds, lipids/fatty acids, proteins, enzymes, pigments and compounds of pharmaceutical and nutraceutical value [3,4].

According to the accepted morphological and ecological descriptions by Desikachary [5], the genus *Anabaena* is identified based on the ‘‘Presence of uniform trichomes, absence of sheath or presence of more or less diffluent sheath forming free or floccose or soft mucilaginous thallus [6]. Biochemical studies in cyanobacteria demonstrated a significant correlation between the morphological complexity of species and their fatty acid composition. Therefore, chemotaxonomic markers such as lipids and their fatty acids have been considered as

complementary methodologies, since they provide interesting information for taxonomic position assignment and some correlations with morphological properties of cyanobacteria [9-13]. They contain a diverse array of pigments, which have tremendous potential as natural dyes, antioxidants, nutritional and pharmaceutical supplements in bio industry [14].

Paddy fields are a suitable environment for the growth of diazotrophic, oxygenic cyanobacteria, by providing suitable temperature, nutrient and water facilities. In return, cyanobacteria provide a large amount of nitrogen and phosphorus, which are the most required nutrients at the time of rice cultivation. Association and importance of cyanobacteria with paddy fields have been known from ancient times. Appearance of cyanobacteria in paddy fields is observed during the early stage of sowing due to continuous supply of water, rich nutrient availability, and high level of CO_2 that favours the growth of cyanobacteria. Apart from nitrogen and phosphorous fixation, they also excrete several organic acids that increase and maintain soil fertility, nutrient availability and water holding capacity [15-17].

Considerable amount of research have been carried out on diversity and distribution of the cyanobacterial flora of rice fields of India [18-20]. Due to the high levels of combined nitrogen in the sea, the heterocyst us forms were rarely seen in the east coast of India [21, 22]. Hyper saline environment namely salt shows wide range of cyanobacterial species and the maximum diversity of the cyanobacterial flora in the Gulf of Mannar region correlated well with the higher salinity, pH and nutrient content of the water [22, 23]. Microalgae and cyanobacteria, until recently in oblivion, uncared for and unrecognized, have shot into fame and popularity owing to a host of their innate properties that make them ideal organisms for use in a variety of ways to meet our needs and to promise us a bright future.

But still there are many paddy fields that remain unexplored, at various locations of paddy fields from Sooriyur, Tiruchirappalli, Tamil Nadu has also received due attention it deserves. Hence, the present attempt has been made to study the diversity of cyanobacteria and proximate analysis of *Anabaena variabilis* NTSS17 isolated from paddy field of Sooriyur Tiruchirappalli, Tamil Nadu.

Material and Methods:

Algae collection, isolation and maintenance

The sampling site of paddy field of Sooriyur Village (10º40’ 29.84ºN Latitude 78º45’ 32.90ºE) is located in Tiruchirappalli District of Tamil Nadu State, India. The collected samples were assessment of biodiversity of microalgae by light microscopy. Cyanobacteria microphotographs were captured at Micros Austria MCX500 microscope in 100X magnification. Morphological observations [presence and absence of sheath, shape and size of the vegetative cells, heterocysts, akinetes (if present), position, and branching pattern] of the axenic cultures of

cyanobacterial strains were made using an Olympus KIC22809 microscope fitted with a digital camera, as described by Desikachary [5].

The isolated cyanobacteria isolates were brought to the microalga germplasm, Department of Microbiology, Bharathidasan University, Tiruchirappalli District maintained with specific culture conditions. The purified isolate were grown in BG11 medium [24]. All the collected cyanobacteria isolates were maintained according to the method of Singh *et al.* [25] at pH 6.8, 24°C ± 2°C light intensity of 14.4 ± 1Wm^2 a 16/8 h light/dark cycle photoperiod for further study.

Confocal laser scanning microscope

Morphological and structural observation of *Anabaena variabilis* was analyzed by using confocal microscope (Carl Zeiss).

Mass cultivation

Anabaena Variabilis NTSS17 was mass cultured in a 20 liter tank and incubated at 24°C ± 2°C along with cool white Sylvania 40W T12 fluorescent lamps at an intensity of 14.4 ± 1Wm2 for a 16/8 h light/dark cycle for further experiments.

Extraction and estimation of Phycobilins from *Anabaena* sp. NTSS17

100 mL of homogenized log phase *Anabaena variabilis* NTSS17 was centrifuged at 8000 rpm to obtain pellet. The pellet was suspended in sterile water and sonicated for 2 min at maximum output and duty cycles. The resulting extract was centrifuged at 8000rpm for 30 min and filtered through Whatman No1 filter paper to remove cell debris. Amount of phycobiliproteins was measured as described by Bennett and Bogorad [26].

Characterization of Phycobilins of *Anabaena* sp. NTSS17

UV–visible spectral analysis

Sample of 1 ml was withdrawn at different time intervals and surface plasmon resonance of phycobilins was characterized using a UV–Vis spectrophotometer (Agilent Technology, USA) at the resolution from 200 to 800 nm.

Proximate analysis of *Anabaena variabilis* NTSS17

Anabaena variabilis NTSS17 were harvested by means of centrifugation. The estimation of carbohydrates was done by the method of Dubois *et al.* [27]. The estimation of total protein was done by the method of Lowry *et al.* [28]. The estimation of total lipids was done by the method of Sato [29].

Results:

In this present study, we collected microalgae from Paddy field of Sooriyur, Tiruchirappalli district. The Collected microalgae identified using light and confocal microscope and biodiversity assessment was were detected from the all locations. From the biodiversity assessment, total of 59 microalgal species belonging to two families Cyanophycean and

Chlorophyecean family (Table 1). Out of the 59 isolates detected, 18 isolates were green algae and 41 isolates were cyanobacteria. As per the diversity and abundance of microalgae, the members of the order of Nostocales were the dominant species in all sites. The most abundant groups were cyanophyta by *Anabaena constricta, Anabaena variablis, Aphanocapsa musicola, Oscillatoria calcuttensis Oscillatoria earli, Oscillatoria terebriformis, Nostoc ellipsosporum* and *Spirulina subsalsa),* Chlorophyta *20% dominated by Ankistrodesmus sigmoides, Pediastrum simplex, Scenedesmus quadricauda, Scenedesmus major, Scenedesmus dimorphous and Coelastrum sphaericum* (Figure 1 and 2).

Table 1: List of microalgae species in sooriyur paddy field

Name of Species		**Sampling stations**		
Cyanophyceae		**Station 1**	**Station 2**	**Station 3**
1	*Anabaena constricta*	+	+	++
2	*Anabaena variablis*	+	-	+++
3	*Aphanocapsa biformis*	-	+	+
4	*Aphanocapsa microscopica*	-	-	+
5	*Aphanocapsa musicola*	++	-	+
6	*Aphanocapsa pulchara*	+++	-	-
7	*Arthrospira platensis*	+	+	-
8	*Chroococcus minutus*	+	+	-
9	*Chroococcus turgidus*	+	-	+
10	*Gloeocapsa punctata*	-	-	+
11	*Lynbya majuscula*	+	++	+++
12	*Lynbya spiralis*	+	-	-
13	*Merismopedia elegans*	++	+	-
14	*Merismopedia glauca*	+	-	+
15	*Merismopedia tenuissima*	-	-	+++
16	*Microcystis aeruginosa*	-	+	+
17	*Microcystis robusta*	-	-	+
18	*Microcystis viridis*	+	-	++
19	*Nostoc ellipsosporum*	-	+	++
20	*Nostoc spongiaeforme*	-	+	-
21	*Oscillatoria acuminata*	+	-	+
22	*Oscillatoria acuta*	+	-	+
23	*Oscillatoria amphigranulata*	+	+	++
24	*Oscillatoria boryana*	+	++	+++
25	*Oscillatoria calcuttensis*	+	+	+++
26	*Oscillatoria chlorina*	-	+	++

27	*Oscillatoria earlei*	+	++	+++
28	*Oscillatoria limosa*	-	+	+
29	*Oscillatoria princeps*	+	++	+++
30	*Oscillatoria quadripunctulata*	-	+	++
31	*Oscillatoria rubescens*	-	-	+
32	*Oscillatoria sancta*	+	+	-
33	*Oscillatoria splendida*	-	+	++
34	*Oscillatoria subbrevis*	-	-	++
35	*Oscillatoria terebriformis*	+	+	+++
36	*Oscillatoria terebriformis*	+	+	+++
37	*Oscillatoria vizagapatensis*	-	+	+
38	*Phormidium ambiguum*	+	+	++
39	*Phormidium calcicola*	-	+	++
40	*Spirulina gigantea*	+	+	+++
41	*Spirulina subsalsa*	+	+++	++

Chlorophyceae		**S1**	**S2**	**S3**
1	*Ankistrodesmus sigmoides*	+	-	++
2	*Coelastrum sphaericum*	+	+	+++
3	*Cosmarium subtile*	-	+	++
4	*Golenkinia radiate*	-	++	+
5	*Pediastrum duodenarium*	-	+	++
6	*Pediastrum duplex*	+	+	+++
7	*Pediastrum muticum*	+	+	++
8	*Pediastrum perforatum*	-	+	++
9	*Pediastrum simplex*	+++	+	+
10	*Scenedesmus acuminatus*	-	+	++
11	*Scenedesmus arcuatus*	-	-	+
12	*Scenedesmus armatus*	+	+	++
13	*Scenedesmus aureus*	-	+	+
14	*Scenedesmus dimorphus*	++	+	+++
15	*Scenedesmus major*	++	++	+++
16	*Scenedesmus muzzanensis*	+	+	+
17	*Scenedesmus obliquus*	+	+	+
18	*Scenedesmus quadricauda*	+	+	+++

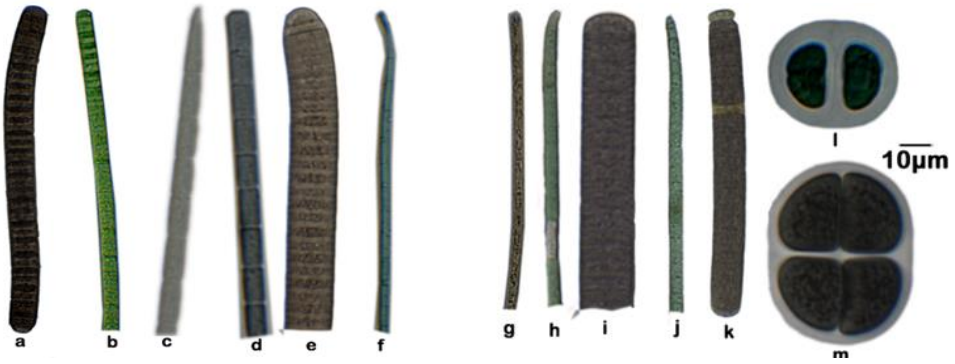

Figure 1: a*. Oscillatoria vizagapatensis*, b. *Oscillatoria subbrevis*, c. *Oscillatoria calcuttensis*, d. *Oscillatoria amphigranulata*, e and k *Oscillatoria princeps*, f. *Oscillatoria splendid*, g. *Oscillatoria quadripunctulata*, h. *Oscillatoria terebriformis*, i. *Oscillatoria limosa* j. *Oscillatoria acuta*, l. *Chroococcus turgidus*, m. *Chroococcus minutes*

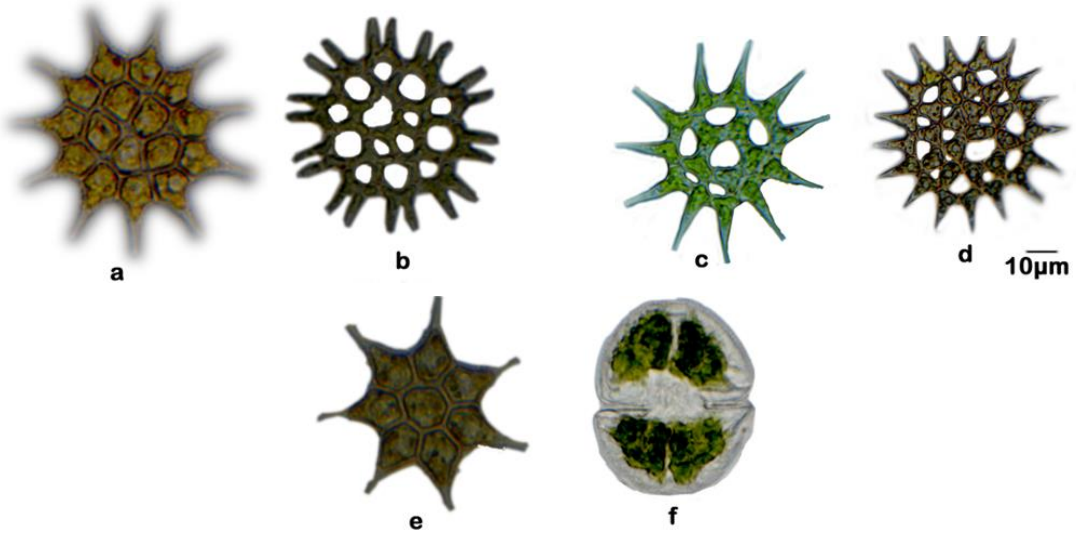

Figure 2: *a. Pediastrum duplex, b. Pediastrum simplex, c. Pediastrum duodenarium, d. Pediastrum muticum, e. Pediastrum perforatum, f. Cosmarium subtile*

The morphology and biodiversity of microalgae were documented with light microscope Figure 1 and 2. Isolation of cyanobacteria using the BG 11 medium by spread plate technique. Pick the pure isolates inoculated in enriched BG11 medium (Figure 3a and 3b). The purity of isolates was checked regular observation under microscope. The morphology and structural properties were visualized by light and confocal microscope. Confocal imaging was dealing that structural and fluorescence properties with high magnification. It confirms that shape and internal structure of the cyanobacteria (Figure 4a and 4b).

High biomass of *Anabaena variablis* was subjected to biochemical composition such Pigments, Carbohydrate, Protein, Lipid and amino acid. In this study, biomass of *Anabaena variablis* NTSS17 pigments was extracted by freeze thawing method using water. The extracted pigments estimated by UV –vis spectrophotometer. UV –vis spectrophotometer shows that

absorbance range in the form of scan (CARY 60 Agilent technologies). The peaks deal that Phycoerythrin (565.0nm), Phycocyanin (615.0nm) and Allophycocyanin (675.0nm) (Figure 5).

In biochemical composition, *Anabaena variablis* biomass was analyzed carbohydrate, protein, Lipid and free amino acid showed that 2.4mg/g, 2mg/g, Lipid 1.5mg/g and 0.43mg/g respectively (Figure 6).

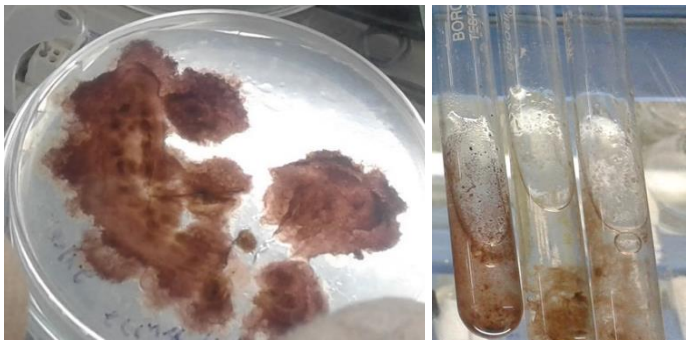

Figure 3: *Anabaena variablis* NTSS17 grown in BG 11 Agar surface (a) and BG 11 medium (b)

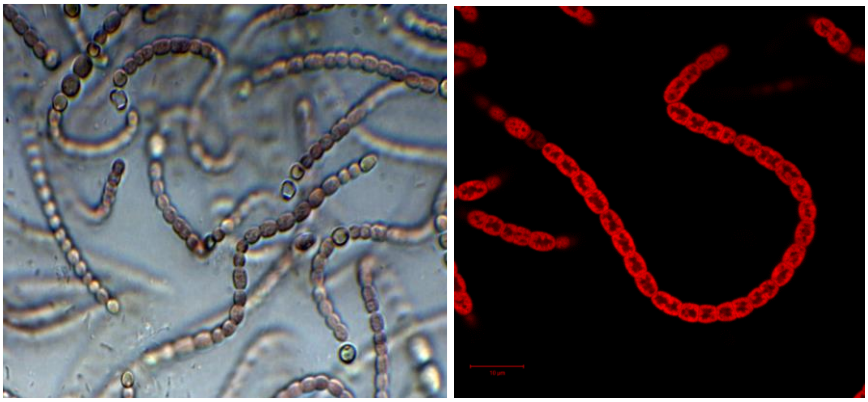

Figure 4: Light and Confocal Laser Scanning Microscopic identification of *Anabaena variabilis* NTSS17

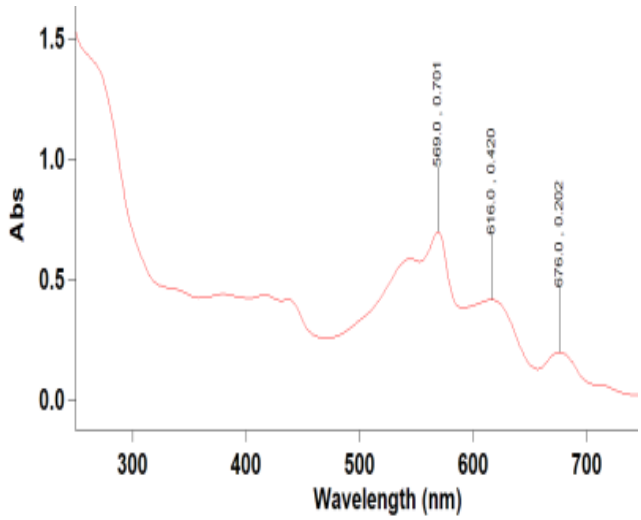

Figure 5: UV- spectrum of Phycobiliproteins of *Anabaena variabilis* NTSS17

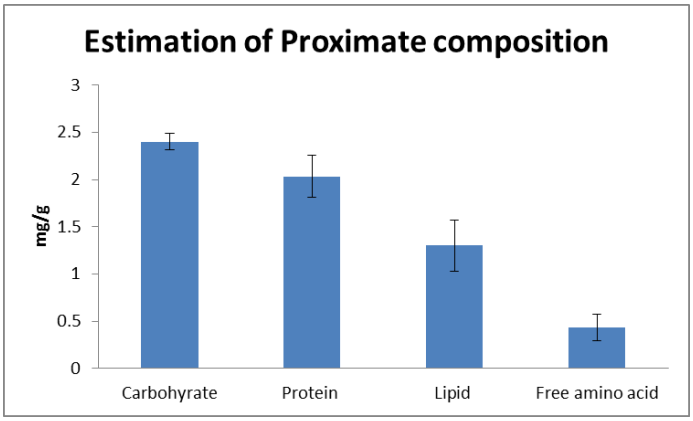

Figure 6: Proximate analysis of *Anabaena variabilis* NTSS17

Discussion:

In this study, an attempt was made to understand the diversity of paddy field of Sooriyur, Tiruchirappalli District. The present study brings out that the members of the orders *Nostocales* were in abundance. Cyanobacteria occupy a wide range of enhanced niches in terrestrial, fresh water, marine and hyper saline environments. Microphotograph of *Anabaena variabilis* NTSS17 observed under confocal and light microscope was documented. In confocal laser scanning microscopy specimens were viewed in plants running parallel to the line of sight; penetrate deep into light scattering tissues: advance remarkable three dimensional views at high resolution and improve the precision of microphotography [30]. Thus confocal microscopy has now emerged as a new technology which makes the morphological identification easier. These organisms also exhibit a high degree of morphological, physiological and developmental complexity. Their distinct biological characteristics made them model systems in understanding metabolic processes in biology.

The topical climate conditions with abundant light, temperature and nutrients were always boon for favouring the algal growth. Climate conditions and the availability of abundant nutrient source are the two major factors which determine the diversity of microalgae in the environment. In freshwater aquatic habitats, the nutrient levels were often found inexcess leading to eutrophic conditions due to drainage of rainwater, industrial wastewater, agricultural wastes and household wastes through sewage. Eutrophication often succeeded in rich aquatic ecosystems with weeds and algal blooms [31]. Research have been attempted to utilize alternative methods such as numericulture numerical code based on morphological and physiological characters or DNA analysis combined with morphological traits Stulp and Stam [32] for identification and characterization of *Anabaena*. One of the commonly observed genera in rice paddies is *Anabaena* which exists both in free living state and also as symbiont with the water fern *Azolla*. Many *Anabaena* strains exhibit high nitrogen fixing potential and have been the favorite organisms for genetic manipulation [33].

The present study shows the level of phycocyanin was more than phycoerythrin, allophycocyanain at 15th day of culture. Kaushik [34] reported that among various cyanobacterial strains, heterocystous forms *Anabaena variabilis*, *Aulosira fertilissima*, *Hapalosiphon* sp. and *Tolypothrix tenuis* can be exploited for phycobilins. Mishra *et al.,* [18] observed that highest chlorophyll content in *Anabaena* sp. in the soil. In the present study the level of carbohydrate, protein, free amino acids, lipids, were observed in *Anabaena variablis*. Li *et al.* [35] reported that the reducing sugars increased rapidly within hours after development began, suggesting that this stage may be the critical phase for the synthesis of carbohydrates and the fast growth of the cyanobacterium. This suggests that carbohydrates, especially non-reducing sugars, were the main components of the sheath. Tsygankov, 2007 [36] reported that among the heterocyst-forming genera, *Anabaena*, *Nostoc*, *Rivularia*, *Stigonema* and *Scytonema showed* nitrogen fixation. Therefore, its growth at low nitrogen concentrations is supported by the nitrogen-fixing process [37]. With this biochemical composition is not a surprise that this microorganism can be used as a food source for animal and humans [38]. Dried microalgal biomasses typically contain 46–63 % protein, 8–17 % carbohydrates, and 4–22 % lipids, as well as a wide range of vitamins and other biologically active substances such as bioactive peptides and pigments Filamentous cyanobacteria *Nostoc*, *Spirulina*, *Arthrospira*, *Anabaena*, *Aphanizomenon*, *Rivularia*, and many others are particularly attractive for the production of high quality biomass, because they represent a source of protein and a variety of chemicals and pharmaceuticals [39]. This study provided an understanding to the vast cyanobacteria diversity of paddy field and isolated and quantified biochemical composition of *Anabaena variabilis* could be explored for their utilization of wide biotechnological application.

Conclusion:

The biodiversity of microalgae in India are still very fragmentary, most of the paper focused on the marine microalgae but this study have focused on freshwater ecosystem particularly paddy field microalga biodiversity. We assessed the biodiversity of microalgae 41 and 18 belongs to Cyanophyceae and Chlorophyceae family were dominant in collected sampling sites. *Anabaena variabilis* NTSS17 showed the high concentration of carbohydrate followed to protein, lipid and free amino acid. In the present work we confirm that this isolates of *Anabaena variabilis* NTSS17 have to ecofriendly important, useful to medical application.

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ASCORBIC ACID SYRUP AS A DIETARY SUPPLEMENT, ITS PREPARATION AND EVALUTION

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Dietary Supplements introduction

Dietary supplements are products that are ingested in addition to the regular diet to provide additional health-promoting nutrients. According to the Dietary Supplement Health and Education Act a dietary supplement is a product that is intended to supplement the diet; contains dietary ingredients including vitamins, minerals, amino acids, herbs, and botanicals; is intended to be ingested as a pill, capsule, tablet, or liquid; and is labeled as being a dietary supplement. Dietary supplements are widely used. They are generally taken to improve and maintain overall health. For women in particular, supplements are intended to support bone integrity and prevent osteoporosis.

Used supplements are multivitamins, mineral supplements, calcium supplements, and omega-3 fatty acids or fish oil. About a quarter of the supplements are used based on the advice of health-care providers. Thus, most decisions to use supplements are made by the consumers themselves. Despite their popularity, the health benefits of dietary supplements are questionable. Lack of vitamins will certainly cause deficiency diseases such as scurvy, beriberi, pellagra, and rickets. However, the vitamin content of a normal well-balanced diet is sufficient to avoid these diseases. Studies aimed at determining effects of supplements often give conflicting results.

- **Dietary supplement definition:**

Dietary supplement meant to fulfill nutrition demands of the body These are available in the form of capsule, tablets or liquid formulation in the market. it acts as a supplement of diet. Dietary supplement fulfill the demand of nutrients in the body but nutraceuticals fulfill the demand of nutrient and prevent or treats the body from diseases too.

- **Herbals:**

Herbal products are the final finished products ready for use by the patients. These are also called as phytoformulation. These may contain active chemical constituents of herbal drugs or a part of herbal plant like aerial or underground part. Sometimes it is available in combination of both.

- **Syrups:**

A saturated solution of sucrose formed in purified water with the concentration of 66% w/w sugar is known as a simple syrup. These preparations are viscous and sweet in taste.

Due to the following reasons the syrup is frequently used:

1) It gets hydrolysed partially in reducing sugars, like laevulose and dextrose, thus, retards oxidation.
2) Bacterial growth, fungal growth and growth of molds are the main reasons of decomposition of vegetables material in solution from. Such contamination is prevented by due to its high osmotic pressure, which prevent decomposition of many vegetables substances.
3) It is advantageous to in corporate syrups in nauseous prepration as the sweetness of sugar makes the preparation palatable.

- **Definition of syrup:**

Syrups are sweet viscous, concentrated aqueous solution of sucrose or other sugars. Syrups containing therapeutic or medicinal agents are medicated syups, while syrups with flavours but no medicinal agents are flavouring o flavoured or non medicated syrups. Syrups containing 85%w/v or 66.7% w/v sucrose retards the growth of microorganism.

Classification of syrup

1) **Simple syrup:** It contain sucrose in purified water alone or in combination of other polyols such as glycerin or sorbitol. These substances are added in syrup to reduce the crystallization of sucrose or improve the solubility of excipients.
   Example. Orange syrup, lemon syrup, and ginger syrup.
2) **Medicated syrup:** It contains some added medicinal substances in the syrups and used for therapeutic purpose.
   Example. Chlorpheniramine maleate syrup, ephedrine sulphate syrup.
3) **Flavoured syrup:** These syrups comprise of different flavoured or aromatic substances which gives a pleasant smell and taste. These are usually added to the preparation for providing a flavor as a preservative or as a vehicle. it does not contain any pharmacological activity.
   Example. Cherry syrup, tolu balsam syrup.

Description of the vitamin C

Vitamin C, or ascorbic acid, is a water-soluble vitamin. It appears as a powder or crystal that is white or slightly yellow with a faintly acidic flavor. Ascorbic acid, also known as vitamin C, is insoluble in benzene, ether, and chloroform but freely soluble in water and only sporadically soluble in alcohol. L-ascorbic acid is the chemical name for ascorbic acid, or vitamin C. C6H806 is the empirical formula, and 176.13 is the molecular weight. Similar to what

is found in nature, vitamin C is now produced on a massive industrial scale. Corn or wheat are the best raw materials for making ascorbic acid, or vitamin C. Specialized companies convert this from starch to glucose and finally to sorbitol.

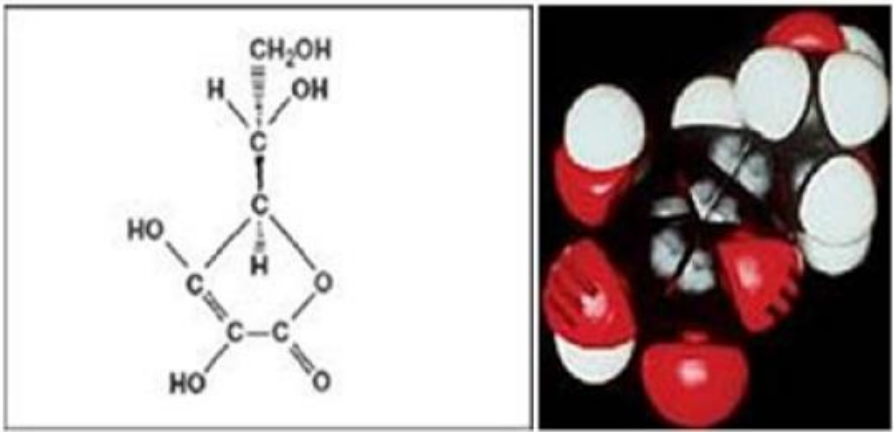
Physico-chemical properties

It is white to slightly yellowish crystalline powder, practically odorless, with a strong acidic taste.

The water-soluble vitamin C is probably the most well-known vitamin. Even before its discovery in 1932, physicians recognized that there must be a compound in citrus fruits preventing scurvy, a disease that killed as many as two million sailors between 1500 and 1800. Later researchers. Discovered that man, other primates and the guinea pig depend on external sources to cover their vitamin C requirements. Most other animals are able to synthesize vitamin C from glucose and galactose in their bodies. Nowadays, health has become the most important property of human's life. Commonly, diets with high contents of fruits are protective against several human diseases such as cardiovascular diseases and even cancer.

In aqueous solution, vitamin C is highly polar, easily soluble, and insoluble in less nonpolar solvents. The hydroxyl group on carbon 3 is easily ionized (pK1 = 4.17), whereas the hydroxyl group on carbon 2 is far more resistant to ionization (pK2 = 11.79), making it an acidic compound.

Ascorbic acid is easily and reversibly oxidized to dehydroascorbic acid, forming the ascorbyl radical anion, also known as semi dihydo ascorbate as an intermediate, according to the structure of L-ascorbic acid, which is depicted in Figure 1. Because dehydroascorbic acid is easily converted to ascorbic acid in the animal body, it has full vitamin C activity.



Structure of L –ascorbic acid.

Material and Methods:

The ascorbic acid was provided from the Faculty of Pharmacy, Uttar Pradesh Univesrity of Medical Sciences Saifai, Etawah, UP. The other excipients ware procured friom the local market.

Nutrients composition:

Ingredient	Quantity
Ascorbic acid	20 gm
Purified water	150 ml
Sugars	20 gm
Sodium benzoate (Preservative)	2 gm
Xanthan gum (Thickening agent)	1gm
Flavouring agent Lemon	Qs

Ascorbic acid syrup is used as a antioxidant which helps to protect your cells. It can also helps wound heal. It is prepared by dissolving ascorbic acid in purified water and then added sugars or excipients. further lemon tincture (Flavouring agent) is added to this and the desired syrup volume is adjusted.it is some time after filtrate the solution with the help of filter paper. If the syrup deteriorates and taste and smells like preservative used the syrup. Air tight containers are used for Ascorbic acid syrup. It should be kept at a place where the temperature does not exceed 25^0C.

Result and Discussion:

Clean and purified vehicle (water): To eliminate any microorganisms and eliminate particles from the water quality control system, the water is filtered and purified at the plant. Before making the syrup, technicians test the water frequently to make sure it is pure and clean. Prior to filling bottles, the syrup undergoes a rigorous filtering process.

Visual inspection: Oral drops and oral solution should be transparent and precipitate-free. Solution discoloration or cloudiness could be signs of microbial contamination or chemical deterioration. Oral suspension and suspension-containing drops exhibit physical instability as evidenced by the formation of flocculants or sediments that are difficult to disperse even after gentle shaking. Visual inspection reveals ascorbic acid syrup to be clear and precipitate-free. The syrup has a slightly yellowish hue.

pH: When the oral liquid preparation is administered, its pH needs to be at its ideal level. Traditionally, the acidity and alkalinity of an aqueous solution are represented by the ph value. Using a glass electrode, a reference electrode, and a digital or analog pH meter, one can potentiometrically determine the ph value of a solution. The ascorbic acid syrup has a pH of 5.8–6.8.

Density of syrup: The measure of how closely a material is packed together is called its density. The mass per unit volume is how it is defined. Density symbol D or ρ density formula

$$\rho = \frac{m}{v}$$

Where ρ is the density and m is the mass or v is the volume of object.

$$\rho = \frac{186.19}{200} = 0.930$$

Viscosity: The resistance of a fluid to deformation under shear stress is known as its viscosity. Pose is the fundamental unit of viscosity. A Newtonian liquid's viscosity can be measured using an Ostwald viscometer, which yields both dynamic and kinematic viscosities. The amount of time needed for a liquid to flow through a vertical capillary tube between two marks (A and B) is measured when the liquid flows by gravity. The test liquid's flow duration is contrasted with the time needed for a liquid with a known viscosity (typically water). It is possible to measure an unknown liquid's viscosity. Ascorbic acid syrup has a viscosity of 0.993 cm/Poise.

$$\eta_1 \frac{\rho 1 t 1}{\rho 2 t 2} \eta_2$$

Where,

ρ_1 =density of unknown liquid,kg/m^3 = 0.930

t_1 = time of flow of unknown liquid, s = 1.34

ρ_2 =density of the known liquid kg/m^3 = 0.998

t_2 =time of flow of known liquid, s = 1.26

η_2= viscosity of the known liquid pa.s = 1.002

$$\eta_1 = \frac{0.930 \times 1.34}{0.998 \times 1.26} \times 1.002$$

$$\eta_1 = \frac{1.246}{1.257} \times 1.002$$

=0.993 poise ans

Physical stability in syrup: The syrup needs to be physically stable, for example its appearance (no microbial growth or crystallization) and color must be entirely soluble in another ingredient.

Taste and odor (palatable): The solid material dissolves completely in liquid.

Creaming: No creaming presents the syrup.

Aggregation: No aggregation is the particle size.

Presence of contamination: No presence of any contamination of syrup.

Flocculation: No floccules is Present the syrup.

Sedimentation rate: Sedimentation is the process by which particles or floccules settle in liquid dosage forms due to gravity. The sedimentation method can be applied to sizes between 1 and 200 μm. sedimentation rate verify the formulation's physical stability. The formulation particles are not settled by the syrup's sedimentation rate.

Time(min)	Initial (vo)	Final (vu)
10	100 ml	100
20	100 ml	100

Sedimentation rate (f) = $\frac{Vu}{Vo}$ $\frac{100}{100}$ **=** 1

Where F = Sedimentation rate

Vu = ultimate volume of sedimentation

Vo = Initial volume of sedimentation

Sedimentation volume: F is denoted as sedimentation volume it is a dimensionless number. Sometimes, F is represented as, Vs and is expressed as percent –age. Similarly, when a measuring cylinder is used to measure the volume. in general, lower the sedimentation volume the better the physical stability. Sedimentation volume is used as one of the common basic quality control tools because it is easy to estimate. The sedimentation volume is ascorbic acid syrup 1 occurs.

Time(min)	**Initial (vo)**	**Final (vu)**
10	50 ml	50
20	50 ml	50

Sedimentation volume (f) = $\frac{Vu}{Vo}$ $\frac{50}{50}$ = 1

Where F = Sedimentation volume

Vu = ultimate volume of sedimentation

Vo = Initial volume of sedimentation

Degree of flocculation: it is defined as

$$\beta = \frac{F}{Fa} = \frac{\text{sedimentation volume of flocculated system}}{\text{sedimentation volume of defloculated system}}$$

$$\frac{100}{100} = 1$$

It gives some indication of how much flocculation there is. This suggests that the system being examined is one that has been deflocculated. However, β can take on any value bigger than 1. Generally speaking, physical stability increases with a higher value of β.It is a destructive testing method because adding a deflocculating agent, like electrolyte, turns a flocculated system into a deflaculated one.

Uses of ascorbic acid syrup:

- It is used to treat or prevent vitamin c deficiency.
- It is used to treat scurvy.
- Vitamin C plays an important role in maintaining the health of your blood vessels, bone and immune system.
- It can also help wounds heal. It is an oxidant. Which help to protect your cells. Vitamin C (Ascorbic acid) helps tissue and bone grow and repair themselves.

Side effects of ascorbic acid:

- Signs of an allergic reaction, like rash; itching; red, swollen, blistered, or peeling skin with or without fever; wheezing; tightness in the chest or swelling of the mouth, face, lips, tongue, or throat.
- Signs of kidney problems like unable to pass urine, change in how much urine is passed, blood in the urine, or a big weight gain.
- Dark urine or yellow skin or eyes.

- Back pain, belly pain, or blood in the urine. May be signs of a kidney stone.
- Upset stomach or Diarrhea.

Storage of ascorbic acid syrup:

Store at room temperature and protect from light. Protect from heat. Store in a dry place. Keep all drugs in a safe place. Keep all drugs out of the reach of children and pets.

Clinical pharmacology:

Ascorbic acid, also known as vitamin C, is an exogenous source that humans need for the synthesis of collagen and the repair of damaged tissue. The body oxidizes ascorbic acid (vitamin C) reversibly to produce dehydroascorbic acid (vitamin C). It is thought that these two vitamin forms play a significant role in oxidation-reduction reactions. Tyrosine metabolism, folic acid conversion to folinic acid, carbohydrate metabolism, protein and lipid synthesis, iron metabolism, cellular respiration, and infection resistance are all impacted by the vitamin.

Scurvy is caused by a deficiency of ascorbic acid, or vitamin C. The majority of affected structures are collagenous, and lesions form in blood vessels and bones. The symptoms of ascorbic acid (vitamin c) deficiency are totally reversed when ascorbic acid (vitamin c) is administered.

Energy is required for the two mechanisms of absorption, which are simple diffusion and active transport. Hexose transporters and sodium-dependent vitamin C transporters (SVCTs) are the two transporters that are involved. Renal excretion controls the absorption site, which is the distal small intestine. Typical daily doses of up to 100 mg are absorbed almost entirely through diet. The pituitary, adrenal, brain, leukocyte, and ocular glands have the highest concentrations of ascorbic acid.

Dosage and administration:

Vitamin C, or ascorbic acid, is typically taken orally. If subcutaneous, intravenous, or IM administration of the drug is not possible or if malabsorption is suspected, these routes of administration can be used. It has been reported that the optimal parenteral route for vitamin administration is via intramuscular injection (IM).

To reduce the risk of adverse reactions from intravenous injection, diluting the drug into a large volume parenteral solution such as glucose, normal saline, or water for injection is advise.

Adults should take 70–150 mg of vitamin C per day on average to be protected. Doses ranging from 300 mg to 1 g daily are advised in cases of scurvy.

Conclusion:

The prepared formulation was stable and the physicochemical properties was found to be significant. Vitamin C is necessary for numerous metabolic pathways in the body as well as for the optimal activity of a number of significant biosynthetic enzymes. On the other hand, the recommended daily allowance (RDA) for vitamin C is 75 mg for women and 90 mg for men, respectively. It is thought that this level is adequate to stop deficiency diseases, but not chronic

illnesses. Because of this, it is still unknown what the appropriate daily dosages of vitamin C are in order to prevent chronic illness. However, the Tolerable Upper Intake Level (UL) for vitamin C is 2000 mg/day, and exceeding this amount can be hazardous due to side effects like kidney stone formation, an increase in the excretion of uric acid, and iron overload.

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A REPORT ON DIFFERENT DIETARY SUPPLEMENTAND THEIR ROLE IN HEALTHY HUMAN BEINGS

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Introduction:

A dietary supplement is a manufactured good that is taken orally as a pill, capsule, tablet, powder, or liquid to complement a diet. To increase the amount of nutrients consumed, a supplement may contain synthetic or extracted nutrients from food sources. The nutrient class consists of fiber, vitamins, minerals, fatty acids, and amino acids. Additionally, animals can provide ingredients for supplements, like collagen from fish or chicken. Given that dietary supplements are products that contain one or more concentrated nutrients and are intended to supplement a person's daily diet when their diet is unbalanced and does not fall under the common food category, they are not considered medications.

Products that are consumed in addition to a regular diet to supply extra nutrients that are beneficial to health are known as dietary supplements. The Dietary Supplement Health and Education Act (DSHEA) defines a dietary supplement as a product that is meant to be taken orally as a pill, capsule, tablet, or liquid; it is labeled as such; and it contains dietary ingredients such as vitamins, minerals, amino acids, herbs, and botanicals. Supplements to diet are commonly used. Generally speaking, they are taken to enhance and preserve general health. Supplements are meant to support bone integrity and prevent osteoporosis, especially in women. Products with one or more concentrated nutrients intended to complement a person's regular diet are called dietary supplements.

Nutritional supplements are not classified as common foods, medications, or specialty diet items, nor are they meant for any particular group of individuals.

Supplements provide the body with the elements it lacks to maintain optimal physical and mental health. In essence, this would prevent weariness and injuries while also preventing the human system from becoming overworked.

Throughout the past ten years, there has been a significant increase in both the production and consumption of dietary supplements. The majority of these supplements come in powder or tablet form. While higher intake is thought to have health benefits, consuming too much can lead to higher vitamin and mineral levels that the body may not be able to handle. Consequently,

overindulgence in dietary supplements exposes consumers to health risks. If people take these supplements without a prescription or medical supervision, the issue gets worse.

Types of dietary supplements

Dietary supplements fall into one of two categories, according to the National Agency of Medicines, based on their intended use:

(1) Food supplements are foodstuffs that are consumed in addition to a regular diet.

Foodstuffs for specific nutritional purposes, such as beverages, are meant for specific population groups, such as healthy infants or children between the ages of two and five, or specific categories of people with disordered metabolism, or specific categories of people in particular physiological conditions. This is because of their unique composition.

Additionally, the supplements can be differentiated based on their source: natural or synthetic.

- According to their texture or available form, they are categorized as follows:
- Supplements containing vitamins and minerals; these can be taken separately or in combination as multivitamins or multiminerals.
- Protein supplements, which can be liquid or tablet-based and may or may not include fats, carbohydrates, vitamins, and minerals.
- Amino acids in all shapes and sizes.
- Meal supplements to help gain weight
- Wafers, biscuits, or powder substitutes for meals.
- Supplements of carbohydrates, either with or without vitamins and electrolytes.
- Supplements that are exempt from the "banned substance" list and have a natural anabolic effect.
- Growth hormone and other hormone "activator" supplements.
- Supplements containing essential fatty acids.
- Food additives or ingredients, such as kelp, yeast, or garlic

Vitamins

Vitamins do not produce energy however they act as a catalyst in the metabolic reaction that produces energy from the fuel stores and assist in the production of red blood cells, the repair of tissues and protein synthesis.

Protein dietary supplement

Athletes and body builders often use protein powders, which are supplements made up of vegetable proteins like soy protein isolate (SPI) and dairy proteins like casein and whey. Formulas for babies are also made from these proteins. With the exception of those who are allergic to cow's milk protein, dairy proteins don't seem to be very harmful, though excessive consumption can put a person in ketosis. On the other hand, there is a continuous discussion

concerning the possible safety of SPI. Among the 100 phytochemicals that are still attached to the protein isolate are the isoflavones, or weakly estrogenic compounds, genistein and daidzein, which are at the center of this controversy.

After consuming soy protein isolate (SPI), these compounds have the potential to reach estrogenic levels in infants fed soy formula, as well as in children, men, and postmenopausal women taking soy protein supplements. Potential early-developmental estrogenic effects that could lead to reproductive toxicity, infertility, demasculinization, and an increased risk of estrogen-responsive cancers like endometrial and breast cancer have been the focus of concerns. Contradictory results have been found in animal studies regarding the toxicity of soy formula and SPI.

Health claims

Supplements in cognitive function

Cognitive function is an intellectual process that deals with awareness, alertness, learning capacity, ability to recall and comprehend ideas within an individual. One study carried out in Australia assessed the effect of vitamin supplementation, i.e., folate, cobalamin, and pyridoxine, on cognitive function in 56 healthy young women with no external stressors. They were administered high doses of B vitamins (750 g folate, 15 g cobalamin, 75 mg pyridoxine) in tablets or capsules for five weeks. Based on the measured Information processing speed, memory, attention, and executive function, the result shows a supplementation group with folate, vitamin B6, and vitamin B12 enhance memory performance compared to the placebo group.

Supplement in cardiovascular diseases

Cardiovascular diseases are those diseases that are related to the reduced efficiency or malfunction of the heart. A series of 11 studies on the association of Omega 3 fatty acid supplements and CVD death risk were reviewed, with total patients of 39,044 participants divided in to 2 groups (i.e high risk and low risk group). The participants were supplemented with an average dose of omega 3 fatty acid containing Eicosa Pentaenoic Acid / Docosa Hexaenoic of 1.8 g/day with a mean follow up duration of 2.2 years. The result depicted that the risk of cardiovascular deaths and sudden cardiac death was significantly reduced at 0.87 95% confidence interval each, while non-fatal cardiovascular issues and all-cause mortality were also reduced at 0.92 95% confidence interval each. The reduced mortality advantage was mainly attributed to the studies that included patients at high risk. The relationship between the daily intake of omega-3 fatty acid supplements and clinical outcomes failed to be proved in a Meta-regression; this brings the scientists to the conclusion that omega-3 fatty acids supplements should be considered in the secondary prevention of CVD.

Dietary supplement in diabetes

Diabetes is a metabolic disorder characterized by high blood sugar level above the normal range, resulting from lack of insulin, insufficient insulin production, or insensitivity of insulin, thus affecting major nutrients, especially carbohydrates. Diabetes is a deadly disorder that can result in several health issues such as retinopathy, neuropathy, nephropathy, and other organ related failures. Researches have been done to ascertain whether dietary supplements affect to promote health condition in diabetic patients. Some of the dietary supplements tested in clinical trials include chromium, omega 3 fatty acid, and alpha lipoic acid [20]. Out of the three supplements mentioned above, only alpha lipoic acid's beneficial impact on diabetes has been shown to be effective. Studies on the effects of chromium and omega 3 fatty acid on diabetic patients have shown little to no efficacy. Sources of alpha lipoic acid include Brussels sprouts, potatoes, broccoli, Brussels sprouts, spinach, peas, and yeast.

Supplements such as vitamins, minerals, botanicals, and amino acids have provided healthier and safer replacements for traditional and costly medicines. These supplements are usually free from significant side effects, readily available, and inexpensive. The use of dietary supplements is anticipated to encourage good health and improve diabetic Patients. However, chromium supplements in a trial on diabetes and non-diabetic Patients. Diabetes patients, other studies on chromium deficient patients showed some benefit on the same markers above.

Supplement in athletes

Athletics is a sport, including ranges of games such as races, football, swimming, jumping, and throwing, etc. while an athlete is a person who is proficient in sports and other forms of physical exercise. Athletes need energy and body building food for their various respective sport requirements; they have an increased demand for nutrient dense food than average adults; this is to cover up for what has been lost during training or competition. But due to the insufficient time for most athletes, preparing nutrient dense food that will provide all requirements to their body may not be achieved. Coincidently, available dietary supplements seem to be a better option. For the athlete undergoing hard training, nutritional supplements are also seen as encouraging adaptations to train, allowing more regular and rigorous training by facilitating rehabilitation between training sessions, minimizing disease or injury induced interruptions to train, and helps to improve competitive performance. An increased intake of specific nutrients from food or supplementation may help to correct identified essential nutrient deficiency in the

Dietary supplement in cancer

Cancer is a generic name for abnormal cells with an abnormally rapid growth rate. It can be either malignant or benign cells, thus affecting health. Its significance makes it one of the most leading causes of mortality because of its rapid ability to spread to different parts of the

body. Cancer patients are always looking obsessed with effective medications, weather from modern functional foods, or traditional medicines. It is believed that cancer patients commonly used Herbal medicines and dietary supplements, but there is concerned over interaction with conventional medicine. It is not strange that the use of complementary and alternative medicines (CAM) such as herbal and dietary supplements is well documented and is common in patients, particularly those suffering from chronic diseases, i.e., cancer, among others.

A pigment “lycopene” in the carotenoid, responsible for a tomato's red color, effectively controlled cancer reported by a group of researchers at Harvard University in the mid-50s and attributed that lycopene effectiveness is as a result of its powerful antioxidative properties. This result's announcement by the research group caused a massive impact worldwide and paved the way for further studies in this field.

Calcium is another supplement widely used in several health issues. An observational study using meta-analysis supports an association between higher calcium intake and reduced risk of breast cancer. Higher calcium intake in a meta-analysis was associated with reduced risk of colorectal cancer.

Dietary supplement in obesity induced erectile dysfunction

Erectile dysfunction, also known as impotence, is a sexual dysfunction characterized by the inability to develop or maintain an erection of the penis during sexual intercourse, ED is the most common symptomatic manifestation of multiple diseases of sexual dysfunction that affect men after 40 years of age. It was estimated that over 150 million men were affected with one or more erectile related dysfunction worldwide, and by 2025 it was forecasted to affect around 250 million men. Dietary supplements play an important role in ameliorating this condition, with several researches shed light on their efficacy on erectile dysfunction.

A recent study has shown that S. platensis, when supplemented in food, provides benefits in healthy rats by promoting a positive effect on the NO signaling pathway in their aorta, it reduces both body adiposity in obese rats ileo and oxidative stress, and it also prevents damage on the erectile function that can be caused by a hypercaloric diet.

Dietary supplement in Bone Mineral Density (BMD)

The amount of bone mineral contained in bone tissue is called bone mineral density. It reflects the strength of bones in an individual represented by the availability of calcium of such an individual. Insufficient bone mineral density is associated with bone fragility at a later stage in life, which leads to a high risk of developing bone related diseases such as osteoporosis. To cater to this risk, individuals need to ingest food containing sufficient calcium at the early and mid-stage of life as a means of primary prevention. Intake food containing adequate calcium should extend through the elderly stage.

Several studies have proved the efficacy of calcium supplement in bone mineral density, one of which was conducted among adolescent girls aged 15-16 in New Zealand by Merrilees *et al.*, which aims to determine the effect of calcium on bone mineral density for 3 years (2 years supplementation and one year follow up). The result shows that the group of girls who ingested a supplement of dairy products containing mean calcium1160mg/day had an increase in BMD at trochanter, lumbar spine and femoral neck compare to those in the control group. The study further shows that the supplementation does not cause adverse health issues on body weight, blood lipid profile, fat, and lean mass. But, during the follow up period (a year after the supplementation period), it was found that the majority of the girls returned to their regular diet, which signifies their selection of the supplemented dairy product is hard to maintain.

Formulation

The different types, sizes, and packages of food supplements vary based on how they are consumed. There are chocolates, effervescent tablets, powders, capsules, tablets, oral ampoules, and mastics that can be purchased in syrup or another form. To be more precise, food supplements can be consumed in any of the subsequent ways:

In order to facilitate absorption and minimize damage to the active ingredient, the American Diabetes Association (ADA) lists the following options: (a) oral pills or powders for relatively quick absorption; (b) sublingual drops or oral disintegrated tablets; (c) nose spray or drops to further improve absorption; (d) injectables through intravenous and intramuscular injections for quick absorption and action; and (e) bone anchored for slow and gradual absorption and prolonged action.

Certain supplements cause irritation to the stomach and intestinal mucosa, while others are nearly entirely destroyed by the stomach's secretions. Some supplements are not well absorbed. For people who have trouble swallowing pills or capsules, powders and liquid preparations can be helpful. Spray-form supplements may result in severe local irritation or even aspiration of the lungs. Supplement injections are always carried out under a doctor's supervision. However, because surgical technique, monitoring, and laboratory control are necessary to prevent local inflammations and complications, bone anchored supplements are only permitted for use in hospitals. if using a supplement causes a noticeable shift in the color of the urine.

Future prespective:

Food supplement industries usually make supplements as a concentrated isolate or, in combination with another bioactive element; this practice is termed as a potential mistake that can lead to deviation of the bioactive agent from its expected health benefit; this is because bioactive agents tend to exhibit many differential physical and chemical properties when they are isolated from their natural environment, so it may not be possible to calculate and measure those

properties in an isolated form. For example, genistein from soya beans in its natural environment has Cross Linking Former (CLF) feature, but when it is isolated from its natural environment, this feature may not be possible to be determined analytically. Thujone" from Salvia officinalis is one of the major substances that trigger cancer proliferation. Does this mean we should not consume tea prepared from this plant? The answer is "No" because It shows a carcinogenic effect only when it is in an isolated form. Observably, when taken as tea in its natural environment containing more than 6,000 metabolites, thujone shows antibacterial and antiviral properties; these properties are entirely different compared to an isolated form of it. Furthermore, two studies reported that the efficacy of dietary supplements could be only achieved when taking through food consumption; both studies depicted dietary supplements in their natural environments have greater influence to confer health benefit than in an isolated form. We are likely to experience greater changes in dietary supplements' modulations and presentation through different techniques to achieve optimum health benefits and clear existing ambiguities on food supplements in the future.

In the near future, food supplements industries that produce isolates of concentrated bioactive agents (food supplements) may need to adjust the production mode and presentation of these supplements. In the other hand, the market trend of dietary supplements will push higher through the next decade as there is an apparent high demandfor such products as a result of multiple reasons we had stated earlier in this article. Some surveys have already forecasted the previous statement, one of which is Zoin market research which stated that the market value for dietary supplements worldwide had been estimated to be around 132.8 billion USD in 2016, with projections to hit approximately 220.3 billion USD in 2022

As food supplements' market share is always trending higher, scientific critics, including knowledge and awareness, are continuously increasing simultaneously. Therefore, we should anticipate more researches concerning many aspects of food supplements in the near future

Conclusion:

Scientists and medical experts concur that dietary supplements may be advantageous to human health in specific situations, but they shouldn't take the place of a full and well-balanced daily diet. There is a sizable market for dietary supplements meant to enhance a consumer's health or wellbeing. These goods aren't always safe for everyone, though. Supplements containing active ingredients that have pharmacological or physiological effects are likely to have side effects in people who are sensitive, just like regular drugs do. To prevent major medical consequences, more attention must be paid to side effects and possible interactions. Both doctors and users should review the most recent research before starting or recommending a regimen involving these drugs. The fact that a sizable portion of the general public uses dietary supplements should be known to medical professionals. In order to provide the best possible

medical care, they should thus ask patients about the supplements they take. Dietary supplement self-prescription should be avoided, and patients, the elderly, expectant mothers, young people, and individuals with disabilities should get information and advice on dietary supplementation from their physicians or pharmacists.

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DIGESTIVE CHURNA: A DIETARY SUPPLEMENT, IT'S FORMULATION AND EVALUATION

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Introduction:

A dietary supplement is a manufactured product intended to supplement one diet by taking a pill, capsule, tablet, powder or liquid. A supplement can provide nutrients either extracted from food source or that are synthetic in order to increase quantity of their consumption. The class of nutrient class includes vitamins, minerals, fibre, fatty acid and amino acid. Animals can also be a source of supplement ingredients such as collagen from chicken or fish. As dietary supplements are defined as the product that contain one or more concentrated nutrients whose goal is to supplement the individual's daily diet, when his diet is not balanced and does not belong to the category of common food, is not medicine.

Dietary supplements are products that are ingested in addition to the regular diet to provide additional health-promoting nutrients. According to the Dietary Supplement Health and Education Act (DSHEA), a dietary supplement is a product that is intended to supplement the diet; contains dietary ingredients including vitamins, minerals, amino acids, herbs, and botanicals; is intended to be ingested as a pill, capsule, tablet, or liquid; and is labeled as being a dietary supplement. Dietary supplements are widely used. They are generally taken to improve and maintain overall health. For women in particular, supplements are intended to support bone integrity and prevent osteoporosis.

Dietary supplements are products that contain one or more concentrated nutrients with the aim of supplementing an individual's daily diet, when his or her diet is not balanced or if nutrients are lacking.

Classification of dietary supplements

According to the National Agency of Medicines, dietary supplements are divided into two categories depending on their intended use (EUFIC 2009):

(1) Food supplements as food product which supplements the usual diet.

(2) Foodstuff for particular nutritional uses such as beverages, which due to their special composition, are intended for certain population groups e.g. for healthy infants or children

between the ages of two and five or for special categories of persons with disordered metabolism, or for categories of persons who are in a special physiological condition.

Supplements can also be distinguished depending on their origin (natural or synthetic). They are classified comparably to their texture or form in which they are available as follows:

(a) Vitamin and mineral supplements, whether they are combined in the form of multivitamins or multi-minerals or not,

(b) Protein supplements in the form of liquid or tablet in combination or not with carbohydrates, fats, vitamins and minerals,

(c) Amino acids of every form and composition,

(d) Supplements for gaining weight,

(e) Meal surrogates in the form of powder, wafers or biscuits,

(f) Carbohydrate supplements with or without electrolytes and vitamins,

(g) Supplements which have natural anabolic effect, and which are not included in the "banned substances list",

(h) "Activator" supplements of growth hormone and other hormones,

(i) Supplements of basic fatty acids,

(j) Foodstuffs or food ingredients such as yeast, garlic, kelp, royal jelly,

(k) Herbs.

Some classes of supplements, their examples and contents are presented

Class	Example	Contents
Activator	Amino acids	Contains growth hormone and other hormones
Carbohydrate	Dextrose	May contain vitamins and electrolytes
Food and Food stuff	Fish oils, mineral and vitamins	Contain garlic, kelp, royal jelly, yeast
Herbs	Ginseng, Fiber	Contains amino acids, other plant source
Minerals	Selenium, multimineral tablets	Contains only minerals
Multivitamins and multiminerals	Vitamin D, calcium supplement	Contains both mineral and vitamins
Oil supplements	Cod liver oil, primrose oil	Contains oil base, with vitamins, minerals
Vitamins	Vitamin C, vitamin B	Contains only vitamins

Health claims:

Dietary supplements are often marketed with health claims related to various diseases or conditions. However, it's important to note that the FDA does not evaluate these claims for dietary supplements before they are marketed, and the effectiveness of these supplements in

treating or preventing diseases may not be supported by sufficient scientific evidence. Always consult with a healthcare professional before using any dietary supplement for a specific disease or condition. Here are some examples of health claims made by dietary supplements in relation to certain diseases:

1. **Heart disease:** Some dietary supplements, such as omega-3 fatty acids (fish oil), coenzyme Q10 (CoQ10), and certain antioxidants like resveratrol, are marketed for their potential to support heart health. They may claim to reduce the risk of heart disease, lower cholesterol levels, or improve cardiovascular function.
2. **Joint health and arthritis:** Glucosamine, chondroitin sulfate, and methylsulfonylmethane (MSM) are commonly marketed as dietary supplements for supporting joint health and relieving symptoms of arthritis. They are claimed to reduce joint pain, improve mobility, and support cartilage health.
3. **Cognitive function and memory:** Some dietary supplements, such as omega-3 fatty acids, phosphatidylserine, and ginkgo biloba, are associated with claims of supporting brain health, memory, and cognitive function. However, the evidence supporting these claims is mixed and often inconclusive.
4. **Immune system support:** Supplements containing vitamins C, D, E, zinc, and herbal extracts like echinacea and elderberry are marketed for their potential to support immune function and reduce the duration or severity of colds and other respiratory infections.
5. **Digestive health and Irritable Bowel Syndrome (IBS):** Probiotic supplements are often promoted for their potential to improve gut health, relieve symptoms of IBS, and support a balanced microbiome.
6. **Age-related Macular Degeneration (AMD):** Certain antioxidants, such as lutein, zeaxanthin, and vitamins C and E, are marketed as dietary supplements for supporting eye health and reducing the risk of AMD, a common cause of vision loss in older adults.

It's essential to approach these claims with skepticism and rely on scientific research and the advice of healthcare professionals when considering using dietary supplements for specific diseases or conditions.

Review of the literature:

1. Blendon *et al.,* revealed about Dietary supplements for health purposes. Based on result of multiple national opinion surveys, including the views of both users and nonusers of supplements, we found that a substantial percentage of American surveyed reported that they regularly take dietary supplements as a part of their routine health regimen.
2. Maughan *et al.,* revealed about Nutritional supplements are often seen as promoting adaption to training, allowing more consistent and intensive training by promoting recovery

between training sessions, reducing interruptions to training because of illness or injury, and enhancing competitive performance.

3. Sobal *et al.,* revealed about Vitamin/Mineral supplements are often used by athletes as ergogenic aids to improve performance. This paper reviews studies of the prevalence, patterns, and explanations for Vitamin/Mineral supplements used among athletes.
4. Pomeroy *et al.,* also depicted plentiful evidence related to the positive effects of some dietary supplements, including tyrosine studies assessed by Stroop task, caffeine, Ginko Biloba, and gimseng in the enhancement of memory and cognitive functions among the different study population.
5. Chen *et al.,* Reported that adequate intake of vitamins and minerals such as vitamin A, vitamin K, zinc, copper, and magnesium (at or above the Adequate Intake level) was associated with reduced fundamental causes of CVD mortality, but the associations only linked to nutrient intake via foods.

Material and Methods:

Plant material

The material used in the present study were purchased from the local market, dried and powdered for further use.

Drug profile

Sr. No.	Common Name	Figure	Category
1	Ginger		Carminative, laxative, stomachic, useful in digestion, aphrodisiac, inflammations
2	Fennel		Carminative, aromatic, stimulant, expectorant, flavouring agent
3	Cinnamon		Carminative, stomachic, Astringent, stimulant, aromatic, Antiseptic
4	Ashwagandha		Carminative, sedative and hypnotic effect, hypotensive

5	Indian gooseberry		Anti inflammatory, antioxidant, reduce blood pressure
6	Cardamom		Carminative, anti spasmodic, antioxidant

Preformulation study:

Method and procedure:

1. Angle of repose - A clear dry funnel was taken and attached to a burette stand. A white paper sheet was 2-5 cm below the tip of the funnel in a dry platform. Gently sample was pore into the funnel. Using a pencil circle was drawn around the tip of the powder. The height is also measured. The same procedure was followed 3 times to obtain average reading.

$$\textbf{Angle of repose } (\theta) = \tan^{-1}\frac{h}{r}$$

Where, h = average height of heap

r = average radius of heap

2. Bulk density - Bulk density is an indicator of compaction. It is calculated as the dry weight of powder divided by its volume. This volume includes volume of powder particles and volume of pores among powder particles.

10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder the volume as noted as bulk volume.

$$\textbf{Bulk density} = \frac{\textbf{weight of powder}}{\textbf{bulk volume}}$$

3. Tapped density - The tapped density of a powder represents its random dense packing. Tapped density of a powder is the ratio of the mass of the powder to the volume occupied by the powder after it has been tapped for a defined period of time.

10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder. Then measuring cylinder was tapped 100 times. The volume noted as tapped volume.

$$\textbf{Tapped density} = \frac{\textbf{mass of powder}}{\textbf{tapped volume}}$$

4. Hausner's ratio - The Hausner's ratio is a number that is correlated to the flowability of a powder or granular material.

It was calculated by using tapped density and bulk density**.**

$$\textbf{Hausner's ratio} = \frac{\textbf{Tapped density}}{\textbf{Bulk density}}$$

5. Carr's index - Carr's index is calculated for compressibility of a powder which is based on tapped density and bulk density. It is measure of powder ability to settle and it permit an assessment of the relative importance of interparticulate interactions.

$$\textbf{Carr's index} = \frac{\textbf{Tapped density} - \textbf{Bulk density}}{\textbf{Bulk density}} \times \mathbf{100}$$

6. Moisture content - 10 gm of powder was weighed in petridish. The petridish was placed in hot air oven. The temperature was adjusted to 100-110℃ for 20-25 minute till weight get constant and collected in desicator and weighed. The loss of weight of powder was regarded as a measure of moisture content.

$$\textbf{\% Moisture content} = \frac{\textbf{Mass of powder} - \textbf{Mass of dry powder}}{\textbf{Mass of powder}} \times \mathbf{100}$$

7. Particle size determination - Sieve analysis is used to obtain the particle size distribution by determining the amount of powder retained on a series of sieves with different sized apertures. A sample is added to the top of nest of sieves arranged in decreasing size from top to bottom.
All the particle passed through sieve number80.

Formulation:

Category: Herbal churna

Composition:

Sr. No.	Ingredients	Amount for 20 gm	Percentage taken
1.	Ginger	5 gm	25 %
2.	Fennel	5 gm	25 %
3.	Cinnamon	3 gm	15 %
4.	Ashwagandha	3 gm	15 %
5.	Indian gooseberry	3 gm	15 %
6.	Cardamom	1 gm	5 %

Procedure:

- Plant raw material used for preparation of churna were dried in an oven preset at 45℃.
- Preparation of dried powder of Ginger, Fennel, Cinnamon, Ashwagandha.
- Pass all the powder separately through sieve No. 80.
- Mix all the powdered herbal drugs geometrically.
- Now pack the powder of churna in suitable air tight container.

Evaluation of formulation:

Angle of repose, Bulk density, Tapped density, Hausner's ratio, Carr's index, Moisture content and Particle size determination is evaluated as per the procedure given above.

Result and Discussion:

Preformulation findings

Parameter	Ingredients					
	Ginger	**Fennel**	**Cinnamon**	**Ashwagandha**	**Indian gooseberry**	**Cardamom**
Visual appearance	Creamy yellow	Green	Red brown	Light brown	Brown	Green
Angle of repose	44.12	41.98	37.75	34.21	36.86	39.69
Bulk density	0.3125	0.454	0.370	0.333	0.416	0.333
Tapped density	0.625	0.588	0.5	0.555	0.588	0.526
Hausner's ratio	2	1.295	1.351	1.66	1.41	1.58
Carr's index	50	22.7		40	29.25	36.6

Formulation findings

1. Angle of repose

The angle of repose of the formulation was found to be

Diameter of the pile (D):

$D_1 = 8.2$ cm

$D_2 = 8.1$ cm

$D_3 = 7.7$ cm

$$D = \frac{D1+D2+D3}{3}$$

$$D = \frac{8.2+8.1+7.7}{3}$$

$$D = 8 \text{ cm}$$

Therefore radius

$$r = D/2$$

$$r = \frac{8}{2} = 4$$

height of the pile (h) = 2.5 cm

$$\textbf{Angle of repose } (\theta) = \tan^{-1}\frac{h}{r}$$

$$\theta = \tan^{-1}\frac{2.5}{4}$$

$$\theta = \tan^{-1} 0.625$$

$$\theta = 32^{o}$$

2. Bulk density

Mass of powder = 10 gm

Bulk volume = 25 ml

Therefore

$$\textbf{Bulk density} = \frac{\textbf{mass of powder}}{\textbf{bulk volume}}$$

$$\textbf{Bulk density} = \frac{10}{25}\ \textbf{gm/ml}$$

$$\textbf{Bulk density} = \textbf{0.4 gm/ml}$$

The bulk density of the formulation was found to be 0.4 gm/ml

3. Tapped density

Mass of powder = 10 gm

Tapped volume = 18 ml

Therefore

$$\textbf{Tapped density} = \frac{\textbf{mass of powder}}{\textbf{tapped volume}}$$

$$\textbf{Tapped density} = \frac{10}{18}\textbf{gm/ml}$$

$$\textbf{Tapped density} = \textbf{0.56 gm/ml}$$

The tapped density of the formulation was found to be 0.56 gm/ml

4. Hausner's ratio

Tapped density = 0.56 gm/ml

Bulk density = 0.4 gm/ml

$$\textbf{Hausner's ratio} = \frac{\textbf{Tapped density}}{\textbf{Bulk density}}$$

$$\textbf{Hausner's ratio} = \frac{0.56}{0.4}$$

$$\textbf{Hausner's ratio} = \textbf{1.4 gm/ml}$$

The hausner's ratio of the formulation was found to be 1.4 gm/ml

5. Carr's index

Tapped density = 0.56 gm/ml

Bulk density = 0.4 gm/ml

$$\textbf{Carr's index} = \frac{\textbf{Tapped density} - \textbf{Bulk density}}{\textbf{Bulk density}} \times \textbf{100}$$

$$\textbf{Carr's index} = \frac{0.56 - 0.4}{0.56} \times \textbf{100}$$

$$\textbf{Carr's index} = \textbf{0.2857} \times \textbf{100}$$

$$\textbf{Carr's index} = \textbf{28.57}$$

The carr's index of the formulation was found to be 28.57

Discussion:

- **Bulk density** of the formulation was satisfactory.
- **Tapped density** of the formulation was satisfactory.
- **Flow property** of powder is good because angle of repose fall in range 31^{o} - 35^{o}

Flow Property	Angle of Repose (Degree)
Excellent	25 - 30
Good	31 - 35
Fair	36 - 40
Passable	41 - 45
Poor	46 - 50
Very poor	51 - 55
Very very poor	> 66

- **Hausner's ratio** of the formulation was poor.
- **Carr's index** of the formulation was found to be 36.6. Therefore the relative flowability of the formulation ispoor.

Flow Character	Carr's Index (%)	Hausner's Ratio
Excellent	≤10	1.00 – 1.11
Good	11 - 15	1.21 – 1.18
Fair	16 - 20	1.19 – 1.25
Passable	21 - 25	1.26 – 1.34
Poor	26 - 31	1.35 – 1.45
Very poor	32 - 37	1.46 – 1.59
Very very poor	>38	>1.60

Formulation

Conclusion:

The gastrointestinal tract digests and absorbs dietary nutrients, protects the body against physical and chemical damage from contents in its lumen, provides immunity against external antigens, and keeps an optimum environment for the gut microbiota. These functions cannot be performed normally in several diseases of which the following are discussed here: irritable bowel syndrome and in lammatory bowel disease, which includes Crohn's disease and ulcerative colitis. Because these diseases are associated with oxidative stress, a host of antioxidant supplements are used for maintenance and recovery of the gut functions. However, the beneits of these supplements have not been established. This is consistent with the current concept that antioxidants act by inhibiting oxidative stress pathways in a tissue- and environment-specific manner and not by simply acting as scavengers.

Dietary supplements have proven health benefits and their consumption (within their acceptable recommended dietary intake) will keep disease at bay and allow humans to maintain overall good health.

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BIOINSPIRATION

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Abstract:

The concept of 'Bio inspiration,' which involves drawing from biological phenomena to inspire research in non-biological fields of science and technology, is a strategic approach that not only sparks novel ideas but also possesses two noteworthy characteristics. Firstly, it can propose research topics that are relatively straightforward from a technical standpoint. Secondly, it has the potential to lead to areas where outcomes can directly contribute to practical functions, surpassing some of the more prevalent trends in chemistry. Consequently, bio inspired research holds promise in being accessible to laboratories with limited resources, providing avenues for the development of new and valuable functions, and bridging the technical and cultural gaps among diverse geographical regions.

Introduction:

1. Origins of ideas

In the realm of science and technology, ideas frequently emerge from the observation of nature. Kepler and Newton, for instance, formulated the initial empirical explanations of gravity through a meticulous examination of the movements of the Sun and planets. Faraday and Maxwell established the foundational principles of electromagnetism by investigating the interactions between electrical currents and magnets. The understanding of thermodynamics evolved from the exploration of heat transfer and mechanical work. Quantum mechanics, to a certain extent, had its roots in spectroscopic examinations of light. Regarding current focal points in chemistry, while there are numerous areas of interest; biology stands out as a particularly rich source, with emphasis often placed on delving into the molecular underpinnings of genetics.

2. Biology, bioinspiration, bioimitation, and biomimicry

The study of life, encompassing everything from single cells to intricate organisms, constitutes the field of biology. However, this discipline extends beyond the exclusive examination of living systems, giving rise to various related subjects. One such area, positioned somewhat on the periphery of the vast information flow from molecular biology, is commonly referred to as 'biomimicry' or 'bioimitation.' This field aims to replicate or imitate characteristics

of biological systems within non-living systems, diverging from the detailed replication or analysis of the biological entity at the molecular level. For instance, comprehending the intricate processes enabling a squid to control its tentacles involves complex systems of sensors, muscles, brain function, and other information-processing organs that remain beyond our current understanding. Instead of attempting to replicate the biological entity in molecular detail, biomimicry involves understanding enough of the tentacle's mechanics to mimic certain characteristics, even if the mechanisms employed in this imitation are unrelated to those used by the squid. This approach is simpler, more immediate, and potentially more practical.

The molecular-level understanding of a living creature, such as a squid, poses a multilayered challenge likely to occupy scientific endeavors for the next century. Conversely, abstracting simplified versions of squid-like behavior—drawing inspiration from its capabilities and mimicking some functionality using simplified and possibly different mechanisms—constitutes a related yet distinct pursuit. This endeavor holds substantial appeal, offering the potential to stimulate the invention of novel processes not present in either squids or current synthetic systems. Moreover, it enables the application of these processes to solve technological puzzles, many of which serve as starting points for invention. When utilizing biological systems as a source of behaviors and functions to imitate, there is no singular 'correct' pathway; biology provides a virtually limitless array of inspiring examples of successful designs, allowing for creative adaptation and utilization.

3. Imitation

Is simplifying and abstracting biology a less challenging and less rewarding pursuit compared to the study of biology itself? Undoubtedly, it is less demanding, given that living systems, without exception, exhibit extraordinary complexity. Even the most basic unicellular organisms, after years of examination, continue to reveal properties and processes that elude complete understanding and replication. Despite this ultimate complexity, a grasp of the fundamental aspects of biological function, such as higher-level phenotypic behaviors, allows us to begin comprehending the optimization processes that have evolved over billions of years of Darwinian evolution. This understanding sheds light on why cells and organisms possess particular structures and offers shortcuts to achieving 'lifelike' function in synthetic systems. To mimic a function, a comprehensive understanding is not always necessary. For instance, using solvents in organic synthesis doesn't require an exhaustive understanding of their molecular workings. Similarly, an airplane, while employing different processes than a bird, shares the fundamental concept of flight. A methane-air flame and a cell both undergo a form of 'burning' involving a reduced carbon compound (methane or glucose), yet they produce distinct outcomes, inspiring those intrigued by understanding the cell as a dissipative system. Biology generates novel ideas about function and its origins. Even when the intricate mechanisms behind these

phenomena are not fully grasped, the remarkable features characterizing biological systems can be imitated, abstracted, and combined to pose a diverse array of scientific and technological challenges, many of which serve as the starting points for invention. In utilizing biological systems as sources of behaviors and functions to imitate, there is no singular 'correct' path, as biology presents virtually limitless and inspiring examples of successful designs, providing the freedom to adapt them as desired.

Biological systems and bioinspiration

1. Bioinspiration: Molecules, materials, structures, and functions

Considering the multitude of extraordinary structures and processes found at various scales in biology, the question arises: where should one direct their focus? In biology, functionality stands out as the paramount concept at all scales. In the fierce Darwinian competition, organisms cannot afford to adorn themselves with features devoid of function. Therefore, when endeavoring to replicate the behaviors and properties of living systems, one inherently delves into the imitation of functional processes and structures. The term 'Bioinspiration' consequently leads, either directly or indirectly, to the exploration of function, some of which serves the organism's purposes, while others may prove beneficial to us. Encompassing function, however, are additional conceptual ideas that shape the selection of problems and the formulation of suitable research strategies in bioinspired investigations.

2. Characteristics of biology and bioinspiration

In our exploration, we have identified three intellectual vectors that are notably intriguing and valuable in guiding the selection of characteristics within biological systems to comprehend and emulate.

Function

Living organisms rarely invest energy in generating structures without a purpose. Such an expenditure would be impractical as organisms must prioritize characteristics that provide them with a survival advantage to avoid being consumed. While we may not always comprehend the nature of this advantage or the means by which it is achieved, investigating these questions remains worthwhile, even if the findings don't immediately yield functions of direct benefit to us. Nevertheless, the essence of much technological advancement ultimately revolves around function (for instance, the molecular structure of polystyrene is of little concern; what matters is its utility in inexpensively producing items like coffee cups). By studying biological function, one begins the exploration in proximity to a functional outcome.

Medical and biotechnological applications:

Various natural species exhibit diverse surface functions crucial for medical devices, including anti-fouling, anti-adhesion, and robust wet attachment. When selecting bionic objects, the similarity in application conditions and surface function demands becomes pivotal.

Considering that medical devices often interface with soft tissues in wet conditions, choosing a natural surface with superior wet functionality is preferable. For instance, insights from the tree frog's anti-slipping surface can inspire new ideas, while the anti-adhesion mechanisms observed in Nepenthes alata's peristome and lotus leaves can inform the development of anti-adhesion or anti-fouling surfaces.

Bioinspired anti-adhesion or slippery surfaces

Soft tissue adhesion is a common issue with medical devices, leading to complications such as thrombosis on vascular stents and tissue adherence on surgical instruments. Drawing inspiration from the Nepenthes pitcher plant, a slippery liquid-infused surface, different from conventional superhydrophobic coatings, has been developed. This innovative surface prevents adhesion by creating a stable liquid layer, similar to how the Nepenthes pitcher plant uses liquid to hinder insect attachment. This approach has found applications in devices like electrical scalpels and endoscope lenses.

Bioinspired wet attachment surfaces

Achieving strong wet attachment without external load, akin to the tree frog's capabilities, is another desired surface function to minimize damage to soft tissue. By emulating the liquid-adjusting behaviors observed on the tree frog's toe pad, a bioinspired hierarchical structure with superior wet attachment has been applied in various medical devices, including heart patches, medical electrodes, and tissue graspers for minimally invasive surgery. This not only ensures strong wet attachment but also reduces soft tissue damage.

Bioinspired structure-guided tissue/cell growth *in vivo* or *in vitro*

For implantable medical devices and drug evaluation, promoting tissue/cell growth in vivo and in vitro is crucial. Bioinspired surfaces have been applied to dental implants to enhance implant quality, and gradient porous structures inspired by nature have been created on bone scaffolds to guide tissue growth. Creating in vitro culturing devices that mimic the living conditions of soft tissue and cells is essential for desired growth and reproduction.

Challenges and perspectives

While bioinspired approaches have shown promise in solving adhesion and slippery issues in medical devices, challenges remain. These include the lack of a robust design theory and cost-effective fabrication methods for bioinspired functional structures, surfaces, and systems. Overcoming these challenges requires addressing issues such as comprehensive understanding of biological function mechanisms, interactions between artificial hierarchical structures and biological entities, designing multi-function-oriented biocompatible structures, developing cost-effective fabrication approaches for biocompatible multiscale, multi-material structures, and conducting in vivo life-cycle assessments.

Bioinspired approaches hold potential in biomaterials, bio-interface, biosensors, and bio-printing processes. Given its interdisciplinary nature, collaboration across materials, chemistry, biotechnology, medical devices, and clinics is essential for the development of bioinspired medical devices for the benefit of humanity.

Ecological and environmental insights:

The field of bioinspiration, which involves drawing insights from the functioning of biological systems to develop new engineering concepts, is currently successful and expanding rapidly. However, only a fraction of the world's biodiversity has been explored for potential engineering inspiration, suggesting that numerous biological systems with valuable engineering applications may have been overlooked. Moreover, the evolutionary relationships across the tree of life, holding crucial insights into form and function, have yet to be explored by engineers. Recent progress in various research areas, including the digitization of museum specimens, techniques for describing and analyzing complex biological shapes, quantitative prediction of biological function based on form, and the analysis of extensive digital datasets, could soon provide access to these insights. Collectively, these emerging capabilities offer the prospect of tapping into the world's known biodiversity as a valuable resource for engineering knowledge. This shift in bioinspiration has the potential to be timely for engineering development, providing precisely the insights needed to enhance technology's autonomy, adaptability, and ability to operate in complex environments.

Neuroscience and artificial intelligence:

Computational intelligence approaches represent nature-inspired methods that provide abundant ideas for solving complex problems. Compared to traditional methods, these approaches exhibit greater power, eliminating the need to reformulate problems when exploring nonlinear and nondifferentiable spaces under real-world conditions with massive parallelism. Another advantage is the adaptability of fitness function formulation, which can be expressed appropriately based on system outputs, making them suitable for addressing multiobjective problems.

Recently, a new category of computational intelligence methods has emerged to overcome the limitations of traditional artificial intelligence. These methods, characterized by mechanisms more lifelike to individuals or groups of organisms, are more easily understood and generally more efficient than traditional artificial intelligence methods. Termed bioinspired intelligent algorithms, they distinguish themselves from traditional methods.

Research in computational intelligence and neuroscience, particularly bioinspired intelligence, has made substantial progress in understanding neuroscience and biological systems, applied notably in various robotic and control systems. This special issue aims to serve as a platform for diverse research efforts in intelligent robotics and control systems, emphasizing

humanoid robots and bioinspired robotics. Methodologies for these robotic systems draw inspiration from the strategies, mechanisms, and functionality of neural and biological systems, such as biologically inspired neural networks, genetic algorithms, and fuzzy systems.

Cross-disciplinary collaboration:

The term "bioinspiration" refers to a creative strategy rooted in observing biological principles and applying them to design. Biomimicry, a recent approach, encompasses a broad spectrum of scientific and technical endeavors that involve interdisciplinary collaboration between biology and other fields. The primary objective is to address practical problems related to innovation or sustainable development. In the realm of life science, various aspects of natural and social sciences, particularly biology, are influencing design activities. Bioinspiration has undergone changes, steering architectural practices toward numerous innovative approaches through different bioarchitectural movements from the past to the present. The primary challenge lies in bridging the gap between in-depth knowledge of biology and its associated scientific domains and the creative process of architectural design, necessitating cross-disciplinary collaboration between architects and biologists. This article explores key bioarchitectural movements, tracing their evolution to contemporary biomimicry. It aims to delineate biomimicry methodologies and demonstrate how this approach is applied in architectural design contexts through the examination of existing case studies. Additionally, the entry addresses the opportunities, challenges, and future prospects within the field.

Innovation in sustainable design:

The development of concepts, approaches, and technologies that mimic and control natural processes, known as bio-inspired design, is poised for rapid advancement and translation into commercial applications. While certain Convergence Accelerator tracks concentrate on specific societal needs, this document illustrates that bio-inspired design encompasses a cohesive and evolving set of science and technology platforms with a distinct ability to address critical societal challenges. To underscore the feasibility of translation, we also spotlight recent instances where bio-inspired design has successfully led to commercial products, emphasizing the substantial untapped potential that targeted initiatives for translation could unlock.

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MARINE MACRO ALGAE OCCURRENCES AND DISTRIBUTION OF SOUTH EAST COAST OF TAMIL NADU, INDIA

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Abstract:

The marine ecosystem provides a vast habitat for macro algal communities as they occupy the rocky shores and submerged intertidal zone. In the present study, more than 100 specimens were collected from five sampling sites at five districts of Tamil Nadu during different seasons from January 2022 to December 2022. A maximum of 37 taxa were recorded in the sampling station 2 such as Mandapam followed by Muttam (36 taxa), Manapad (35 taxa) and Idinthakarai (33 taxa). The minimum of taxa was observed in the Manora (29 taxa). Among the species, the green algae *Ulva fasciata* and *Ulva lactuca*, brown algae *Sargassum wightii* and red algae *Gracilaria edulis were* recorded in all the sampling stations dominating others species. The brown algae *Stoechospermum marginatum* was found to be only in June to September 2019. *Sarconema sp and Hypnea musciformis* were recorded in the summer and north east monsoon seasons.

Keywords: *Gracilaria edulis*, Manora, seaweeds, *Ulva fasciata*, ecosystem and brown algae.

Introduction:

Marine algae

Marine algae are an important source of medicinal products in the marine ecosystem. Particularly seaweeds are directly exposed and are susceptible to ambient microorganisms such as bacteria and fungi. Marine algae are classified as red algae (Rhodophyta), brown algae (Phaeophyta) and Green algae (Chlorophyta). Algae are described as heterogeneous group of organisms with considerable metabolic diversities. It includes compounds such as, sterols, isoprenoid, terpenoids, steroid, phenolic compounds, fatty acids, acrylic acid and alkaloids. Exceptional sources act as antimicrobials, anticancer, antioxidants, antiviral, anti-inflammatory, wound healing and neuro-protective compounds.

Marine algae from Indian coasts amounting to 844 species (including forma and varieties) are distributed among 217 genera (Anatharaman *et al.*, 2007). To date, researchers have isolated approximately 7000 marine natural products, 25 percent of which are from algae. Seaweeds are able to produce a variety of secondary metabolites characterized by a broad spectrum of biological activities. Compounds with cytostatic, antiviral, anthelmintic, antifungal

and antibacterial activities have been detected in green, brown and red algae (Lindequist 2001). Seaweeds are scientifically termed macro algae literally meaning large algae. Algae are relatively simple photosynthetic plants with unicellular reproductive structure the range from unicellular organisms to non-vascular filamentous are thalloid plants.

Seaweeds are commercially important renewable resource and they are used as food, medicine, fertilizer. Seaweeds also possess a wide application in food and pharmaceutical industry. It has become an untapped resource for the potential bioactive compounds as compared to terrestrial plants for food and health benefits. Among the diverse group of marine organisms, algae are considered as a most nutritious and possess wide range of bioactive compounds. Seaweeds or marine macro algae are potential renewable resources in the marine environment (Khaled *et al.,* 2012). Interest in seaweeds has increased markedly through the world due to their value in nutrition and in medicine. Nutritionally valuable seaweeds are being used as fresh or dried vegetables or as ingredients in wide variety of prepared foods. From nutritional point of view, they are low calorie food, with high concentration of minerals (Mg, Ca, P, K and I), vitamins, proteins, indigestible carbohydrates and low concentration of lipids (Ambreen *et al.,* 2012).

Marine Natural Products (MNP) offers a rich chemical content of bioactive molecules that have become an important source of pharmacologically active metabolites. The Antarctic Peninsula presents a wide variety of MNP, mainly marine algae. The western region of the Peninsula exhibits abundant macro algae biomass, about 44% are endemic. It is possible to classify macro algae into three groups according to predominant photo synthetic pigments, storage products and cell wall components such as Green algae, Red algae, and Brown algae. Marine algae have been used as food since ancient times, and today are consumed as a regular part of the diet, especially in Asian countries (Gressler *et al.,* 2010). A derivate from the cyan bacteria group known as spirulina has been used as food taken its high amount of protein, among them the phycocyanin and essential nutrients such as carotenoids, vitamins and minerals. Lipid extract from these group of algae also were able to exert anti-inflammatory properties. Macro algae are currently used in the diet and may provide human beings with beneficial fatty acid once used as nutrient sources in food products (Pereira *et al.,* 2012).

Seaweeds are primitive non-flowering plants without true roots, stem and leaves. They grow in the intertidal, shallow and deep sea areas up to 180 meter depth and also in estuaries, backwaters and lagoons on solid substrates such as rocks, dead corals, pebbles, shells, mangroves. About 2400 natural products have been isolated from macro algae belonging to the classes' rhodophyceae, phaeophyceae and chlorophyceae. Seaweed contains virtually all the minerals and it is useful in preventing free radical formation seaweed contain several vitamins.

Red brown algae are rich carotenes (Arnon, 1949). Seaweeds also contain a range of unique phytochemicals not present in terrestrial plants.

Seaweeds are a group of photoautotrophic, multicellular algae occurring in marine environments. They can perform photo synthesis and the term includes some members of the red, brown and green algae. Seaweeds are commercially important renewable resource and they are used as food, medicine, fertilizer. Seaweeds also possess a wide application in food and pharmaceutical industry (Abdala Diaz *et al.,* 2006). It has become an untapped resource for the potential bioactive compounds as compared to terrestrial plants for food and health benefits. Among the diverse group of marine organisms, algae are considered as a most nutritious and possess wide range of bioactive compounds.

Generally, the algae which produce these materials occur in fresh water and marine habitats but they have adapted to life on land in a variety of terrestrial environments. They commonly grow either on the surface or at a depth of up to several centimeters in soil. The activities of soil algae are thought to enhance soil formation and water retention, stabilize soil, increase the availability of nutrients of plant growing nearby and reduce soil erosion. Marine macro algae or seaweeds are one of nature's most biologically active resources as they possess a wealth of bioactive compounds. It is exploited for both human and animal health applications. Phaeophyta, or brown seaweeds, are predominantly brown due to the presence of the carotenoid, fucoxanthin and the primary polysaccharide present includes alginates, laminarins, fucans and cellulose. Algae are otherwise called bionanofactories because they synthesized nanoparticles with high stability, are easy to handle and eliminate cell maintenance.

Structure of seaweed

The basic structure of seaweed, from the bottom up, includes the holdfast which is needed to attach the base to the rock bed, a haptera which may be present as an extension of the holdfast to attach to other algae, a stipe which acts as a stem-like structure which may or may not be present in the species, a thallus or float which forms the major part of the body of the algae, a lamina or blade which acts as a 'leaf' and a sorus, also known as fucus or kelp, which is a floatation assisting organ between the blade and the stem.

Growth of seaweed

Seaweed has two prerequisites for production and growth; the first being sunlight which is required for photosynthesis and the second being fresh seawater which is required for nutrient uptake. Seaweed are found at different locations in the environment with most preferring growth on rock beds close to the seashore and a few preferring growth either far out to sea, at greater depths or in tidal pools. Seaweed locations are referred to as littoral zones and they extend from shorelines to submerged rock formations. At times, various classes of seaweed prefer certain parts of the littoral zone with red algae growing at the deepest parts (Luning *et al.,* 1990).

Classification of seaweed

The different classes Chlorophyta (green), Rhodophyta (red) and Ochrophyta (brown) can be distinguished by colour alone but have other differences associated with them such as the compounds that they contain. Chlorophyta and Rhodophyta fall within the kingdom Plantae while Ochrophyta falls within the kingdom Chromista. Seaweeds have been shown to be eukaryotic due to the presence of mitochondria, chloroplasts, paired chromosomes, a nucleus and organelle cells, causing them to be referred to as plants (Corliss, 2002).

Chlorophyta

Chlorophyta, commonly referred to as green seaweed, gets its green colour from the chloroplasts that contain chlorophyll a and b. They also contain accessory pigments including beta carotene, xanthophylls and thylakoids as well as cellulose making up the cell walls and starches being the carbohydrate present (Paul and Fenical, 1987). Green algae have 8000 known species with the majority not being seaweed species, but rather single celled species.

Rhodophyta

Rhodophyta, commonly referred to as red seaweed, with an ancient Greek meaning of rose plant, gets its red colour from phycobiliproteins and phycoerythrin, the accessory pigments. The cell walls are made up of carrageenan, a sulfated polysaccharide. Red algae also produce tannins known as phlorotannins while some produce porphyran. Red algae are the basis of coralline algae known as corali which are highly calcinated species containing calcium carbonate (Woelkerling, 1993). Red algae are the oldest identified seaweed species with over 10000 known species and 5000-6000 of those being Rhodophyta seaweed.

Ochrophyta

Ochrophyta, commonly referred to as brown seaweed, gets its brownish colour from the pigment known as polysaccharide fucoxanthin. Brown algae contain compounds of P700 with chlorophyll a, chlorophyll c, carotenoids and phlorotannins (more than that of red algae) where the cell walls are made up of cellulose, alginic acid and aragonite (Zubia *et al.*, 2008). Brown algae are different from green and red algae as it adopts different metabolic pathways that cause more rapid growth. Approximately 1500-2000 species of brown algae have been identified worldwide.

Economic potentials of seaweed

(a) Food

Most seaweed are edible and beneficial due to their high nutritional value (including trace elements, proteins, carbohydrates, vitamins and folic acid), other more industrially important uses include the production of agar (gelatinous substance extracted from red seaweed and used as a food thickener or substitute for gelatin), carrageenan (sulfated polysaccharides from red seaweed used as a food thickener) and alginate (viscous substance from brown seaweed used as a

food thickener). Alginate and agar are used as food additives in food items rich in sugar and carbohydrates, beverages, meat and poultry, and desserts while carrageenan is utilised in dairy and baked products, sauces, salad dressings, diet manufactured items and meat and fish preservatives (Dhargalkar and Pereira, 2005).

(b) Medicine

In medicine and herbalism, seaweed have been used to combat influenza, sore throat, urinary infections, goitre, worm infestations, malnutrition, obstructions of the gall bladder, swelling of the legs, intestinal infections, congestion, headaches, constipation, water stools, cataracts, allergies, abdominal wall abscesses, clammy skin, dry skin and hair, obesity, oedema, ulcers, testicular pain and swelling, colitis, scrofula, sluggishness of prostate and cervical dysmenorrhea causing irregular menstruation. It has also been shown to possess curative properties towards tuberculosis, arthritis, cancer, diabetes, tumours and growths and cardiovascular diseases. It acts as a disinfectant towards external wounds due to the alginate present, encourages heavy metal chelation, promotes proper functioning of the liver, kidneys, pancreas, thyroid and nervous system, aids in the removal of radioactive toxins present in the body, and regulates blood pressure by arterial cleansing. Most promising activity being 100% antifertility (anti-implantation) activity observed in three species (Watanabe *et al.,* 2001).

(c) Skincare

In skincare and cosmetics, seaweed are used for their anti-inflammatory properties. It is known to improve the elasticity of the skin and reduce the formation of cellulite. Brown seaweed is reported to strengthen and nourish the scalp and promote hair growth by fighting off bacteria eating away at the hair follicles (Capitanio *et al.,* 2012).

(d) Seaweed as Bio-fuels

Bio-fuel from seaweed is produced by converting alginate, mannitol and fiber contained in seaweed into ethanol, butanol, etc. Seaweed is a known potential carbon-dioxide (CO_2) neutral source of second-generation bio-fuels. Energy is stored inside the cell as lipids and carbohydrates, and can be converted into fuels such as biodiesel (in the presence of oils) and ethanol (in the presence of carbohydrates). Its high protein content implies that waste from the feedstock conversion process may yield a saleable waste stream as well. Fuels derived from algae generally fall into two groups; oils which are extracted from algae by a mechanical or chemical process; and ethanol resulting from the fermentation of algae in the presence of a yeast and isolating the ethanol produced. Its use can reduce greenhouse gas emission up to 40 %. (Bajhaiya *et al.,* 2010).

(e) Seaweed as Bio-fertilizer

There is a long history of coastal people using seaweeds, especially the large brown seaweeds, to fertilize nearby lands. One of the well documented beneficial effects of seaweed

extracts is that it enhanced the seed germination and plant growth, act as potential biocide. Seaweed as a fertilizer is suitable in organic agriculture. Marine algae consist of macro and micro nutrient amino acid, Vitamins, cytokinins, gibberellins, auxins, auxin-like and other growth-promoting compounds. More over seaweeds are used in soil amendment; pests control and plant diseases management. Liquid extracts obtained from seaweeds have gained importance as foliar sprays and soil drench for several crops including various grasses, cereals, flowers and vegetable species (Kumari *et al.,* 2011).

Distribution of seaweeds in South East Coast of Tamil Nadu

Sampling sites

The seaweeds were collected from the coastal regions of five districts of Tamil Nadu such as, Thanjavur S1 (Manora, 10° 16' 4.8'' N, 79° 18' 14.4'' E), Ramanathapuram S2 (Mandapam, 9° 16' 48'' N, 79° 7' 12'' E), Tirunelveli S3 (Idinthakari, 8° 10' 43'' N, 77° 44' 37'' E), Tuticorin S4 (Manapad, 8° 28' 59.88'' N, 78° 7' 0.12'' E) and Kanyakumari S5 (Muttam, 8° 7' 48'' N, 77° 19' 12'' E). A total of 5 localities were selected from these five districts and the seaweeds were recorded once in a month from January 2022 to December 2022. In each locality five to six areas were randomly selected (3 × 3 m each) for this study. Numbers of species were collected from each district at each locality during four different seasons such as winter (January-February), summer (March-May), South West Monsoon (September-December) and North East Monsoon (June-August). The district wise and various season wise species distribution also assessed.

Occurrences of seaweeds

In the present study, 40 species of marine algae were identified among this 16 species of Chlorophyta (*Halimeda macroloba, Halimeda opuntia, Halimeda tuna, Bryopsis plumose, Caulerpa cupressoides, Caulerpa racemosa, Caulerpa peltata, Chaetomorpha antennina, Chaetomorpha linoides, Chaetomorpha linum, Chaetomorpha tortusa, Ulva fasciata, Ulva lactuca, Ulva compressa, Ulva reticulate* and *Enteromorpha prolifera*), 09 species Ochrophyta (*Sargassum wightii, Sargassum ilicifolium, Sargassum swartzii, Sargassum duplicatum, Padina gymnospora, Padina pavonica, Padina antillarum, Calpomenia sinuosa* and*Stoechospermum marginatum*) were recorded and 15 species of Rhodophyta (*Sarconema sp, Acanthophora spicifera, Gelidium pusillum, Gracilaria corticata, Gracilaria edulis, Gracilaria verrucosa, Gracilaria foliifera, Gracillaria crassa, Hydropuntia edulis, Hypnea flagelliformis, Hypnea valentiae, Hypnea musciformis,Amphiroa anceps, Amphiroa rigida* and *Amphiroa foliacea*).


CHLOROPHYTA
Halimeda macroloba
Halimeda opuntia
Halimeda tuna
Caulerpa cupressoides
Caulerpa racemosa
Caulerpa peltata
Chaetomorpha antennin
Chaetomorpha linoides
Chaetomorpha linum
Chaetomorpha tortusa
Ulva fasciata
Ulva lactuca


PHAEOPHYTA
Sargassum ilicifolium
Sargassum swartzii
Sargassum duplicatum
Padina gymnospora,
Padina pavonica
Padina antillarum

District-wise distribution

A maximum of 37 taxa were recorded in the sampling station 2 such as Mandapam followed by Muttam (36 taxa), Manapad (35 taxa) and Idinthakarai (33 taxa). The minimum of taxa were observed in the Manora (29 taxa). In all the sampling sites, green algae were dominated over red and brown algae. The sampling station 1 (Manora) containing 13 species of green algae, 8 species of brown algae and 8 species of red algae. The Mandapam station, 14 species of each green and red alga and 9 species of brown algae also observed. Idinthakarai, 13 species if green, 12 species of red and 8 species of brown algea were recorded. Manapad station occurred in 14 species of green, 12 species of red and 9 species of brown algae. The station s5 such as Muttam containing 14 species of green, 13 species of red and 9 species of brown algae were assesses. Among the species, the green algae *Ulva fasciata* and *Ulva lactuca,* brown algae *Sargassum wightii* and red algae *Gracilaria edulis* were recorded in all the sampling stations dominating others species. On the other hand, *Bryopsis plumose, Chaetomorpha antennina, Chaetomorpha linoides, Enteromorpha prolifera, Stoechospermum marginatum, Sarconema sp, Acanthophora spicifera, Gelidium pusillum, Gracilaria verrucosa, Hypnea valentiae, Hypnea musciformis, Amphiroa rigida* and *Amphiroa foliacea* were observed only in particular sampling sites.

District wise distribution of macro algae in various sampling site

S.No	Phylum	S1	S2	S3	S4	S5
1	Chlorophyta	13	14	13	14	14
2	Ochrophyta	08	09	08	09	09
3	Rhodophyta	08	14	12	12	13
Total		**29**	**37**	**33**	**35**	**36**

The potential areas for luxuriant growth of several species of green, brown and red algae occur along the southeast coast of Tamilnadu from Mandapam to Kanyakumari covering 21 islands in the Gulf of Mannar. The other places in the east and west coast where rich seaweed beds occur are Bombay, Karwar, Ratnagiri, Goa, varkaJa, vizhinjam, Pulicat and Chilka (Kaliaperumal and Kalimuthu, 1997).

Season wise distribution

A species distribution was influenced by the various climatic conditions. In the present study, climatic conditions divided by the four seasons such as winter (March to May 2022), summer (January to February 2022), south west monsoon (June to September 2022) and north east monsoon (October to December 2022). The maximum species were recorded in the summer season at Muttam (30 sp.) and Manora (20 sp.). In winter season also observed the maximum species at Mandapam (30 sp.), Manapad (27 sp.) and Idinthakarai (26 sp.). In overall, the maximum number of species were recorded in the winter season (124 sp) followed by summer (118 sp), north east (109 sp) and south west monsoon (108 sp) at all the sampling sites. *Ulva compressa Ulva fasciata, Ulva lactuca, Sargassum wightii, Gracilaria edulis, Padina gymnospora, Padina pavonica, Padina antillarum, Calpomenia sinuosa, Gracilaria corticata, Gracilaria foliifera, Hydropuntia edulis, Hypnea flagelliformis, Hypnea valentiae* and *Amphiroa anceps* were recorded during all seasons at sampling sites. The brown algae *Stoechospermum marginatum* was found to be only in June to September 2022. *Sarconema sp and Hypnea musciformis* were recorded in the summer and north east monsoon seasons.

Seasonal studies on marine macroalgae from East and west coast of India and other islands were studied by various authors. It is evident from out data that *Caulerpa scalpelliformis, C. veravalensis, C. crassa* and *S. wightii* were recorded throughout the year in Tamil Nadu. However, none of these macroalgae were recorded at Bhimili coast Visakhapatnam on the east coast of India. Previously it was observed that *C. scalpelliformis, C. veravalensis* and *S. wightii* were drifted mainly during January, December and April-May from Gulf of kutch at Gujarat (Northwest coast of India) indicating that the extensive drifting of seaweeds always occurs during the tail end of the seaweed growth period (Thakur *et al.,* 2008).

These seaweeds have a very great importance in medical field for treating many complicated diseases. They can also be used as a raw food substance. From this we conclude that seaweeds are abundant in Mandapam, Muttam and followed by Manapad coastal region. The present study could be useful as new baseline record for future bio monitoring studies in this coast. Further systematic studies on the seaweed resources may provide useful data for the conservation of marine algal resources in this region.

Distribution of seaweeds in the east coastal area of Tamil Nadu during different seasons of the study periods

Name of the species	Winter					Summer					South west monsoon					North east monsoon				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
CHLOROPHYTA																				
Halimeda macroloba	-	+	+	-	-	-	+	+	-	+	+	+	+	-	+	+	+	-	-	+
Halimeda opuntia	-	-	+	+	-	-	-	+	+	+	-	+	+	+	+	-	+	+	+	+
Halimeda tuna	+	+	+	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
Bryopsis plumose	+	+	-	+	+	-	-	+	-	+	-	+	+	-	-	-	-	+	-	+
Caulerpa cupressoides	+	+	-	+	-	+	+	-	-	-	+	+	-	-	-	+	+	-	+	-
Caulerpa racemosa	+	+	+	+	-	+	-	-	-	+	+	-	-	+	+	+	+	+	-	-
Caulerpa peltata	+	+	-	+	+	+	-	+	+	+	-	+	+	+	+	-	-	+	+	-
Chaetomorpha antennina	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	-	-	+	+	+
Chaetomorpha linoides	-	-	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+
Chaetomorpha linum	-	+	-	+	-	+	+	-	-	-	+	+	-	-	-	+	+	+	-	-
Chaetomorpha tortusa	-	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
Ulva fasciata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ulva lactuca	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ulva compressa	-	+	+	+	+	-	+	+	+	+	+	+	+	+	-	-	+	+	+	-
Ulva reticulate	-	+	-	-	+	+	-	-	+	+	-	-	+	-	+	-	-	+	-	+
Enteromorpha prolifera	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-	+	+	-	-	-

PHAEOPHYTA																				
Sargassum wightii	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sargassum ilicifolium	+	+	+	+	-	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+
Sargassum swartzii	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+
Sargassum duplicatum	-	-	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
Padina gymnospora,	-	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	+	+	+	+
Padina pavonica	+	+	-	-	-	+	+	-	+	+	+	+	-	+	+	+	+	-	+	-
Padina antillarum	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
Calpomenia sinuosa	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	-
Stoechospermum marginatum	-	-	+	+	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-
RHODOPHYTA																				
Sarconema sp	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	+	-	-	-
Acanthophora spicifera	-	+	-	-	-	+	+	-	+	+	-	-	-	-	-	-	+	-	-	-
Gelidium pusillum	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
Gracilaria corticata	+	+	+	+	+	+	+	-	-	+	+	+	+	+	-	+	+	+	+	+
Gracilaria edulis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gracilaria verrucosa	-	-	-	-	+	-	-	+	+	+	-	-	-	-	-	-	-	+	+	+
Gracilaria foliifera	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	+	-
Gracillaria crassa	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+	+	+	-
Hydropuntia edulis	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+
Hypnea flagelliformis	-	+	+	+	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-	+
Hypnea valentiae,	-	+	-	+	+	-	+	-	-	+	+	+	-	+	-	-	-	-	+	-
Hypnea musciformis,	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+
Amphiroa anceps	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+
Amphiroa rigida	-	+	+	-	-	-	+	+	+	+	-	-	-	-	+	-	-	-	-	+
Amphiroa foliacea	-	+	+	-	-	-	+	-	-	+	-	-	-	-	+	-	+	-	-	-

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HERBAL REMEDIES FOR ALOPECIA

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Abstract:

Hair lacks significant physiological function in humans, yet it holds considerable value for our self-esteem. The most prevalent forms of hair loss, androgenic baldness and alopecia areata, pose significant challenges. Despite various therapeutic compounds of synthetic origin, their efficacy, safety, and duration for visible results are subjects of debate. Consequently, there's a burgeoning interest in exploring alternative treatments for hair loss, focusing on plant-derived compounds. Extensive research has investigated the efficacy of plants and their derivatives in addressing hair loss, with herbs like pink and blue ginger, green tea, pumpkin, red clover, and Chinese red ginseng showing promising evidence against alopecia. Inhibiting 5α-reductase appears to be the primary mechanism, aiding nutritional support and scalp blood circulation.

Keywords: Herbal, Alopecia, Hair loss, Alopecia Areata, Androgenic Baldness.

Introduction:

Hair might not have a significant physiological function in modern humans, yet it holds immense emotional value. The common types of hair loss - androgenic baldness and alopecia areata - have emotional consequences, leading to heightened levels of anxiety and depression. Keratin, the primary protein in hair, forms a structured composition within hair follicles. The growth of hair begins within the hair bulb matrix, generating keratinocytes that eventually form the lifeless hair shaft within a hair cavity. Hair comprises various elements, including moisture, fats, and melanin combined with keratin, forming six concentric layers from the base of the hair cavity. These layers include the cortex, cuticle, medulla, and inner and outer root sheaths.

Hair, irrespective of its inherent characteristics like curliness or straightness, is composed of the root, shaft, and hair. The dermal papilla, a cluster of keratinocytes surrounding the hair follicle's epithelial area, regulates the hair cycle and directly influences hair diameter. The hair growth cycle comprises three stages: anagen, catagen, and telogen. These stages involve shifts in hair morphology and follicle activity, resulting in hair growth, reduction, and shedding.

Various factors, including infections, stress, diet, hormonal changes, and immune system dysfunction, can contribute to increased hair loss. Permanent hair loss arises from issues like genetic predisposition, hormonal imbalance, inflammation, and the follicular bulb's extracellular matrix loss. Androgenic hormones, especially the conversion of testosterone into

dihydrotestosterone (DHT) by the 5α-reductase enzyme, play a significant role in male pattern baldness by inducing cellular apoptosis in hair follicles.

Androgenic baldness and alopecia areata are the most common types of baldness. While the former results from high sensitivity of follicles to DHT, the latter is an immunological response leading to hair loss. Synthetic drugs like minoxidil, finasteride, and corticosteroids are commonly used for hair loss treatment but pose uncertainties regarding effectiveness and safety, prompting interest in herbal remedies. Herbal preparations offer advantages such as fewer side effects, broader activity, and increased accessibility. Research continues to explore traditional herbal remedies and their active components as potential alternatives for hair loss treatment, yet scientific studies validating their efficacy remain insufficient.

Various herbs have been explored for their potential in treating baldness are discussed in the following section.

Garlic and onion

Garlic contains alliin, which, when transformed into allicin, is believed to hold medicinal properties. However, research on garlic's effectiveness in treating androgenic alopecia remains limited. Its impact on immunity regulation might play a role as androgenic alopecia is immune system-dependent. A clinical trial combining a steroid with an odorless 5 percent garlic gel showed promising results, indicating that topical garlic gel therapy might offer lasting benefits in hair growth. Onion, sharing chemical similarities with garlic, was also studied topically for patch baldness. In a comparative study, patients treated with raw onion juice displayed evident hair regrowth within two weeks compared to the group using tap water.

Green tea

Green tea, derived from the Camellia sinensis plant, contains catechins like catechin, gallocatechin, epicatechin, and epigallocatechin gallate (EGCG). Studies suggest that catechins inhibit 5α reductase, aiding in the prevention or treatment of androgenic alopecia. Research utilizing epigallocatechin gallate showed promising results in extending the hair growth stage and increasing hair growth by multiplying dermal papillae and suppressing cell death. An experimental study on female rats with sudden baldness explored the impact of polyphenolic compounds from green tea extract. Rats consuming water with a catechin extract from dried green tea exhibited noticeable hair regrowth compared to those in the control group, suggesting a positive effect on hair growth.

Pumpkin

Pumpkin, belonging to the Cucurbitaceae family, is known for its fruits and seeds, rich in beneficial components like fatty acids, beta-carotene, tocopherols, squalene, and phytostanols. Some research highlights the potential of pumpkin oil in managing symptomatic benign prostatic hypertrophy due to its phytostanols, which inhibit 5α reductase and exhibit an androgenic

antagonist effect. Although animal studies support the inhibition of 5α reductase by pumpkin oil, the exact mechanism remains unclear. In a 2014 randomized controlled trial, men with mild to moderate spot baldness received a dietary supplement containing 400 mg of pumpkin oil for 24 weeks. The group treated with pumpkin oil showed a 40% increase in hair count compared to a 10% increase in the placebo group. This suggests a positive impact of pumpkin oil on hair growth, possibly through 5α-reductase inhibition, although its effect on dihydrotestosterone levels wasn't assessed.

Pink and blue ginger

Curcuma aeruginosa, also known as pink and blue ginger, is a plant native to South Asia and closely related to turmeric. Its rhizome extract has demonstrated effectiveness in inhibiting testosterone conversion to DHT, crucial in androgenic alopecia reversal. This extract contains active substances like 1,8-Cyneol, Curcumenone, Curcumenol, Iso-Curcumenol, and Camphor, acting as anti-inflammatory and anti-androgenic agents. Studies compared the effectiveness and safety of 5% Curcuma aeruginosa hexane extract alone, in combination with minoxidil, and against a 5% minoxidil solution. Results suggested that Curcuma aeruginosa extract, particularly when combined with minoxidil, stimulated hair growth and reduced hair loss. This combination approach might enhance therapeutic efficacy due to their distinct mechanisms—minoxidil stimulates hair growth directly, while Curcuma aeruginosa acts as a 5α-reductase inhibitor, particularly beneficial for androgenic alopecia. Combining both could potentially create a more effective topical treatment for this type of hair loss.

Ginseng

In the Araliaceae family, the Panax genus comprises 11 slow-growing species with fleshy roots rich in ginsenosides. Native to eastern Asia's colder regions, ginseng is renowned in herbal medicine for enhancing the immune system, strength, and energy. Red and white ginseng roots, processed differently, with red ginseng believed to be more active due to higher components, have long been used in Korea to promote healthy hair growth and combat hair loss. Studies have shown red ginseng's efficacy in treating androgenic baldness. A study in 2012 evaluated red ginseng's in vivo effectiveness for spot baldness. One group received oral red ginseng extract along with corticosteroid injections, while the other received only corticosteroid injections. After 12 weeks, the group using red ginseng extract showed significant improvement in hair thickness and density compared to the corticosteroid-only group, indicating the herb's efficacy. Further investigations aimed to understand red ginseng's impact on hair growth pathways. In vivo studies in mice and tests on patient-derived dermal papilla cells revealed that red ginseng extract and its ginsenosides stimulated cutaneous papilla cells' growth, activated ERK and AKT signaling pathways, and inhibited dihydrotestosterone-stimulated androgen receptor expression.

Red clover

Red clover, a Fabaceae family crop, is used in traditional medicine for various conditions. Its preparations contain isoflavonoids, cyanogenic glycosides, coumarin derivatives, and essential oils with therapeutic effects. Polyphenols in red clover, such as Biochanin A, have been shown to inhibit 5α-reductase activity more effectively than epigallocatechin gallate found in green tea. Clinical research examined red clover extract and acetyltetrapeptide 3 for their potential in preventing hair loss. The study utilizing red clover extract and acetyltetrapeptide 3 demonstrated increased scalp hair density and numbers after four months of treatment. The ratio of follicles in the anagen to telogen phases increased, indicating potential stimulation of hair growth. This combination harnesses the beneficial properties of Biochanin A and acetyltetrapeptide 3 for treating alopecia.

Essential oils

For over a century, essential oils like thyme, lavender, rosemary, and Atlas cedar have been used to treat baldness. A study in 1998 revealed the effectiveness and safety of these oils for treating spot baldness. Patients applied the oil blend to their scalps nightly for seven months, demonstrating its superiority over a control group using a combination of jojoba and grape seed oils. Another trial in 2003 explored the use of local essential oil application alongside low-intensity electromagnetic pulses for androgenic baldness treatment. Combining these oils with electromagnetic radiation proved beneficial for hair growth, enhancing follicular cell nutrition and showing significant hair regrowth in patients. Rosemary, an evergreen bush from the Lamiaceae family, has been a traditional remedy for hair loss due to its microcapillary circulation improvement. Its essential oil, comprising camphene, camphor, cineol, and borneol, was compared to 2% minoxidil in a six-month study for androgenic alopecia treatment. While both groups showed increased hair count after six months, scalp itching was noted as a minor side effect.

Procyanidins

Procyanidins, a class of polyphenols with diverse pharmacological actions, have been studied for their potential in stimulating hair growth. Procyanidin B-2 from sources like barley, grape seeds, and apples was applied topically for six months in men, demonstrating results similar to finasteride and minoxidil in treating androgenic alopecia. While some experienced itching and inflammation, the procyanidin showed effects on stimulating hair growth and density through its antioxidant properties.

Conclusion:

The most common types of hair loss include spot baldness and androgenic baldness. While many hair loss conditions cannot be fully cured, their progression can be slowed or halted. Achieving optimal nutrition and following a proper hair care routine significantly contribute to

this process. It's important to note that changes in hair growth don't happen suddenly due to the natural cycle of hair development. Future research should focus on understanding the duration required to restore follicles and cease hair loss or determine the treatment period. Some synthetic medications may lead to a resurgence of baldness in a more severe manner after a certain period. There's a growing interest in plant-based remedies that either prevent hair loss or stimulate hair growth. Plant-based treatments are often preferred by patients due to their higher acceptance, fewer severe side effects, lower treatment costs, and the broader range of physiological actions offered by various plant extracts. While plant-based medicines are a valuable addition to traditional therapies, they also represent a potential alternative for certain patient groups who prefer treatments without synthetic chemicals.

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A REVIEW ON PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILE OF *PERGULARIA DAEMIA*

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Abstract:

Pergularia daemia Linn, a perennial herb in India, has antibacterial, antiinflammatory, analgesic, and antipyretic effects and is used to treat arthritis. Its methanol extract has been tested for its anti-inflammatory effects. *Pergularia daemia* is widely used in folk medicine for treating diabetes and liver disorders. The plant contains various phytochemicals, including terpenoid, flavonoids, sterols, and cardenolids. The roots of the plant are used to treat liver disease. The study aims to explore the medicinal pharmacological potential, bioactive remedies and phytochemical profile of *Pergularia daemia.*

Introduction:

Herbal medicine research complements synthetic research, as the World Health Organization promotes the development of traditional medicine systems. The biggest drawbacks of current synthetic drugs are side effects, toxicity, and recurrence of symptoms after discontinuation. Therefore, there is a need to search for new anti-inflammatory agents without side effects while maintaining therapeutic efficacy. Native plants, such as *Pergularia daemia* (Apocyanaceae), have been investigated for cardenolides, alkaloid and saponins, and have been found to contain various triterpenes and steroidal compounds (Tatiya and Hatappaki, 2003). Both plants are widely distributed in the Southern parts of India, and their roots have been used to treat inflammation, pain, and fever by the folklore people of Salem, Dharmapuri and Coimbatore district, Tamilnadu state, India. The leaves of *Pergularia daemia* are used as pain killers and for toothache relief, while the roots are used to treat leprosy, mental disorders, anaemia and piles (Singh *et al.*, 2003).

Phytochemical profile

Inhibitory potential of important phytochemicals:

The study identified b-sitosterol, b-amyrin, a-amyrin, and lupeol in leaf GC-MS and performed molecular docking studies on phospholipase A2 and L-amino acid oxidase enzymes in snake venoms. B-sitosterol showed high affinity for binding to these enzymes, according to the analysis (Maheshwari and Vijayarengan, 2020).

Phytochemical screening & GC - MS analysis:

The study identified b-sitosterol, b-amyrin, a-amyrin, and lupeol in *Pergularia daemia* linn leaf using GC-MS. The results were relevant to the NIST library and showed the presence of flavonoids, tannins, alkaloids, phenols, and steroids. This could lead to the production of herbal medicine using *Pergularia daemia* leaves (Maheshwari and Vijayarengan, 2020).

Larvicidal activity of silver nanoparticles synthesized:

The study identifies b-sitosterol, b-amyrin, a-amyrin, and lupeol in *Pergularia daemia* linn leaf using GC-MS. The results of GC-MS analysis are relevant to the National Institute of Standard & Technology (NIST) library (Prajapati *et al.,* 2003). The bioactivity of latex-producing plant *Pergularia daemia* and synthesized silver nanoparticles (AgNPs) against larval instars was found to be many fold lower than crude latex-treated *A. aegypti* and *A. Stephensi* (Kokwaro, 1981). UV-visible analysis shows absorbance for AgNPs at 520 nm, and TEM reveals a spherical shape of synthesized AgNPs. Particle size analysis reveals particles ranging from 44 to 255 nm with an average size of 123.50 nm. AgNPs were clearly inhibitory against larval instars (Singh *et al.,* 2003).

Qualitative & quantitative analysis of stem bark of *P. daemia*:

This study identifies the inhibitory potential of important phytochemicals in the leaf of *Pergularia daemia* linn using GC-MS. The results of GC-MS analysis are relevant to the National Institute of Standard & Technology (NIST) library. The bioactivity of latex producing plant *Pergularia daemia* and synthesized silver nanoparticles (AgNPs) against larval instars was investigated. The study also investigates the qualitative and quantitative analysis of the stem bark of *Pergularia daemia* in different solvents like thanol, ethanol, chloroform, petroleum ether, and aqueous. The results show the presence of alkaloids, steroids, terpenoids, flavanoids, saponins, phenols, tannins, aminoacids, cardiac glycosides, carbohydrates and proteins. The quantification of compounds like alkaloids, flavanoids and phenols was estimated (Anooj *et al.,* 2022). The results confirm that the stem of *Pergularia daemia* contains significant phytocomponents, as mentioned in traditional claims, and highlight it as a source of many pharmacological studies and a curative for various ailments (Prajapati *et al.,* 2003).

Phytochemicals studies on the leaves:

Pergularia daemia, a perennial herb with a fetid odour, is widely used as a medicinal plant since ancient times. This study analyzes the leaves of *Pergularia daemia* in various solvents and the crude methanolic extract using High Performance Liquid Chromatography. The analysis reveals the presence of alkaloids, steroids, terpenoids, flavanoids, saponins, phenols, tannins, aminoacids, cardiac glycosides, carbohydrates and proteins. Quantification of these compounds was performed using HPLC, revealing two major peaks and two major components in the methanolic extract. The results suggest that *Pergularia daemia* has significant

phytocomponents and can be used for pharmacological studies and as a curative for various ailments (Anooj *et al.*, 2022).

Pharmacological profile as a phytomedicine:

Pergularia daemia, a plant native to tropical and sub-tropical regions, is known for its medicinal properties, including anthelmintic, laxative, antipyretic, and antibacterial properties. The plant contains various phytochemicals, including terpenoid, flavonoids, sterols and cardenolids. In the Western Ghats of India, it is used for various ailments, with roots primarily used for liver disease and jaundice (Prajapati *et al.*, 2003).

Antifertility activity of alkaloidal fraction:

The study investigates the antifertility activity of the ethanolic extract of *Pergularia daemia*, specifically its alkaloidal fraction (Henshaw and De Laszlo, 1954). Oral administration of 200 mg/kg of the extract showed significant activity in preimplantation of stage in female mice (Prajapati *et al.*, 2003).

Amelioratory effect of flavonoid:

The ethanolic extract of *Pergularia daemia*, its steroidal fraction, has been found to have antifertility properties. This study examined the alkaloidal fraction of the ehtanolic extract to observe its antifertility activity. Oral administration of 200 mg/kg of the ethanolic fraction of alkalodal extract showed significant activity in pre implantation. The whole plant, *Pergularia daemia*, extract (50% alcohol), was investigated for its antiurolithiatic and diuretic activity. Ethylene glycol feeding resulted in hyperoxaluria and increased renal excretion of calcium and phosphate. The alcoholic extract (400 mg/kg) of *P. daemia* was given orally in curative and preventive regimens over 28 days, with results comparable to the standard drug cystone (750 mg/kg) (Prajapati *et al.*, 2003).

Anti Inflammatory, analgesics and antipyretic activity:

The crude ethanol extract of *Pergularia daemia* leaves was fractionated with various solvents and tested for anti-inflammatory activity in rats. The ethanol extract and its butanol fraction showed significant anti-inflammatory activity, comparable to aspirin. Another study found that the alcohol extract reduced paw swelling at a dose of 300 mg kg-1 b.wt., equivalent to diclofenac sodium (Parotta, 2001). The anti-inflammatory activity was attributed to the presence of steroids. The analgesic effect of the aqueous and ethanol extract was demonstrated in experimental models using Eddy's hot plate and Heat conduction method. Both extracts showed analgesic activity compared to the control and were analyzed statistically using the Tukey Kramer Multiple Comparison Test. Antipyretic activity was also reported from the aerial parts of *Pergularia* (Pushpangadan and Atal, 1984).

Central nervous system depressant activity:

The study evaluated the central nervous system depressant activity of *P. daemia* roots on Swiss albino mice using chloropromazine and pentobarbitone sodium-induced sleeping time. Both alcohol and aqueous root extracts showed significant activity, mainly due to the presence of glycosides in the roots, compared to control and drug-treated groups (Council for Research In Ayurveda and Siddha, New Delhi, 1996).

Hepatoprotective activity:

The study evaluated the central nervous system depressant activity of *Pergularia daemia* roots on Swiss albino mice, using chloropromazine and pentobarbitone sodium-induced sleeping time. The results showed that both alcohol and aqueous root extracts showed significant depressant activity, mainly due to the presence of glycosides in *P. daemia* (Jalalpure *et al.,* 2002). A preliminary investigation on the aerial parts of *Pergularia daemia* showed significant hepatoprotective activity at a fixed dose level of 200 mg kg-1. The study also identified active compounds responsible for hepatoprotection, including triterpenoids and flavonoids in the ethanolic extract. *In vitro* evaluations of the ethanolic extract also confirmed that flavonoids, such as quercetin, kaempferol, and isorhammetic glycosides, could be responsible for various liver disorders (Parotta, 2001).

Antioxidant activity:

The study conducted an in vitro screening of the antioxidant activity of *P. daemia* root extract, revealing the presence of various pytochemical constituents such as alkaloid, glycoside, steroid, flavonoid, saponin, terpinoid, tannin and phenolic compound. The findings suggest that *P. daemia* may have potential applications in preventing oxidant stress-related diseases (Council for Research in Ayurveda and Siddha, New Delhi, 1996).

Antidiabetic activity:

The study investigated the ethanol and aqueous extract of *Pergularia daemia* plant against alloxan-induced hyperglycemia. The extract showed significant hypoglycemic activity, possibly due to the presence of β-sitosterol and quercetin (Raghunathan and Roma Mitra, 1996). Oral administration of *P. daemia* also showed significant antidiabetic potential, possibly due to its bioactive compounds in the leaves extract. This suggests that *P. daemia* antidiabetic effect may be due to its bioactive compounds.

Anticancer activity:

The study screened *Pergularia daemia's* anticancer activity against 60 human cancer cell lines, including laukaemia, melanoma, lung, colon, kidney, ovary and central nervous system. Results showed α-amyrin had low potency anticancer activity. Triterpenoids are crucial anticancer agents, and structural modification could lead to innovative cancer treatments (Singh *et al.,* 2003).

Antibacterial activity:

The anticancer activity of *Pergularia daemia* was tested against sixty human cancer cell lines, including laukaemia, melanoma, lung, colon, kidney, ovary and central nervous system. α-amyrin showed low potency against cancer. Triterpenoids play a crucial role as anticancer agents, and structural modification of these compounds can lead to innovative treatments. The ethanol and aqueous extract of *Pergularia daemia* plant was investigated against alloxan-induced hyperglycemia, showing hypoglycemic activity (Singh *et al.,* 2003). The presence of β-sitosterol and quercetin may be responsible for this effect. Oral administration of *P. daemia* possesses significant antidiabetic potential, possibly due to its bioactive compounds. This could be a potential drug for cancer treatment (Raghunathan and Roma Mitra, 1996).

Pharmacognostic and phytochemical investigation:

The study investigates the pharmacognostic and phytochemical properties of *Pergularia daemia* stem, including microscopical character determination, standardization using ash value, water soluble extractive and alcohol soluble extractive values, fluorescence analysis, and preparation of alcoholic and aqueous extracts (Pushpangadan and Atal, 1984). The results reveal the presence of carbohydrates, alkaloids, flavonoids, steroids and tannins in the alcoholic extract.

Discussion:

The qualitative phytochemical analysis of *Pergularia daemia* aerial plant sections. *Pergularia daemia* aerial plant component extracts contain alkaloids, flavonoids, lignin, phenol, steroids, tannins and terpenoids. All three solvent systems contained alkaloids, steroids, phenols, and tannins. Only the chloroform and ethanolic extracts contained flavonoids. Lignins were only found in petroleum ether extract. Proteins and saponins were discovered to be lacking in terpenoids were found in all three solvent systems, including petroleum ether**.**

Conclusion:

This review discusses the botanical description, ethnomedicinal uses, phytochemistry and pharmacological profile of *Pergularia daemia*. It highlights its phytochemicals, including flavonoid, alkaloid, terpenoid, tannin and steroid and its pharmacological properties, including anti-inflammation, analgesic, antipyretic, antioxidant, anticancer, antidiabetic, hepatoprotective, antibacterial, antifungal and central nervous system depressant activity.

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FUTURE PERSPECTIVES IN CLINICAL PHARMACY SERVICES IN INDIA

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Abstract:

In recent years, clinical pharmacy in India has witnessed a significant transformation as healthcare systems evolve, and patient care becomes increasingly complex. This transformation is driven by various factors, including the growing disease burden, advancements in medical technology, the prevalence of polypharmacy, a shift towards patient-centered care, government initiatives, and the growth of the pharmaceutical industry. As clinical pharmacy evolves, it is moving away from traditional roles of medication dispensing and basic drug information towards a more patient-centric, evidence-based, and comprehensive model of pharmaceutical care. Clinical pharmacists are now integral members of the healthcare team, playing a crucial role in medication safety, therapy optimization, and patient education. Furthermore, the integration of telepharmacy and telemedicine is a significant development, bridging geographical gaps to provide pharmaceutical care to remote and underserved populations. This advancement includes medication therapy management, adherence support, and drug information services. Pharmacogenomics is another promising field, allowing pharmacists to tailor medication regimens to individual genetic profiles, thereby reducing adverse drug reactions and enhancing treatment efficacy. However, there are challenges that need to be addressed for the future of clinical pharmacy in India. These challenges include the need for a more developed regulatory framework, workforce expansion, robust information technology infrastructure, and patient education. Overcoming these challenges will be essential to fully realize the potential of clinical pharmacy services in India. In conclusion, the future of clinical pharmacy in India is promising, with exciting possibilities, but it requires careful navigation of challenges and a commitment to continuous improvement to deliver high-quality pharmaceutical care that meets the evolving healthcare needs of the population.

Introduction:

In recent years, the field of clinical pharmacy has undergone significant transformations globally, with India being no exception. As healthcare systems evolve and patient care becomes more complex, the role of clinical pharmacists in India is poised for substantial growth and development. This chapter explores the future perspectives of clinical pharmacy services in

India, highlighting key trends, challenges, and opportunities that are likely to shape the landscape of pharmaceutical care in the country. Evolution of Clinical Pharmacy in India: Historically, clinical pharmacy in India primarily revolved around traditional roles of dispensing medications and providing basic drug information. The clinical pharmacist's duties were largely confined to ensuring the proper dispensation of medications and offering rudimentary guidance on drug usage. However, the healthcare landscape in India has transformed dramatically over the years. The shift towards a more comprehensive and patient-centered approach in clinical pharmacy is partly due to the Pharmaceutical Society of India (PSI) taking proactive steps to advance the field. Recognizing the need for a more patient-oriented and evidence-based model of pharmaceutical care, PSI has played a pivotal role in emphasizing the importance of clinical pharmacy in enhancing patient care and safety. In recent decades, the demand for advanced pharmaceutical care in India has surged, driven by several factors: India has grappled with a mounting disease burden, encompassing both communicable and non-communicable ailments, necessitating a more robust clinical pharmacy service capable of managing intricate medication regimens tailored to individual patient needs. Furthermore, the integration of cutting-edge medical technologies, such as precision medicine and personalized healthcare, has expanded the role of clinical pharmacists, demanding the customization of medication regimens to each patient's genetic and clinical profile. The rising prevalence of polypharmacy underscores the need for comprehensive medication management to avert adverse drug interactions and safeguard patient well-being. Moreover, the evolving healthcare landscape in India places a growing emphasis on patient-centered care, prompting clinical pharmacists to engage in collaborative care with patients and other healthcare professionals to optimize treatment outcomes. The government has recognized the pivotal role of clinical pharmacists, introducing policies and regulations to facilitate their integration into the healthcare system. In tandem with the remarkable growth of the pharmaceutical industry in India, clinical pharmacists have pursued higher education and training to enhance their clinical skills, knowledge, and competencies to meet the evolving demands of healthcare effectively. These factors collectively indicate a notable paradigm shift in the role of clinical pharmacists in India, evolving from mere medication dispensers to integral members of the healthcare team. The field is progressively moving towards providing patient-centered, evidence-based pharmaceutical care, and this transformation is poised to shape the future of clinical pharmacy services in the country. In the following sections, we will delve deeper into the challenges and opportunities that lie ahead, along with emerging trends that will influence the trajectory of clinical pharmacy in India.

Clinical pharmacy services include as:

Telepharmacy and telemedicine integration

The fusion of telepharmacy and telemedicine represents a transformative development in clinical pharmacy services, offering increased accessibility and enhanced patient care. Telepharmacy, particularly in remote and underserved areas, allows clinical pharmacists to reach patients via digital platforms, providing essential services. This innovation improves patient access to pharmaceutical care, addressing geographical barriers and reducing the need for extensive travel, especially for those with chronic conditions. Telepharmacy supports medication therapy management (MTM), enabling clinical pharmacists to remotely review medication regimens, make real-time recommendations, and enhance treatment outcomes. It also fosters medication adherence by offering reminders and educational support, ultimately leading to better health outcomes. Moreover, telepharmacy serves as a valuable resource for drug information services, allowing patients and healthcare providers to access accurate and up-to-date medication information. This integration is poised to play a pivotal role in optimizing patient outcomes, expanding the reach of clinical pharmacy services, and advancing the field as technology and healthcare delivery models continue to evolve.

Pharmacogenomics and personalized medicine

Pharmacogenomics, the study of how an individual's genetic makeup influences their response to medications, holds immense promise for the future of clinical pharmacy in India. It allows clinical pharmacists to tailor medication regimens to each patient's unique genetic profile, reducing the risk of adverse drug reactions and enhancing treatment effectiveness. By identifying genetic variations that impact how individuals metabolize and respond to specific drugs, clinical pharmacists can make precise medication recommendations, ensuring the right drug at the right dose for each patient. In India's diverse population, these insights are crucial for addressing disparities in drug responses among different ethnic groups. As pharmacogenomics advances, clinical pharmacists are likely to collaborate closely with healthcare providers to integrate genetic data into treatment plans, reducing trial-and-error approaches and optimizing patient care. This aligns with the concept of personalized medicine, where clinical pharmacists play a central role in delivering patient-centered, tailored medication regimens. The integration of pharmacogenomics offers safer and more effective medication management, benefiting patients and advancing the field of clinical pharmacy in India.

Medication Therapy Management (MTM):

Medication Therapy Management (MTM) is set to play an increasingly central and standardized role in the landscape of clinical pharmacy services in India. Clinical pharmacists are poised to become pivotal in this regard, engaging in comprehensive medication reviews and interventions for patients, particularly those with chronic conditions. This proactive approach

involves assessing the appropriateness and effectiveness of a patient's medication regimen, identifying and resolving medication-related problems, and optimizing drug therapy. Clinical pharmacists will collaborate closely with patients and other healthcare providers to ensure that medications are tailored to individual patient needs and are used effectively. This shift towards more standardized MTM services not only enhances patient outcomes but also holds the potential to reduce healthcare costs by preventing medication-related complications and hospitalizations, aligning with the broader goals of value-based healthcare delivery.

Interprofessional collaboration

Interprofessional collaboration represents a cornerstone of effective clinical pharmacy services in the future healthcare landscape of India. Clinical pharmacists are anticipated to work in tandem with physicians, nurses, and other healthcare professionals to ensure the seamless and comprehensive care of patients. This collaborative approach promotes better communication, enhances patient safety, and optimizes medication management, especially in cases involving complex medical conditions that require a multifaceted and team-based approach. The coordination between clinical pharmacists and other healthcare providers serves to reduce medical errors, improve the quality of care, and foster a patient-centric approach that addresses both the clinical and medication-related aspects of healthcare.

Pharmacovigilance and drug safety

As the pharmaceutical industry continues to experience significant growth in India, the role of clinical pharmacists in ensuring drug safety is paramount. Pharmacovigilance, the science and activities related to the detection, assessment, understanding, and prevention of adverse effects or any other drug-related problems, is expected to become a core responsibility for clinical pharmacists. With a growing array of medications and therapies available to patients, clinical pharmacists will increasingly focus on monitoring adverse drug reactions and ensuring the safe and effective use of these medications. The integration of advanced technologies, such as artificial intelligence and data analytics, will aid in the early detection of safety issues and regulatory compliance, enabling clinical pharmacists to take proactive measures to safeguard patient well-being. Their expertise in pharmacovigilance will be instrumental in upholding the highest standards of medication safety in a rapidly evolving pharmaceutical landscape.

Continuing education and certification

The future of clinical pharmacy services in India will necessitate an ongoing commitment to professional development and knowledge expansion. Continuous education and professional certification will be integral for clinical pharmacists to stay abreast of the rapidly evolving healthcare environment and the latest advancements in pharmaceutical sciences. It is likely that the Indian government and professional organizations will establish frameworks for accreditation and certification, ensuring that clinical pharmacists meet and maintain a high standard of

practice. These educational and certification initiatives will not only foster the professional growth of clinical pharmacists but also guarantee the delivery of safe, effective, and evidence-based pharmaceutical care to the diverse and evolving healthcare needs of the Indian population. In this evolving landscape, clinical pharmacists will remain lifelong learners and experts dedicated to improving patient care and medication management.

Challenges and opportunities

While the future of clinical pharmacy services in India holds immense promise, it also presents several critical challenges and opportunities that demand attention and proactive measures:

Regulatory framework

A major challenge is the need for the development and strengthening of the regulatory framework for clinical pharmacy services in India. Establishing consistent standards of practice and formal recognition for clinical pharmacists is essential to ensure the delivery of high-quality pharmaceutical care. Regulatory bodies and policymakers must work collaboratively to define the scope of practice, licensure, and accreditation standards, enabling clinical pharmacists to practice with clarity and confidence.

Workforce development:

As the demand for clinical pharmacy services continues to grow, there is a pressing need to expand and educate the clinical pharmacist workforce. Educational institutions and professional organizations should invest in training programs, specialized curricula, and certifications that equip pharmacists with the knowledge and skills required to excel in this evolving field. This also necessitates creating incentives for pharmacists to pursue careers in clinical pharmacy.

Information technology infrastructure:

To harness the full potential of telepharmacy and digital health records, India must invest in a robust and secure information technology infrastructure. Telepharmacy services, in particular, depend on dependable internet connectivity and secure platforms for remote patient consultations and data exchange. Developing a national health information system that supports interoperability and data security is essential for the seamless integration of clinical pharmacy services into the healthcare system.

Patient education:

Patient education will be pivotal in realizing the full benefits of clinical pharmacy services. Clinical pharmacists must actively engage in educating patients about their medications, treatment plans, and the importance of adherence. As healthcare transitions to a more patient-centered model, effective patient education can enhance medication adherence, mitigate adverse effects, and empower patients to take an active role in their healthcare

decisions. Collaborative efforts between clinical pharmacists and other healthcare providers are crucial for delivering consistent and evidence-based patient education.

Conclusion:

The future of clinical pharmacy services in India is indeed filled with exciting possibilities. As the healthcare landscape evolves and healthcare needs become more complex, clinical pharmacists will emerge as indispensable members of the healthcare team. Their role in ensuring medication safety, optimizing therapy, and delivering comprehensive pharmaceutical care is poised to enhance patient outcomes and contribute to the overall quality of healthcare in India. However, to realize this future, it is imperative to address the challenges that stand in the way. Strengthening the regulatory framework, expanding the clinical pharmacist workforce, investing in information technology infrastructure, and prioritizing patient education are key steps to overcome these challenges. Embracing technology, fostering collaboration, and committing to lifelong learning will be essential for clinical pharmacists to navigate this dynamic landscape successfully and continue to provide high-quality pharmaceutical care that meets the evolving healthcare needs of the Indian population. The synergy of these efforts will shape a healthcare ecosystem where clinical pharmacy services are a driving force behind safer and more effective patient care.

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NUTRACEUTICALS AS BIOFUNCTIONAL NUTRIENTS IN HEALTHY BODY AND HEALTHY SOCIETY MANAGEMENT

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Introduction:

A new diet health paradigm that emphasizes the benefits of diet has emerged in recent years. The modern lifestyle that people have embraced has altered their fundamental eating habits. Nutraceuticals, according to DeFelice, are foods or food components that have the potential to offer a range of health and medical benefits and are used in the prevention and/or treatment of a wide range of illnesses. This all-encompassing phrase is used to characterize any food-derived product that offers noteworthy health advantages beyond just the food's basic nutritional content. These can be categorized as non-specific biotherapies, which are intended to prevent symptoms and cancerous processes while fostering social well-being.

Figure 1: Types of Nutraceuticals

Nutraceuticals are based on the saying of Hippocrates, a Greek physician and also well known as father of medicine, let food be your medicine. Nutraceuticals are multi - targeted mixtures at a very low concertation whereas, pharmaceuticals are pure unitargeted with a very high concentration use. Also, the nutraceuticals are not regulated or tested like the pharmaceutical products. As, according to Food Safety Standard Act 2006, nutraceuticals are termed as the part of food and should not evaluate as a form of drug formulation or pharmaceuticals. There are over 470 nutraceutical products available in the market that are well known for various health benefits. Now, the patients are shifting their interest towards the nutraceuticals because these are having least side effects and contraindications as compared to the chemical drugs in long term as well as short term therapy. So, the interest to avoid the use of

chemical drugs has come to trend and eventually led to the new research with alternate therapies with the help of nutraceuticals. This review is generally based on the promising therapeutic approaches of nutraceuticals as the commercial remedies.

Categories of nutraceuticals

Depending on how easily understood and applied they are, nutraceuticals can be arranged in a variety of ways, such as for dietary guidance, clinical trial design, academic instruction, or the development of functional foods. Nutraceuticals can be categorized using a variety of common criteria, such as chemical makeup, mechanism of action, and food sources. All of the natural food sources that are utilized to make nutraceuticals fall into the following categories (Kalia, 2005; Kokate *et al.*, 2002):

1. Fiber from food
2. Lactobacilli
3. Prebiotics
4. Fats with polyunsaturated chains
5. Vitamin antioxidants
6. Carotenoids
7. Condiments

A brief summary of the health and medicinal advantages of a few of these nutraceuticals is provided in the following section of the review.

Nutraceuticals can be divided into two categories more broadly i.e. potential supplements and supplements that are already proven

Dietary fiber

Dietary fiber is the food—more specifically, the plant material—that is broken down by the microbiota in the gut rather than being hydrolyzed by digestive tract-secreted enzymes. Non-starch polysaccharides (NSP) like celluloses, hemicelluloses, gums, pectins, lignin, resistant dextrins, and resistant starches make up the majority of dietary fibers. Soluble fiber-rich foods include beans, oats, barley, and fruits. Table 1 shows the amount of dietary fiber in different foods. In terms of chemistry, dietary fiber refers to carbohydrate polymers that are neither absorbed nor digested in the small intestine and have a degree of polymerization of at least 3. Dietary fibers can be categorized into two types based on how soluble they are in water:

1. Insoluble dietary fiber (IDF), which is partially fermented in the colon and consists of celluloses, certain hemicelluloses, and lignins.
2. Soluble dietary fiber (SDF), which is fermented in the colon and consists of β-glucans, pectins, gums, mucilages, and hemicelluloses.

The combined term for the IDF and SDF compounds is non-starch polysaccharides (NSP).

Due to their capacity to produce viscosity and bulk, the soluble components of dietary fiber cause the stomach to empty more slowly (Leclere et al. 1994). This influences the rate at

which nutrients are absorbed and digested as well as producing a satiety sensation. It has been demonstrated that soluble fiber enhances glucose tolerance and reduces serum LDL cholesterol selectively. They also improve the glycaemic response and insulin receptor binding. Dietary fiber in the colon causes faecal bulking because it increases water retention, transit time, and the mass of faecal bacteria through fermentation of soluble fiber. Additionally, the fiber helps Bifidobacteria—especially fructooligosaccharides—grow in the stomach.

Table 1: Level of dietary fiber in foods

Product	AOAC(g/100g)[a]
Apples(withskin)	2.0
Bananas	1.9
Carrots(boiled)	3.1
Bakedbeans	4.2
Cabbage	2.0
WhiteBread	2.0
BrownBread	4.5
WholemealBread	7.4

Polyunsaturated fatty acids

For quite some time, dietary supplements containing polyunsaturated fatty acids (PUFAs) have been promoted with a number of health benefits. Based on their structural makeup, the main dietary polyunsaturated fatty acids (PUFAs) are categorized as omega-3 and omega-6, and they are regarded as vital nutrients. Despite sharing a structural similarity, the two classes of PUFAs exhibit distinct biological activities that may or may not be advantageous to humans. While some of these biological activities are well-established, others are just becoming clear from the numerous dietary studies on polyunsaturated fats. Nonetheless, there is ongoing discussion surrounding the health benefits of PUFAs, with mixed results. This review addresses dietary sources and provides an overview of our current understanding of the biological activities of polyunsaturated fats (PUFAs).

Probiotics

Living microorganisms such as bacteria, yeast, viruses, fungi, etc. are called probiotics. They go by the name "good bacteria" as well. During the digestive stages, we will be able to extract vitamins, vital trace elements, and other substances that are necessary for the body's overall health thanks to this colony of living bacteria. However, certain conditions, like using antibiotics or having a poor diet, can upset the equilibrium of these ecosystems. Thus, some diseases or mycoses may appear more frequently when the "good bacteria" of the microbiota are destroyed.

The intestinal microbiota is the most significant microbiota in the body, with an estimated 100,000 billion microorganisms present. In fact, a variety of phenomena are associated with the microbiota, including:

1. Immunity: The bacteria that make up the intestinal flora help to maintain the intestinal barrier, which keeps pathogenic organisms from colonizing the intestine.
2. Digestion: the microbiota's bacteria are capable of producing vitamins, fermenting indigestible foods, and breaking down fiber.
3. Specific pathologies: disorders like diabetes and inflammatory bowel diseases (like Crohn's disease) are linked to an imbalance in the gut microbiota.

Our food contains natural sources of probiotics. Unbeknownst to us, we eat probiotics on a daily basis, particularly in fermented foods. Yogurt is the most well-known food source of probiotics. Ageing unpasteurized cheeses like Gouda, Gruyere, and Cheddar encourages the body to produce its own natural probiotics.

Prebiotics

It is crucial to define the term prebiotic, also known as "fiber," as it is still poorly understood and sometimes confused with the closely related term probiotic. Prebiotics are chemical compounds that are not active. They stand for the probiotics' "meal." Prebiotics are not strictly necessary for probiotics to survive, but their presence helps the bacteria proliferate and become more effective, which enables them to benefit the host's health.

Therefore, prebiotics are necessary dietary components for the development or function of probiotics. Prebiotic foods include beans, onions, garlic, bananas, apple peels, and many more. Prebiotic fibers are highly advantageous for bacterial colonies because they pass through the small intestine and ferment in the large intestine.

Selenium

The defense against the toxicity of reactive oxygen species, the control of cells' redox states, and the regulation of thyroid hormone metabolism all depend on selenium, an important trace element. One ounce of Brazil nuts has about 200 micrograms of selenium, making them the highest known source of the mineral. Lack of it has resulted in major health consequences for humans, including Keshan's disease, a potentially fatal cardiomyopathy (disease of the heart muscle) that primarily affects children and young women. The antioxidant selenium-containing proteins and enzymes, like thioredoxin reductase and glutathione peroxidase, play the most significant role in the body. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) can cause oxidative damage to cells, and glutathione peroxidase is an important defense against these harmful substances.

The enzyme glutathione peroxidase, which has selenium as a trace element, uses the pentose phosphate pathway to help shield erythrocytes from hemolysis. Selenium's antioxidant activity supports healthy immunity maintenance as well as the prevention of cardiovascular

illnesses. However, it has been discovered that a diet high in selenium can lessen the effects of reperfusion, and that a deficiency in selenium can severely impair intrinsic myocardial tolerance to ischemia. Additionally, it has been discovered that selenium functions as a chemopreventive agent, lowering oxidative stress, limiting DNA damage, and triggering cell-cycle arrest. An increasing number of epidemiological studies have shown that Se status and cancer risks are inversely correlated in human populations.

Antioxidant vitamins

Vitamins like vitamin C, vitamin E and carotenoids are collectively known as antioxidant vitamins. These vitamins act both singly as well as synergistically for the prevention of oxidative reactions leading to several degenerative diseases including cancer, cardiovascular diseases, cataracts etc. (Elliot, 1999). These vitamins are abundant in many fruits and vegetables and exert their protective action by free-radical scavenging mechanisms. Vitamin E which comprises of tocopherols together with tocotrienols transfer hydrogen atom and scavenge singlet oxygen and other reactive species thus protecting the peroxidation of PUFA within the biological membrane and LDL (Meydani, 2000). Tocotrienols are more mobile within the biological membrane than tocopherols because of the presence of the unsaturated side-chain and hence penetrate tissues with saturated fatty layers, i.e. in brain and liver more efficiently. They have more recycling ability and are a better inhibitor of liver oxidation (Watkins *et al.,* 1999). Vitamin E and selenium has a synergistic role against lipid peroxidation. Vitamin C, better known as ascorbic acid donates hydrogen atom to lipid radicals, quenches singlet oxygen radical and removes molecular oxygen. Scavenging of aqueous radicals by the synergistic effect of ascorbic acid along with tocopherol supplementation is a well-known antioxidant mechanism (Lee *et al.,* 2004). Carotenoids like lycopene, βcarotene, lutein, zeaxanthin are known to be the most efficient singlet oxygen quencher in the biological systems without the production of any oxidizing products. βcarotene traps peroxy free radicals in tissues at low oxygen concentrations. Hence β-carotene complements the antioxidant properties of vitamin E.

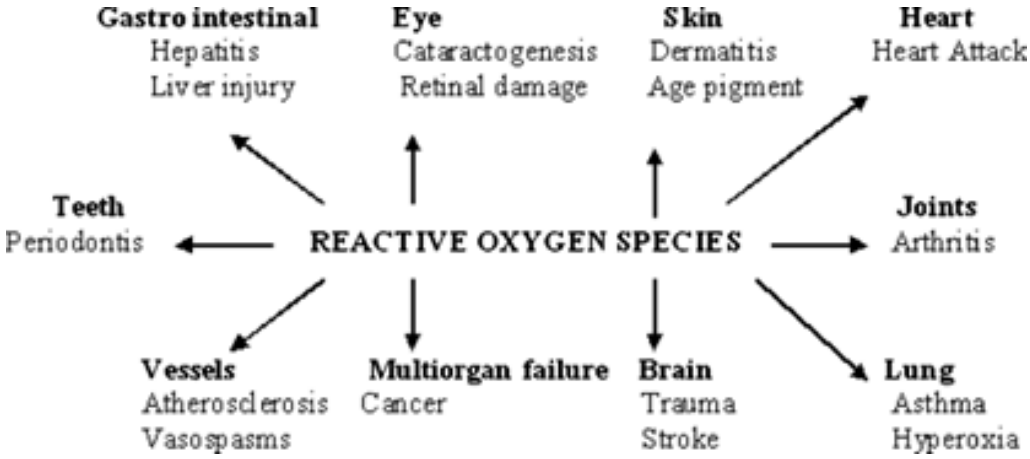

Figure 2: Clinical conditions involving reactive oxygen species

Polyphenols

These days, studies looking for secondary metabolites that can prevent or slow down degenerative and chronic illnesses (such as cancer, heart disease, and neurological disorders) find that phenols and polyphenols—which are abundant and widely distributed in diets derived from plants—are good for human health. These substances are touted as nutraceuticals with the inherent antioxidant capacity to counteract oxidant species over-genesis in healthy cells and the potential to prevent or treat illnesses linked to oxidative stress. In this particular context, it was discovered that pure (poly)phenols and/or their herbal/food complexes exhibited both pro- and anti-oxidant activities, indicating a possible chemopreventive efficacy.

Because of their structural chemistry, polyphenols are primarily recognized for their antioxidant properties. In vitro research has demonstrated that, when compared to vitamin E and C, polyphenols are a more potent antioxidant. The biological activity of polyphenols is significantly influenced by their bioavailability. This is dependent upon the enzymatic availability for metabolism, intestinal absorption, intestinal conjugation and reconjugation, and the chemical characteristics of the polyphenol (Yang *et al.,* 2001). An intriguing feature of polyphenols has also been the subject of research. The expression of γglutamylcysteine synthetase, a crucial enzyme that limits the synthesis of glutathione, has been observed to be modulated by flavonoids.

Plant-food polyphenols have been linked to several aspects of type 2 diabetes mellitus, and there is mounting evidence that these properties could make them special nutraceuticals or adjunctive therapies. In this piece, we have examined the possible benefits of polyphenols—such as phenolic acids, flavonoids, stilbenes, lignans, and polymeric lignans—on diabetes-related metabolic disorders and complications. Dietary plant polyphenols and polyphenol-rich products modulate blood sugar and lipid metabolism, attenuate hyperglycemia, dyslipidemia, and insulin resistance, enhance adipose tissue metabolism, and reduce oxidative stress, stress-sensitive signaling pathways, and inflammatory processes, according to a number of in vitro, animal, and human studies. Additionally, long-term diabetes complications such as neuropathy, nephropathy, cardiovascular disease, and retinopathy can be avoided by taking polyphenolic compounds.

Spices

Spices are exotic culinary additions that have been used for thousands of years to improve food's sensory appeal. The tropical countries are known for their extensive consumption of both large and diverse varieties of spices. They change the texture of food and give it a distinct flavor, scent, piquancy, or color that piques our appetite. According to recent studies, even trace amounts of dietary spices can have a significant positive impact on human health through their actions on the immune system, gastrointestinal tract, cardiovascular system, respiratory system, blood circulation system, reproductive system, and other systems (Kochhar,

2008; Lampe, 2003; Kretchmer, 1994; Kohlmeier *et al.*, 1995; Hendrich *et al.*, 1994; Rao, 2003; John, 2001). Some of these functional aspects of the spices are described in the Figure 3.

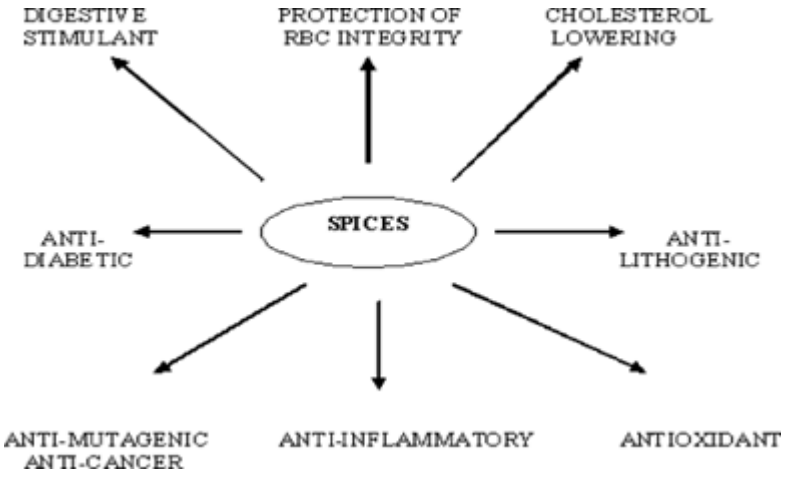

Figure 3: Summary of potential health benefits of spices

Terpenes and other components of essential oils make up the majority of the spice's ingredients. In various forms, they have been found to be effective. For example, 50 g of raw onion and 5-7 cloves of raw garlic are sufficient to reduce cholesterol in the human body. Recent research on the blood pressure and lipid profile of individuals with moderately high cholesterol revealed that aged garlic extract supplementation had greater positive effects than fresh garlic supplementation (Steiner *et al.*, 1996). Garlic and fish oil co-administration reduced total cholesterol, LDL cholesterol, and triglyceride concentrations together, which had a greater positive impact on serum lipid and lipoprotein concentrations.

Conclusion:

Owing to the constantly evolving human lifestyle, oxidative stress is frequently caused by an overloading of the antioxidant defense systems. Furthermore, as people age, their levels of antioxidant defense mechanism decline noticeably. Numerous diseases could arise as a result of these. As a result, research over the previous few decades has mostly concentrated on various nutraceuticals. Products containing antioxidants can either naturally scavenge free radicals (like vitamins and polyunsaturated fats) or they can specifically boost the body's defenses. This illustrates the possible benefits and drawbacks of nutraceuticals in healthy people. But the main factors influencing a person's vulnerability to any given disease are their genetic makeup and unhealthy lifestyle choices, such as heavy drinking and smoking. Therefore, each person's reaction to nutraceuticals may be different.

When consumed in moderation within the acceptable Recommended Dietary Intakes, nutraceuticals have been shown to have numerous health benefits and can prevent disease and promote general well-being in humans.

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ARJUNA POWDER MIXTURE AS A NUTRACEUTICAL: ITS PREPARATION AND EVALUATION

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Introduction:

The field of nutraceuticals has emerged as a ground breaking area of research and development, focusing on the intersection of nutrition and pharmaceuticals. Nutraceuticals offer unique opportunities to improve health and well-being through the utilization of bioactive compounds derived from natural sources. This project aims to introduce the concept of nutraceuticals, highlighting their definition, significance, diverse applications, and potential benefits.

Definition of nutraceuticals:

Nutraceuticals are bioactive substances obtained from natural sources, including plants, animals, and microorganisms. They possess health-promoting properties and provide physiological benefits beyond basic nutrition. Nutraceuticals encompass a wide range of compounds such as vitamins, minerals, herbal extracts, antioxidants, probiotics, and omega-3 fatty acids, among others.

Significance of nutraceuticals:

The growing interest in nutraceuticals stems from their potential to bridge the gap between nutrition and medicine. These innovative compounds offer a proactive approach to health management, focusing on disease prevention, overall well-being, and improving quality of life.

Diverse applications of nutraceuticals:

Nutraceuticals find application in various domains, including:

- Health supplements
- Functional foods and beverages
- Cosmeceuticals
- Sports nutrition
- Animal nutrition
- Agriculture
- Personalized Nutrition

Potential benefits of nutraceuticals:

The utilization of nutraceuticals offers several potential benefits:

- Disease prevention: Nutraceuticals are associated with reducing the risk of chronic diseases such as cardiovascular disorders, diabetes, and certain types of cancer.
- Health maintenance and enhancement: Nutraceuticals provide essential nutrients, antioxidants, and other bioactive compounds that support overall well-being, boost immunity, and improve cognitive function.
- Targeted therapeutic effects: Nutraceuticals with specific properties can target and modulate various physiological processes, such as inflammation, oxidative stress, and cellular repair.
- Improved Nutritional Status: Nutraceuticals can help bridge nutritional gaps by providing essential vitamins, minerals, and other nutrients that may be lacking in the regular diet. They can help optimize nutrient intake and support overall health.
- Enhanced Immune Function: Certain nutraceuticals, such as vitamins C, D, E, and zinc, are known to support immune function. They can strengthen the body's defences against pathogens and promote a healthy immune response.
- Cardiovascular Health: Many nutraceuticals have been studied for their potential cardiovascular benefits. For example, omega-3 fatty acids found in fish oil may help lower blood pressure and reduce the risk of heart disease. Plant sterols and stanols found in certain functional foods may also help lower cholesterol levels.
- Joint Health: Nutraceuticals like glucosamine and chondroitin sulfate are commonly used for joint health. They are believed to support the structure and function of joints, potentially reducing joint pain and improving mobility, particularly in individuals with conditions like osteoarthritis.
- Cognitive Function: Some nutraceuticals, such as omega-3 fatty acids and certain antioxidants, have been associated with improved cognitive function and brain health. They may help protect against age-related cognitive decline and support memory, attention, and overall brain function.

Arjuna powder as a nutraceutical:

Arjuna powder is derived from the bark of the Terminalia arjuna tree, a revered plant deeply rooted in traditional Ayurvedic medicine. Known for its versatile medicinal properties, Arjuna has been used for centuries to support various aspects of well-being. The powdered form of this ancient herb has gained recognition as a powerful nutraceutical due to its rich bioactive composition and numerous health benefits.

The primary appeal of Arjuna powder lies in its potential to promote cardiovascular health. The heart is the engine that keeps our bodies running, and maintaining its optimal

function is crucial for overall well-being. Arjuna powder is renowned for its cardioprotective properties, supported by a robust scientific foundation. It contains a unique combination of antioxidants, flavonoids, and polyphenols, which work synergistically to support heart muscle strength, enhance circulation, and help maintain normal blood pressure levels.

Studies have shown that Arjuna powder can be particularly beneficial in managing cholesterol levels, reducing the risk of atherosclerosis—the buildup of plaque in the arteries—and preventing the oxidation of LDL cholesterol.

Furthermore, Arjuna powder has demonstrated the ability to promote healthy cardiac rhythm and stabilize heart contractions. This unique property makes it an excellent addition to the daily routine of individuals looking to maintain a steady heartbeat and support overall cardiovascular stability.

Arjuna powder offers an additional advantage in that it is a natural product with a favourable safety profile. As a nutraceutical, it provides a gentle and non-toxic alternative to synthetic medications, making it suitable for long-term use without major side effects.

In conclusion, Arjuna powder represents a compelling nutraceutical option for those seeking natural ways to support their well-being. Its rich heritage in traditional medicine, combined with a growing body of scientific evidence, positions it as a promising supplement for promoting cardiovascular health. By incorporating Arjuna powder into one's daily regimen, individuals can take proactive steps toward optimizing their overall health and well-being.

Material and Methods:

1. Collection and preparation of arjuna powder

1.1. Collection of arjuna bark:

- The bark of Terminalia arjuna trees was collected from areliable source or a specific geographical location (mention the location, if applicable).
- Proper identification and authentication of the collected bark were carried out by an expert botanist or taxonomist.

1.2. Drying and grinding of arjuna bark:

- The collected bark was thoroughly cleaned to remove any foreign particles, dust, or impurities.
- The cleaned bark was then dried under controlled conditions (mention the temperature, humidity, and duration) to remove moisture content.
- Once dried, the bark was finely powdered using a mechanical grinder or any other suitable method.

Preformulation study:

Method and procedure:

1. Angle of repose - A clear dry funnel was taken and attached to a burette stand. A white paper sheet was 2-5 cm below the tip of the funnel in a dry platform. Gently sample was pore into the funnel. Using a pencil circle was drawn around the tip of the powder. The height is also measured. The same procedure was followed 3 times to obtain average reading.

$$\textbf{Angle of repose } (\theta) = \tan^{-1}\frac{h}{r}$$

Where, h = average height of heap

r = average radius of heap

2. Bulk density - Bulk density is an indicator of compaction. It is calculated as the dry weight of powder divided by its volume. This volume includes volume of powder particles and volume of pores among powder particles.

10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder the volume as noted as bulk volume.

$$\textbf{Bulk density} = \frac{weight\ of\ powder}{bulk\ volume}$$

3. Tapped density - The tapped density of a powder represents its random dense packing. Tapped density of a powder is the ratio of the mass of the powder to the volume occupied by the powder after it has been tapped for a defined period of time.

10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder. Then measuring cylinder was tapped 100 times. The volume noted as tapped volume.

$$\textbf{Tapped density} = \frac{mass\ of\ powder}{tapped\ volume}$$

4. Hausner's ratio - The Hausner's ratio is a number that is correlated to the flowability of a powder or granular material.

It was calculated by using tapped density and bulk density**.**

$$\textbf{Hausner's ratio} = \frac{Tapped\ density}{Bulk\ density}$$

5. Carr's index - Carr's index is calculated for compressibility of a powder which is based on tapped density and bulk density. It is measure of powder ability to settle and it permit an assessment of the relative importance of interparticulate interactions.

$$\textbf{Carr's index} = \frac{Tapped\ density - Bulk\ density}{Bulk\ density} \times 100$$

6. Particle size determination - Sieve analysis is used to obtain the particle size distribution by determining the amount of powder retained on a series of sieves with different sized apertures. A sample is added to the top of nest of sieves arranged in decreasing size from top to bottom.

Formulation:

Sr. No.	Ingredients	Amount for 5gm
1.	Arjuna (*Terminalia arjuna*, St. Bk.)	5 gm
2.	Cardamom	q.s.

Procedure:

- Collect the bark of Terminalia arjuna reliable.
- Clean the bark to remove any foreign particles, dust, or impurities.
- Then dried under controlled conditions (mention the temperature, humidity, and duration) to remove moisture content.
- Once dried, the bark was finely powdered using a mechanical grinder or any other suitable method.
- Pass all the powder separately through sieve No. 44.
- Collect the powder in separate container.
- Add cardamom as flavouring agent.

Evaluation of formulation:

1. Angle of repose - A clear dry funnel was taken and attached to a burette stand. A white paper sheet was 2-5 cm below the tip of the funnel in a dry platform. Gently sample was pore into the funnel. Using a pencil circle was drawn around the tip of the powder. The height is also measured. The same procedure was followed 3 times to obtain average reading.

$$\textbf{Angle of repose } (\theta) = \tan^{-1}\frac{h}{r}$$

Where, h = average height of heap

r = average radius of heap

2. Bulk density - Bulk density is an indicator of compaction. It is calculated as the dry weight of powder divided by its volume. This volume includes volume of powder particles and volume of pores among powder particles. 10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder the volume as noted as bulk volume.

$$\textbf{Bulk density} = \frac{\textbf{Mass of powder}}{\textbf{bulk volume}}$$

3. Tapped density - The tapped density of a powder represents its random dense packing. Tapped density of a powder is the ratio of the mass of the powder to the volume occupied by the powder after it has been tapped for a defined period of time.10 gm of powder sample was weight accurately. Then it was transferred into a 100 ml measuring cylinder. Then measuring cylinder was tapped 100 times. The volume noted as tapped volume.

$$\textbf{Tapped density} = \frac{\textbf{mass of powder}}{\textbf{tapped volume}}$$

4. Hausner's ratio - The Hausner's ratio is a number that is correlated to the flowability of a powder or granular material.

It was calculated by using tapped density and bulk density**.**

$$\textbf{Hausner's ratio} = \frac{\textbf{Tapped density}}{\textbf{Bulk density}}$$

5. Carr's index - Carr's index is calculated for compressibility of a powder which is based on tapped density and bulk density. It is measure of powder ability to settle and it permit an assessment of the relative importance of interparticulate interactions.

$$\textbf{Carr's index} = \frac{\textbf{Tapped density} - \textbf{Bulk density}}{\textbf{Bulk density}} \times \mathbf{100}$$

6. Particle size determination – Sieve analysis is used to obtain the particle size distribution by determining the amount of powder retained on a series of sieves with different sized apertures. A sample is added to the top of nest of sieves arranged in decreasing size from top to bottom.

All the particle passed through sieve number 44.

Result and Discussion:

Preformulation findings

Parameter	Arjuna Powder
Visual appearance	Brownish
Angle of repose	30.75^{o}
Bulk density	0.39gm/ml
Tapped density	0.51gm/ml
Hausner's ratio	1.3
Carr's index	23.5 %
Particle Size	335 microns
Compression Ratio	0.235

Formulation findings

1. Angle of repose

The angle of repose of the formulation was found to be

Diameter of the pile (D):

$D_1 = 8.5$

$D_2 = 8.4$

$D_3 = 8.5$

$$D = \frac{D1+D2+D3}{3}$$

$$D = \frac{8.5+8.4+8.5}{3}$$

$$D = 8.4 \text{ cm}$$

Therefore radius

$$r = D/2$$

$$r = \frac{8.4}{2} = 4.1$$

height of the pile (h) = 3.5 cm

$$\textbf{Angle of repose } (\theta) = \tan^{-1}\frac{h}{r}$$

$$\theta = \tan^{-1}\frac{3.5}{4.1}$$

$$\theta = \tan^{-1} 0.85$$

$$\theta = 40.36^{o}$$

2. Bulk density

Mass of powder = 13.8 gm

Bulk volume = 35 ml

Therefore

$$\textbf{Bulk density} = \frac{\textbf{mass of powder}}{\textbf{bulk volume}}$$

$$\textbf{Bulk density} = \frac{13.8}{35}\ \textbf{gm/ml}$$

$$\textbf{Bulk density} = 0.39\ \textbf{gm/ml}$$

The bulk density of the formulation was found to be 0.39 gm/ml

3. Tapped density

Mass of powder = 13.8 gm

Tapped volume = 27 ml

Therefore,

$$\textbf{Tapped density} = \frac{\textbf{mass of powder}}{\textbf{tapped volume}}$$

$$\textbf{Tapped density} = \frac{13.8}{27}\textbf{gm/ml}$$

$$\textbf{Tapped density} = 0.51\ \textbf{gm/ml}$$

The tapped density of the formulation was found to be 0.51 gm/ml

4. Hausner's ratio

Tapped density = 0.526 gm/ml

Bulk density = 0.333 gm/ml

$$\textbf{Hausner's ratio} = \frac{\textbf{Tapped density}}{\textbf{Bulk density}}$$

$$\textbf{Hausner's ratio} = \frac{0.51}{0.39}$$

$$\textbf{Hausner's ratio} = 1.3\ \textbf{gm/ml}$$

The hausner's ratio of the formulation was found to be 1.3 gm/ml

5. Carr's index

Tapped density = 0.51 gm/ml

Bulk density = 0.39 gm/ml

$$\textbf{Carr's index} = \frac{\textbf{Tapped density} - \textbf{Bulk density}}{\textbf{Bulk density}} \times \mathbf{100}$$

$$\textbf{Carr's index} = \frac{\mathbf{0.51 - 0.39}}{\mathbf{0.51}} \times \mathbf{100}$$

$$\textbf{Carr's index} = \mathbf{0.235} \times \mathbf{100}$$

$$\textbf{Carr's index} = \mathbf{23.5\ \%}$$

The carr's index of the formulation was found to be 23.5 %

6. Partice Size

Sieve analysis is used to obtain the particle size by determining the amount of powder retained on a series of sieves with different sized apertures. For this formulation, we need the particle which are able to pass the sieve no. 44, that means the particle size can be determine as **335 microns**.

7. Compression Ratio

Tapped density = 0.51 gm/ml

Bulk density = 0.39 gm/ml

$$\textbf{Compression Ratio} = \frac{\textbf{Tapped density} - \textbf{Bulk density}}{\textbf{Bulk density}}$$

$$= \frac{\mathbf{0.51 - 0.39}}{\mathbf{0.51}} = \mathbf{0.235}$$

Discussion:

- **Bulk density** of the formulation was satisfactory.
- **Tapped density** of the formulation was satisfactory.
- **Flow property** of powder is fair because angle of repose fall in range 36^{o} - 40^{o}

Flow Property	Angle of Repose (Degree)
Excellent	25 - 30
Good	31 - 35
Fair	36 - 40
Passable	41 - 45
poor	46 - 50
Very poor	51 - 55
Very very poor	> 66

- **Hausner's ratio** of the formulation was **1.3** (passable).

- **Carr's index** of the formulation was found to be **23.5%**. Therefore, the relative flowability of the formulation is passable.

Flow Character	Carr's Index (%)	Hausner's Ratio
Excellent	≤10	1.00 – 1.11
Good	11 – 15	1.21 – 1.18
Fair	16 – 20	1.19 – 1.25
Passable	21 – 25	1.26 – 1.34
Poor	26 – 31	1.35 – 1.45
Very poor	32 – 37	1.46 – 1.59
Very very poor	>38	>1.60

Conclusion:

In conclusion, Arjuna powder is a remarkable nutraceutical derived from the bark of the Terminalia arjuna tree. This unique herbal supplement has gained recognition for its numerous health benefits and potential therapeutic applications. Arjuna powder is rich in bioactive compounds, including antioxidants, flavonoids, and saponins, which contribute to its remarkable properties.

The consumption of Arjuna powder has been associated with several benefits, such as promoting cardiovascular health by supporting healthy blood pressure levels, improving cardiac function, and reducing oxidative stress. Additionally, it possesses anti-inflammatory properties, which may aid in the management of various inflammatory conditions.

Moreover, Arjuna powder has demonstrated potential in managing cholesterol levels, reducing the risk of atherosclerosis, and supporting overall heart health. Its ability to enhance the production of nitric oxide contributes to vasodilation and improved blood flow, further benefiting cardiovascular function.

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PRECISION PHARMACOLOGY: TAILORING DRUGS FOR INDIVIDUAL NEEDS

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Abstract:

Precision pharmacology, a cornerstone of modern medicine, represents a paradigm shift in drug development and therapeutic interventions. This chapter explores the transformative landscape of precision pharmacology, emphasizing the tailoring of drugs to meet individual needs. Beginning with an overview of the foundations, the discussion delves into the intricate interplay of genomics, biomarkers, and advanced technologies in reshaping the pharmacological landscape. The exploration of genomic insights forms a crucial component, elucidating the genetic determinants influencing drug responses. Emphasis is placed on pharmacogenomics as a powerful tool, highlighting its role in predicting and optimizing drug efficacy. Biomarkers, as pivotal guides in the precision medicine journey, are examined for their potential in predicting and assessing drug responses across various therapeutic areas. Technological advances, including high-throughput screening and omics technologies, are dissected to unveil their contributions to personalized drug discovery. The integration of artificial intelligence and machine learning emerges as a transformative force, with a focus on algorithms predicting individualized drug responses and optimizing treatment strategies. The chapter proceeds to showcase compelling case studies, with a particular focus on oncology and neurological disorders. Success stories in tailoring cancer treatments based on genetic profiles and breakthroughs in personalized therapies for neurological conditions underscore the tangible impact of precision pharmacology on patient outcomes. As the narrative unfolds, attention is directed towards the ethical considerations inherent in precision medicine, including privacy concerns, informed consent, and the imperative of ensuring equitable access. The evolving regulatory landscape is scrutinized, with an emphasis on adapting frameworks to accommodate the unique challenges posed by personalized therapies.

Keywords: Pharmacology; Medicine; Drugs; Genomics; Biomarkers.

Introduction:

Precision pharmacology, a revolutionary paradigm within the realm of medical science, epitomizes a transformative shift from the traditional one-size-fits-all approach to a nuanced

strategy that tailors drug interventions to the specific needs of individuals [1]. This chapter embarks on a journey through the intricate tapestry of precision pharmacology, exploring the scientific underpinnings and transformative implications of tailoring drugs for individual needs. The foundation of precision pharmacology lies in the understanding of genomic intricacies influencing drug responses. Genomic variations, identified through groundbreaking research, play a pivotal role in elucidating individual differences in drug metabolism, efficacy, and adverse reactions.[2] The Human Genome Project, a monumental milestone in genomics, paved the way for decoding the blueprint of human DNA, providing unprecedented insights into the genetic basis of health and disease. Advancements in pharmacogenomics further underscore the potential to tailor drug regimens based on an individual's genetic makeup. For instance, the discovery of genetic variants influencing drug metabolism enzymes, such as cytochrome P450, has opened avenues for predicting and optimizing drug responses [2]. Research endeavors like the Clinical Pharmacogenetics Implementation Consortium (CPIC) and the Pharmacogenomics Research Network (PGRN) have contributed substantially to translating genomic knowledge into clinical practice [3]. The identification and utilization of biomarkers stand as another cornerstone in precision pharmacology, offering a window into the dynamic interplay between drugs and individual biological systems. Biomarkers serve as measurable indicators of normal biological processes, pathogenic processes, or responses to therapeutic interventions [5]. Landmark studies, such as the validation of HER2 as a predictive biomarker for response to trastuzumab in breast cancer [6], exemplify the impact of biomarker-driven approaches in guiding targeted therapies. Technological innovations have propelled precision pharmacology to new heights. High-throughput screening technologies and omics approaches, including genomics, proteomics, and metabolomics, enable a comprehensive understanding of the molecular intricacies underpinning individual responses to drugs [4]. These technologies not only expedite drug discovery but also pave the way for the identification of novel therapeutic targets and the development of more effective and personalized treatment strategies. Artificial intelligence (AI) and machine learning algorithms represent cutting-edge tools in precision pharmacology, with the ability to analyze vast datasets and uncover intricate patterns that elude traditional analytical approaches. Studies leveraging machine learning have demonstrated success in predicting drug responses based on genetic, clinical, and demographic factors [5]. The integration of AI into precision pharmacology holds promise for enhancing the accuracy of treatment predictions and optimizing therapeutic outcomes. As we embark on this exploration of precision pharmacology, we will delve into case studies that exemplify its application across diverse therapeutic areas, with a particular focus on oncology and neurological disorders. Through these cases, we witness the transformative impact

of tailoring drugs to individual needs, bringing us closer to the realization of truly personalized medicine [6]. In the subsequent sections, we will scrutinize the ethical considerations and regulatory frameworks surrounding precision pharmacology. The ethical landscape is evolving in tandem with scientific advancements, necessitating a thoughtful examination of privacy concerns, informed consent, and the imperative of ensuring equitable access to personalized therapies [7]. Simultaneously, regulatory bodies worldwide are grappling with the challenges of adapting existing frameworks to accommodate the unique aspects of precision medicine. In conclusion, this chapter seeks to provide a comprehensive overview of precision pharmacology, highlighting its scientific foundations, technological enablers, and real-world applications [8]. As we navigate the intricate web of genomics, biomarkers, and advanced technologies, we anticipate that precision pharmacology will continue to redefine the landscape of drug development, offering new hope and tailored solutions for individuals facing diverse health challenges.

Foundation of precision pharmacology

1. Genomic insights:

Understanding the role of genetics in drug response is paramount for advancing the field of precision pharmacology. Genetic variations among individuals can significantly influence how the body metabolizes and responds to drugs. This variability is particularly evident in genes encoding drug-metabolizing enzymes, such as those belonging to the cytochrome P450 family [9]. The polymorphic nature of these genes can result in distinct enzyme activities, impacting drug metabolism and bioavailability. For instance, the CYP2D6 gene exhibits extensive genetic diversity, leading to a spectrum of enzyme activity levels. Individuals with different CYP2D6 genotypes may metabolize drugs at varying rates, influencing both therapeutic efficacy and the risk of adverse reactions. This understanding has prompted research efforts to unravel the genetic basis of drug metabolism, contributing to the emergence of pharmacogenomics as a field dedicated to tailoring drug treatments based on an individual's genetic profile [10].

The importance of pharmacogenomics in tailoring treatments lies in its ability to predict individual responses to medications based on genetic information. Pharmacogenomics involves the study of how an individual's genetic makeup influences their response to drugs, including drug metabolism, efficacy, and susceptibility to adverse reactions. This personalized approach to medicine holds great promise in optimizing therapeutic outcomes while minimizing the risk of adverse effects. Scientific studies have demonstrated the practical applications of pharmacogenomics in tailoring treatments. For example, the Clinical Pharmacogenetics Implementation Consortium (CPIC) provides guidelines based on genetic information to optimize drug therapy [11]. One notable example is the CPIC guidelines for thiopurine

methyltransferase (TPMT) genotype and thiopurine dosing, which offer recommendations for adjusting thiopurine drug doses based on an individual's genetic profile, thereby reducing the risk of severe toxicities [1]. These guidelines underscore the potential of pharmacogenomics to guide clinicians in making informed decisions about drug selection and dosing, leading to more effective and safer treatments tailored to the genetic characteristics of each patient.

2. Biomarkers as guide:

The use of biomarkers in predicting drug efficacy is a critical aspect of precision medicine, allowing for the identification of patients who are more likely to respond positively to a specific treatment. Biomarkers, which can be biological molecules or other indicators, provide valuable information about the state of a patient's disease and their likelihood of responding to a particular therapeutic intervention [12]. This approach enables a more targeted and personalized treatment strategy, optimizing therapeutic outcomes while minimizing unnecessary exposure to potentially ineffective or harmful medications. One illustrative example of biomarkers in predicting drug efficacy can be found in the field of oncology. The identification of specific genetic mutations, such as the epidermal growth factor receptor (EGFR) mutations in non-small cell lung cancer (NSCLC), serves as a biomarker for predicting the efficacy of targeted therapies like tyrosine kinase inhibitors (TKIs). Patients with EGFR mutations often exhibit heightened responsiveness to these targeted treatments, resulting in improved outcomes and reduced side effects compared to conventional chemotherapy. In addition to genetic biomarkers, other types of biomarkers, such as protein expression levels or specific cellular characteristics, can also play crucial roles in predicting drug efficacy. For instance, the expression of human epidermal growth factor receptor 2 (HER2) serves as a biomarker in breast cancer, guiding the use of targeted therapies like trastuzumab [13]. The incorporation of these biomarkers into clinical practice represents a paradigm shift, enabling oncologists to tailor treatments based on the unique molecular characteristics of each patient's tumor.

The discovery of biomarkers, crucial for predicting drug efficacy and tailoring treatments, has been greatly accelerated by the integration of emerging technologies. These advanced techniques enable a more comprehensive and precise understanding of the molecular and cellular features associated with specific diseases [14]. Here are some key emerging technologies for biomarker discovery, along with relevant scientific references:

2.1 Next-Generation Sequencing (NGS): NGS technologies, such as RNA sequencing and whole-genome sequencing, allow for the comprehensive analysis of genetic material, revealing intricate details about gene expression patterns and genetic mutations associated with diseases [15].

2.2 Mass spectrometry-based proteomics: Mass spectrometry enables the identification and quantification of proteins in complex biological samples. This technology is crucial for discovering protein biomarkers associated with diseases or treatment responses [16].

2.3 Single-cell RNA sequencing: Single-cell RNA sequencing provides a high-resolution view of gene expression at the individual cell level, allowing the identification of rare cell populations and uncovering heterogeneity within tissues [17].

2.4 CRISPR/Cas9 genome editing: CRISPR/Cas9 technology allows precise genome editing, enabling the creation of cell or animal models with specific genetic alterations to elucidate the functional roles of genes and identify potential biomarkers [18].

2.5 Liquid biopsy: Liquid biopsy involves analyzing circulating biomarkers, such as cell-free DNA, RNA, or proteins, in bodily fluids like blood. It provides a minimally invasive method for monitoring disease progression and treatment response [19].

2.6 Metabolomics: Metabolomics involves the comprehensive analysis of small molecules (metabolites) in biological samples, providing insights into the metabolic changes associated with diseases and drug responses [20].

These emerging technologies, along with others, are collectively shaping the landscape of biomarker discovery, fostering a deeper understanding of disease mechanisms and facilitating the development of more precise and personalized therapeutic interventions.

High-throughput screening and omics technologies

High-throughput screening (HTS) methods are a critical component of drug discovery, enabling the rapid and systematic testing of large compound libraries for their biological activity. HTS has revolutionized the field, allowing researchers to identify potential drug candidates, study biological processes, and uncover novel therapeutic targets efficiently. [21]. Here's an overview of high-throughput screening methods with scientific references:

1. Biochemical assays: Biochemical assays involve testing the interaction between compounds and specific biological targets in a controlled, in vitro environment. Enzymatic assays, receptor binding assays, and activity-based assays are common biochemical approaches used in HTS. [22].

2. Cell-based assays: Cell-based assays involve testing the effects of compounds on living cells. Fluorescence, luminescence, or absorbance-based readouts are often used to measure changes in cell viability, proliferation, or specific cellular responses [23].

3. High Content Screening (HCS): HCS combines automated microscopy with image analysis to assess multiple cellular parameters simultaneously. This method provides detailed information on cell morphology, subcellular localization, and dynamic cellular processes [24].

4. Label free screeing: Label-free screening methods detect changes in physical or biochemical properties without the need for labels or fluorescent tags. This includes technologies such as surface plasmon resonance (SPR) and mass spectrometry-based assays [25].

5. Fragment-based screeing: Fragment-based screening involves testing small, low molecular weight compounds for their ability to bind to a target. This approach is particularly useful for identifying starting points for drug development [26].

6. RNA Interference (RNAi) screening: RNAi screening utilizes small interfering RNAs (siRNAs) to selectively silence gene expression, allowing researchers to study the impact of gene knockdown on cellular phenotypes [27].

High-throughput screening methods play a crucial role in accelerating the drug discovery process, providing researchers with powerful tools to identify potential drug candidates and understand the complex interactions within biological systems

Integration of genomics, proteomics and metabolomics in drug discovery:

The integration of genomics, proteomics, and metabolomics has become increasingly instrumental in reshaping the landscape of drug discovery. Genomics, by studying the entire genome, identifies genetic variations associated with diseases and potential drug targets. The Human Genome Project was a pivotal milestone, providing a comprehensive map of the human genome and laying the foundation for genomic research in medicine [28]. Proteomics delves into the large-scale study of proteins, elucidating their structures, functions, and interactions. Integrating proteomics helps identify disease-specific proteins and unveils potential targets for drug interventions [29]. Metabolomics focuses on small molecules involved in cellular processes, providing insights into the biochemical changes associated with diseases.

Integration with genomics and proteomics offers a holistic understanding of the interconnected molecular pathways, aiding in the identification of novel drug targets. The synergistic integration of genomics, proteomics, and metabolomics is exemplified in systems biology and network pharmacology. Systems biology combines multi-omics data to model complex biological systems, offering a systems-level perspective on diseases and potential drug responses [30]. Network pharmacology constructs biological networks to understand the interactions between drugs, proteins, and metabolic pathways, facilitating the identification of drug targets with higher precision. These integrated approaches enhance the efficiency and success of drug discovery by providing a more comprehensive view of the molecular intricacies underlying diseases, ultimately leading to the development of targeted and personalized therapeutic interventions.

AI and machine learning in precision pharmacology

Artificial intelligence (AI) plays a pivotal role in revolutionizing drug discovery and development, particularly in predicting and optimizing drug responses. Its application spans various stages of the drug development pipeline, from target identification to clinical trial optimization [31]. Here's an overview of the key roles AI plays in predicting drug responses:

1. Target identification and drug discovery: AI algorithms analyze vast biological datasets, including genomics, proteomics, and metabolomics, to identify potential drug targets and predict how these targets might respond to specific interventions. Machine learning models can identify patterns and relationships in complex biological data, aiding researchers in pinpointing novel targets with therapeutic potential [32].

2. Prediction of drug-drug interactions: AI is utilized to predict potential interactions between drugs, helping to anticipate adverse effects or synergistic actions. By analyzing large datasets of known drug interactions and pharmacokinetic information, machine learning algorithms can predict the likelihood of interactions, guiding clinicians in making informed decisions about drug combinations [33].

3. Personalized medicine and pharmacogenomics: AI contributes significantly to the field of pharmacogenomics, tailoring drug treatments based on individual genetic profiles. Machine learning models analyze genetic data to predict how an individual is likely to respond to a specific drug, helping to optimize drug selection and dosage for personalized and more effective treatments [34].

4. Analysis of clinical trial data: AI algorithms analyze diverse datasets from clinical trials, including patient demographics, genetic information, and treatment outcomes. By identifying patterns in these data, AI can help predict patient responses to experimental drugs, optimize trial design, and identify biomarkers associated with positive outcomes [35].

5. Drug repurposing and optimization: AI facilitates the identification of existing drugs that may be repurposed for new therapeutic uses. Machine learning models can analyze biological data to predict the potential efficacy of known drugs against different diseases, accelerating the drug development process and reducing costs [36].

6. Real-time monitoring of patient responses: AI contributes to real-time monitoring of patient responses during treatment. Continuous analysis of patient data, including vital signs, lab results, and imaging data, enables early detection of adverse reactions or insufficient responses, allowing for prompt adjustments in treatment plans [37].

Ethical consideration and challenges in AI-driven precision pharmacology

The integration of artificial intelligence (AI) in precision pharmacology raises significant ethical considerations and challenges that necessitate careful examination. Issues such as data privacy, consent, and the potential for bias in AI algorithms demand thoughtful ethical frameworks. Additionally, the interpretability of complex AI models poses challenges in understanding the rationale behind their predictions, impacting transparency and trust. Striking the right balance between the benefits of AI-driven precision pharmacology and safeguarding patient privacy and autonomy is crucial. The ethical implications of AI in healthcare, including precision pharmacology, have been widely discussed in literature, with studies highlighting the importance of transparent, accountable, and patient-centric approaches to AI implementation [38].

Case studies in precision pharmacology:

Tailoring cancer treatments based on genetic profiles, a cornerstone of precision oncology, represents a transformative approach aimed at optimizing therapeutic outcomes for cancer patients. By identifying specific genetic alterations in tumors, clinicians can tailor treatment strategies to target the underlying molecular drivers of cancer. Comprehensive genomic profiling, facilitated by technologies like next-generation sequencing (NGS), enables the identification of actionable mutations, guiding the selection of targeted therapies and immunotherapies [39]. Notable examples include the use of tyrosine kinase inhibitors (TKIs) for tumors with specific kinase mutations and immune checkpoint inhibitors for cancers with high PD-L1 expression. The integration of liquid biopsies for monitoring genetic changes during treatment further enhances the adaptability of therapeutic interventions based on the evolving genetic landscape of the tumor [40]. This paradigm shift towards personalized cancer therapy holds promise for improving treatment efficacy, minimizing adverse effects, and ultimately advancing patient care.

Immunotherapy has emerged as a revolutionary approach in cancer treatment, leveraging the body's immune system to target and destroy cancer cells. Recent advancements in immunotherapy include the development of personalized cancer vaccines, a promising avenue that tailors treatment to an individual's unique tumor profile. These vaccines are designed to stimulate the immune system specifically against the antigens expressed by a patient's tumor cells, enhancing the body's ability to recognize and attack cancer. Personalized cancer vaccines are created by identifying neoantigens—mutations unique to the individual's cancer—and formulating a vaccine to elicit a robust immune response. This approach aims to overcome the challenges of tumor heterogeneity and immune evasion, offering a personalized and targeted

therapeutic strategy [41]. Clinical trials and research efforts are underway to assess the efficacy and safety of personalized cancer vaccines across various cancer types, marking a significant stride towards more precise and effective cancer immunotherapy.

Neurological disorders:

Personalized treatments for neurological conditions represent a transformative shift in the approach to managing disorders of the nervous system. Recognizing the inherent heterogeneity among patients with neurological conditions, personalized medicine tailors interventions based on individual genetic, molecular, and clinical profiles. Advances in genomic research, neuroimaging, and biomarker identification have contributed to a deeper understanding of the underlying mechanisms of neurological disorders, allowing for more precise diagnostics and targeted therapeutic strategies. From tailored drug regimens to emerging interventions like gene therapies and neuromodulation techniques, personalized treatments aim to optimize efficacy while minimizing adverse effects. This patient-centric approach holds promise for improving outcomes in conditions ranging from neurodegenerative diseases to neurological disorders with complex etiologies, fostering a new era of personalized neurology that accounts for the unique characteristics of each individual's neurological profile [42].

Biomarkers and genetic factors play pivotal roles in influencing drug responses within the realm of neurology. Identifying specific biomarkers allows clinicians to predict individual patient responses to certain drugs, aiding in treatment selection and dosage adjustments. In neurology, genetic factors significantly contribute to inter-individual variability in drug metabolism, receptor sensitivity, and overall treatment efficacy. For instance, genetic variations in drug-metabolizing enzymes or drug transporters can impact the pharmacokinetics of neuroactive substances. Additionally, genetic polymorphisms in neurotransmitter receptors may influence a patient's response to psychotropic medications. Understanding these genetic factors and utilizing biomarkers can guide neurologists in tailoring treatments to the unique genetic and molecular characteristics of each patient, enhancing therapeutic outcomes and minimizing the risk of adverse effects. Ongoing research in pharmacogenomics and biomarker discovery holds promise for further refining personalized approaches to drug prescribing in neurology.

Future prospects in precision medicine for brain-related disorders:

Future prospects in precision medicine for brain-related disorders hold immense promise for transforming the diagnosis and treatment landscape. Advancements in technologies such as genomics, neuroimaging, and big data analytics are paving the way for a more comprehensive understanding of the intricate molecular and genetic underpinnings of neurological conditions. The integration of multi-omics data, including genomics, transcriptomics, and proteomics, is

expected to refine our understanding of the heterogeneity within brain disorders, enabling the identification of precise molecular signatures and therapeutic targets. This personalized approach aims to move beyond a one-size-fits-all paradigm, recognizing the unique genetic and molecular profiles of individuals affected by conditions such as Alzheimer's disease, Parkinson's disease, and various neuropsychiatric disorders [43].

Furthermore, the advent of artificial intelligence (AI) and machine learning is set to revolutionize the interpretation of complex neurological data, allowing for more accurate diagnosis, prognosis, and treatment predictions. AI algorithms can analyze vast datasets, uncover subtle patterns, and identify potential biomarkers that might escape traditional analysis methods. This synergy of technological innovation and biological insights positions precision medicine at the forefront of brain-related disorder research, offering hope for more targeted interventions, personalized treatment strategies, and improved outcomes for individuals grappling with these complex and challenging conditions [44].

Conclusion:

In conclusion, the exploration of precision pharmacology in this chapter underscores the transformative potential it holds in reshaping the landscape of drug development and patient care. As we delve into the era of tailoring drugs for individual needs, the amalgamation of genomics, proteomics, and other omics technologies provides unprecedented insights into the unique molecular signatures that govern individual responses to pharmaceutical interventions. This personalized approach allows us to move beyond the conventional one-size-fits-all paradigm, recognizing the inherent diversity among patients and acknowledging the impact of genetic, environmental, and lifestyle factors on drug metabolism and efficacy.

The journey through precision pharmacology showcases its applications in identifying novel therapeutic targets, predicting patient responses, and minimizing adverse effects. The integration of advanced technologies, such as artificial intelligence and machine learning, further refines our ability to analyze complex datasets and predict individual drug responses with greater accuracy. As we navigate this frontier, collaboration between researchers, clinicians, and industry stakeholders becomes imperative to translate these insights into tangible clinical applications. The promise of precision pharmacology lies not only in optimizing therapeutic outcomes but also in contributing to the broader goals of healthcare—improving patient well-being, enhancing treatment efficacy, and advancing towards a more personalized and effective future in medicine.

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A REVIEW OF ALZHEIMER'S DISEASE AND FORTHCOMING POSSIBILITIES

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Abstract:

Alzheimer's disease stands out as a profoundly debilitating neurological condition affecting the elderly, presenting a significant yet insufficiently addressed public health challenge. Over the past decade, there has been a growing commitment to unraveling the origins of the disease and devising pharmacological interventions. Currently, a range of medications, including antidepressants, antipsychotics, mood stabilizers, anxiolytics, and hypnotics, is employed to manage behavioral disturbances associated with the condition. Looking ahead, the trajectory of research and treatment for Alzheimer's disease involves several crucial aspects. Early diagnosis and the assessment of treatment effectiveness are expected to benefit from the application of functional brain imaging techniques. The pursuit of novel medication classes operating on diverse neurotransmitter systems, such as cholinergic and glutamatergic systems, is underway. This encompasses addressing both cognitive deficits and behavioral disturbances. Additionally, there is a concerted effort towards the development of preventive strategies to mitigate the impact of Alzheimer's disease.

Keywords: Alzheimer's ailment, anti-inflammatory substance, hormone replacement therapy, behavioral disruption.

Introduction:

Alzheimer's disease accounts for over 50% of all dementia cases, impacting more than 24 million individuals worldwide. Annually, there are over 5 million new reported cases, and the incidence rises from 1% between the ages of 60 and 70 to 6-8% at the age of 85 years or older. This trend is expected to escalate as a larger proportion of the population ages. Approximately 10% of individuals older than 70 experience significant memory loss, with over half likely having Alzheimer's disease. Furthermore, an estimated 25% to 45% of individuals older than 85 years are affected by dementia.

The global prevalence of dementia is estimated to be as high as 24 million, projected to double every 20 years until at least 2040. With the global population aging, the number of individuals at risk, especially among the elderly, is anticipated to increase. Alzheimer's disease, marked by impaired memory, is a leading cause of dementia. Its neuropathological characteristics include amyloid plaques and neurofibrillary tangles. While the etiology remains unclear, it is likely influenced by both genetic and environmental factors. The field of

Alzheimer's disease faces a challenge due to the varied meanings associated with the diagnostic label "Alzheimer disease." This review aims to trace the evolution of the use of AD from 1968 to the present, exploring contemporary antemortem biomarkers. A clinicopathologic model, linking amnestic dementia with specific pathologic features, was a foundational approximation in conceptualizing a disease about which little was known. In 1984, the diagnostic term "probable AD" was adopted by the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) workgroup, gaining near-universal acceptance in the research community [1,2].

Current strategies for addressing Alzheimer's disease:

Demonstrate compelling evidence of significantly reducing AD amyloidogenesis in the PDAPP mouse model through immunization with Aβ-peptide. Immunizing younger mice effectively prevented the formation of amyloid, neuritic dystrophy, and astrogliosis, observed in untreated controls. Notably, administering treatment to older animals already experiencing amyloid formation and associated issues resulted in a notable reduction in AD-like neuropathologies. Comprehensive further research is necessary to gain a more comprehensive understanding of the involved mechanisms. This supports the hypothesis that modifying Aβ-peptide levels, whether through Alzheimer precursor protein (APP) processing inhibition or alternative therapeutic approaches, holds promise for AD treatments [3].

Exploring the interaction between endoplasmic reticulum (ER) and mitochondria and its impact on apoptotic pathways provides insights into studies involving animal and/or cellular models of AD. Therapeutic strategies that modulate the ER present a promising avenue for preventing or treating AD. Additionally, nanotechnology-based diagnostic tools, drug carriers, and theranostics offer highly sensitive molecular detection, effective drug targeting, and their combination. Over the past decade, extensive research in this area has yielded significant outcomes in AD therapy. Various nanoparticles within the natural and inorganic nanomaterial categories have been thoroughly examined for their effectiveness against Alzheimer's Disease (AD). These nanoparticles offer targeted drug delivery capabilities and play a role in theranostic processes, encompassing both diagnosis and therapy for managing AD. Results from AD animal models have shown promising outcomes for both active and passive immune treatments targeting Aβ. However, there is limited evidence from human studies supporting the clinical benefits of these approaches [4,5].

The cognitive implications of alterations in sleep patterns are also explored. New roles for circadian clock genes, including period-1, period-2, and bmal1, in memory formation are discussed in the context of age-related cognitive decline. The potential for chronobiological approaches in the treatment and prevention of Alzheimer's disease warrants further exploration

from a pharmacotherapeutic standpoint, recognizing that the timing of drug delivery could enhance or diminish treatment efficacy.

In the realm of pharmacological interventions, memantine, by blocking the pathological stimulation of NMDA receptors, safeguards neural cells from glutamate-mediated excitotoxicity. Acetylcholinesterase (AchE) inhibitors induce a temporary slowdown in cognitive function by reducing cholinesterase activity, leading to elevated acetylcholine (Ach) levels and consequently improved cognitive functions.

Combination therapy:

A retrospective analysis of medical records involving 130 patients from the Ohio State University Memory Disorders Clinic aimed to assess the prolonged effects of combining donepezil and vitamin E in individuals with Alzheimer's disease. The extended use of combined therapy with donepezil and vitamin E appears to be beneficial for patients with Alzheimer's disease.

To evaluate the real-world clinical effectiveness and long-term outcomes in Alzheimer's disease patients, a study compared combination (COMBO) therapy involving cholinesterase inhibitor (CI) plus memantine (MEM) with CI monotherapy and no treatment. The results indicated that COMBO therapy, slowing cognitive and functional decline in Alzheimer's disease, outperformed CI monotherapy and no treatment. These positive effects demonstrated small-to-medium impact sizes that increased over the course of treatment and remained sustained for years. As of now, there is a lack of effective pharmacotherapy for Alzheimer's disease following the progression of the deterioration process during acetylcholinesterase inhibitor therapy. New drugs for Alzheimer's disease, such as immunotherapy or secretase inhibitors, show promise as potential future treatments. However, further investigation is required to assess their safety and tolerability [6,7].

Combination therapy for patients diagnosed with Alzheimer's disease (AD) has been proposed, yet the additional benefits of this combined approach remain a subject of controversy. Memantine is approved for the treatment of moderate-to-severe AD, but the National Institute for Clinical Excellence guidelines do not recommend its use in conjunction with acetylcholinesterase inhibitors. This recommendation contradicts a meta-analysis, the findings of which were disputed by the manufacturer [8,10].

Managing dementia has become a crucial challenge in clinical practice, with acetylcholinesterase inhibitors currently serving as the first-line treatment for Alzheimer's disease. Memantine, approved for moderate-to-severe AD, complements these choices. When used in combination, memantine and cholinesterase inhibitors may offer additional benefits in Alzheimer's disease. A study evaluated the effectiveness and safety of combining memantine

with ongoing donepezil treatment in patients with moderate to severe AD and a subset with moderate AD [11,13].

The results indicated that combination therapy with memantine added to ongoing donepezil treatment in patients with moderate to severe AD is associated with significant benefits in reducing the 24-week decline in cognition, function, and overall status. This combined treatment approach results in substantially lower rates of marked clinical deterioration, exhibits good safety and tolerability, and yields effect sizes that are both statistically significant and clinically meaningfulX

Alterations in the treatment of Alzheimer's disease:

In the United States, cholinesterase inhibitors stand as the sole available treatment for individuals with mild to moderate AD. They play a role in preserving cognitive and functional abilities in a majority of patients, with some experiencing favorable behavioral outcomes. Memantine, recognized as an NMDA receptor antagonist, has recently gained approval in Europe for treating individuals with mild AD. In the treatment of severe to extreme Alzheimer's disease (AD), currently under investigation in the United States, memantine has gained approval in Europe. Its potential mechanism of action may involve enhanced neurotransmission in various systems, coupled with ant excitotoxic effects. The enzyme β-Site Amyloid Precursor Protein Cleaving Enzyme 1 (BACE1) plays a crucial role in the processing of amyloid precursor protein (APP) and the formation of amyloid β peptide (Aβ) species, considered essential in the pathogenesis of Alzheimer's disease. AZD3839, a potent and selective inhibitor of human BACE1, demonstrated concentration-dependent inhibition of BACE1 activity in biochemical fluorescence resonance energy transfer (FRET) assays. In primary cortical neurons and in vivo studies, AZD3839 exhibited efficacy in reducing Aβ levels in the brain, cerebrospinal fluid (CSF), and plasma across various preclinical species [14,16].

The complexity of Alzheimer's disease, known for its multifactorial etiology and intricate pathophysiology, may contribute to the lack of efficacy observed in certain drug compounds. Finding a suitable drug effective across the entire trial population is challenging, given the disease's complexities. Despite unresolved aspects of AD pathogenesis, progress over the past 25 years has allowed the identification of rational strategies, with a focus on reducing Aβ42 formation and tau protein phosphorylation deemed crucial.

Different anti-amyloid strategies target various steps in APP metabolism, aiming to modulate enzymatic pathways responsible for specific APP processing. Efforts concentrate on inhibiting γ and/or β-secretase and activating α-secretase to reduce Aβ production. Specific inhibition of β-secretase, initiating the amyloidogenic pathway for APP processing, is challenging due to potential severe adverse effects. Drugs like semagacestat (LY450139) and avagacestat have been developed to inhibit γ-secretase, showing promise in reducing Aβ levels in

human studies. Multiple clinical trials have evaluated their pharmacokinetics and efficacy against AD [17].

Conclusions:

Current treatment approaches for dementia are grounded in varying levels of scientific evidence, indicating an incomplete grasp of the fundamental pathophysiology of Alzheimer's disease (AD). Cholinergic deficits have been extensively documented, and there is consistent evidence to support the use of cholinesterase inhibitors (such as donepezil, tacrine, rivastigmine, and galantamine) as the recommended treatment for cognitive disturbances in individuals with AD. Symptomatic treatment, primarily centered on cholinergic therapy, has undergone clinical assessment through randomized, double-blind, placebo-controlled, parallel-group studies that measure performance-based evaluations of cognitive function, activities of daily living, and behavioral aspects.

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INSIGHTS OF TREMATODES –FLAT WORMS

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Introduction:

Trematodes are flat worms which are dorso-ventrally flattened, leaf like. They are also called as Platyhelminthes. They are hermaphrodite (monocious) except Schistosoma species which are diocious and are commonly harbouring aquatic fauna like fish, mollusc and snails. Its name is derived from the Greek word name helminths meaning 'worms' referred to e bilaterally symmetrical diatoms.

These flukes or diatoms are are digenetic (depending on two different hosts for their life cycle). Colour is creamy white and there are two suckers one is generally on anterior or terminal for sucking while the other sucker is on central or near to posterior end for attaching to host or organ. Body cavity is absent, it is triploblastic (possessing ectoderm, endoderm and mesoderm). Parasitic specie`s body is coated by thick tegument or cuticle but free living species like turbellarians have syncytial or cellular epidermis. The body is typically fragile due to lack of and covered in barbs, spicules and spines. They cause high morbidity and mortality worldwide of people besides different diseases in humans as well as anaemia and malnutrition. These trematodes harbours on two or sometimes three different hosts like intermediate host (snail), definitive host (vertebrates). As these Flukes lays operculated or spiny eggs with five larval stages in life cycle including miracidium, redia, cercaria, metacercaria and adults.

Depending on position of suckers the cercaria are again classified as:

1) In Amphistome type, acetabulum is located at the posterior end of the body while ovary is located posterior to the testes,
2) The Monostome type is characterized by the presence of only one anteriorly located oral sucker.
3) The Gastrostome type, has mouth being located not in the centre of anterior sucker but in middle of ventral sucker (which in this case is oral sucker).
4) The Holostome type, where the anterior is provided with auxillary suckers flanking it. A special glandular adhesive organ called the tribocytic organ is located immediately posterior to the acetabulum.
5) The Echinostome type possess collar of large spines surrounding the oral sucker.

Many trematodes are classified according to their location of infection such as blood flukes, intestinal flukes, liver flukes and lung flukes.

1) Blood Flukes: The flukes reside in blood vessels of various organs. Eg. *Schistosomes* species.
2) Intestinal Flukes: They are found in any part of intestine. Eg: *Fasciolopsis* species.
3) Liver Flukes: They harbour liver of vertebrates and bile ducts. Eg: *Clonorchis* species.
4) Lung flukes: The trematodes inhabit lungs of vertebrates. Eg: *Paragonimus* species.

Typical life cycle of trematodes:

The zygote is formed from fussion of female and male gamets is encased within an egg shell. as the eggs are numerous become lodged in long and coiled uterus then moving to utero position the eggs are liberated into the host's intestinal lumen through the genital pore and afterwards are passed to the outside in the host's feaces.

The eggs are deposited in water and eventually hatch where miracidium emerges to penetrate the integument of a molluscan host which act as an first intermediate host by shedding its epidermis in the process. Finally, the naked miracidium develops into a sporocyst migrating through blood vessels and other tissue spaces migrating to digestive gland or to specific organ. In few species, the eggs enter the molluscan host passively. It means that the eggs are ingested by the host and the miracidia hatch out within the hosts digestive tract, gonad, mantle, lymph spaces surrounding the intestine, gill chambers etc serve which is a good site for further development of sporocyst which increases in size leading to the development of redia. The redia give rise to tail bearing cercaria which escapes from Molluscan hosts and becomes free swimming unless they come in contact with second intermediate host –often an arthropod or some other invertebrates, even a vertebrate by penetrating host`s body thus gradually maturing as an adult.

The outer surface of the adult digenean is covered by a tegument consisting of two zones where the outer ones separated from the environment by a unit membrane, cytoplasmic syncytium embedding a thin layer of mitochondria, endoplasmic reticulum, vacuoles and sometimes glycogen granules and other types of inclusions. The outer surfaces is thrown into folds to form microvilli. These undulations not only serve to increase the absorptive surface but pinicytotic vesicles are also formed in the crypts between adjacent microvilli for intake of large molecules and particulate materials. In some species, the outer zone also contains tegumentary spines. The outer syncytial zone is connected by cytoplasmic bridges to nucleated bodies called as cytons embedded deeply in the parenchyma. Digeneans possess an incomplete digestive system. The mouth is situated in the anterior sucker leading to muscular pharynx then a short pharynx serving as a masticatory organ leading to oesophagus bifurcating in to a large caecum. The male reproductive system consists of two testes, multi-testicular or with a single testis depending on species. In fact the position of thse gonads are of considerable importance in identification of species. Leading from each testis is a vas efferenst ducts uniting to form

common vasa efferentia entering cirrus pouch which is situated at the terminal of the male reproductive system enclosing seminal vesicle, the prostrate glands and the protrusible cirrus. In some trematodes permanent penis is present.

The female reproductive system consists of a single ovary either anterior or posterior to testes depending on species. Ova formed within ovary are released from that organ via oviduct that opens into a minute chamber, the ootype. Three auxillary organs empty into the ootype: (1) The Mehli`s gland-cluster of unicellular glands surrounding and independently emptying into ootype. (2) the common vitelline duct serves each receives the material from the vitelline glands via the left and right ducts deposit them in the ootype and (3) the duct from the seminal receptacle (absent in some species) which delivers sperms into the ootype or oviduct. In some species a fourth structure-the vitelline reservoir is present as a diverticulum of the common vitelline duct which is a reservoir of vitelline material. The Mehlis gland has several functions:

- These glands secrete a fluid enhancing the hardening or tanning process of newly formed eggs by maintaining desired pH, redox potential and so on.
- Its secretion lubricates the uterus, facilitating passage of the eggs, release of shell globules, forming a thin membrane and activates spermatozoa.

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