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PHYSIOLOGICAL AND  
NUTRITIONAL DYNAMICS OF  
**Alphonso Mango**



**Dr. Ravindra Y. Thakur**

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## ***PREFACE***

Mango (*Mangifera indica* L.), fondly acclaimed as the “King of Fruits,” occupies a unique place in the cultural, nutritional, and economic landscape of India. Relished for its succulence, rich aroma, and exquisite flavour, mango enjoys unparalleled popularity across the country and holds a position of pride among fruit crops worldwide. In tropical regions, its importance is comparable to that of apple in temperate climates. With India contributing nearly half of the global mango production, the fruit not only symbolizes agricultural abundance but also represents the livelihood of millions of farmers.

The mango tree exhibits remarkable adaptability, thriving across diverse climatic zones ranging from the warm, humid coastal belts to regions experiencing seasonal frost. However, fruit quality and yield are profoundly influenced by soil type, altitude, temperature, and rainfall. Among the many mango-growing regions of India, the Konkan coastal belt of Maharashtra has earned international recognition, particularly for the Alphonso variety. The distinctive aroma, taste, and texture of Alphonso mangoes from Ratnagiri and Sindhudurg districts—especially the Devgad region—have made them highly sought after in both domestic and global markets.

Despite its popularity and economic significance, mango cultivation faces numerous challenges. Climatic uncertainties such as untimely rainfall, cyclones, and heat stress often result in premature fruit drop and yield losses. In addition, pests and diseases necessitate the use of pesticides, raising concerns about residue levels and food safety. Post-harvest losses further compound the problem, as mango is highly perishable, with substantial spoilage occurring before it reaches consumers. These realities underline the need for scientific interventions, value addition, and sustainable management practices.

This book has been conceived with the objective of presenting a comprehensive understanding of Alphonso mango, with special emphasis on physiological changes during fruit maturation and ripening. It also explores the often-overlooked potential of mango seed kernels by examining their nutritional composition and possible industrial and dietary applications. Furthermore, the book addresses contemporary concerns related to pesticide residues in mango pulp, particularly in fruits available in local markets, thereby highlighting issues of consumer health and safety.

By integrating physiological, nutritional, and safety aspects of mango production, this book aims to bridge the gap between scientific research and practical relevance. It is intended to serve as a useful reference for students, researchers, horticulturists, food technologists, extension workers, and policymakers, as well as mango growers and enthusiasts who wish to understand the science behind this celebrated fruit.

It is hoped that this work will contribute to improved awareness, encourage further research, and promote sustainable and value-added utilization of mango resources, particularly in the Konkan region. Ultimately, this book seeks to celebrate the mango not merely as a fruit, but as a vital component of India's agricultural heritage and economic strength.

**- Dr. R. Y. Thakur**

## **ACKNOWLEDGEMENT**

I wish to express my profound sense of gratitude and reverence to my very first research guide, the late Professor Dr. Pramod Kokate, whose guidance laid the foundation of my research journey. His scholarly vision and encouragement continue to inspire me, and I remember his contribution with deep respect and gratitude.

I am deeply indebted to my Ph.D. Guide, Dr. (Mrs.) Supreya Yeragi, for her constant guidance, academic insight, and unwavering support throughout the course of my doctoral research. Her mentorship played a pivotal role in shaping this work and bringing it to fruition.

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I also express my sincere thanks to Bhumi Publication for accepting this manuscript and providing the opportunity to bring this work to a wider audience.

**- Dr. R. Y. Thakur**

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## **1. INTRODUCTION**

Among the important fruit crops of the world, the mango (*Mangifera indica* L.) is greatly relished for succulence, exotic flavour and delicious taste. It enjoys the same popularity in tropics as the apple does in temperate regions. It is the premier fruit of India. India is the largest producer of choice table varieties of mango in the world. Mango undoubtedly deserves to be the national fruit of India. In the area, the production, the nutritive value and the popularity of appeal, no other fruit can compete with it. It is the favourite fruit of all parts of India and has been repeatedly acclaimed as the "king of fruits". Its common vernacular name Aam means 'the common'. Although the name does not trace its origin, it is befitting to call so, as it is not only common throughout India but is also the fruit of the common people. Its name Amra used in Sanskrit literature has been used as a suffix to mark distinction and adoration for people and things.

The mango is one of the most ancient fruits of India which is known since the Vedic time. The invading armies of Alexander the Great found it growing in the Indus Valley in 327 B.C. It is now a common fruit in all of the Malayan Archipelago, Indonesia, the Philippines, the West Indies and Madagascar. It has also been introduced into many other lands such as Brazil, the U.S.A. and Queensland in Australia.

Mango is said to have originated in the Indo-Burma region. Vavilov (1949-50) assigned *Mangifera indica* L. for its origin Hindustan centre. Mukherjee (1974) presents evidence that the genus *Mangifera* originated in the area of Burma, Siam and Indo-China or in the Malayan Peninsula, but that, the mango itself probably came from the region of Assam and Burma. He points out that most of the species closely related to *Mangifera indica* L. occur in that region. However, truly wild mangoes have not been found in Malaya, but do occur in Assam and Chittagong hills and that good cultivated varieties of the mango do not occur in Malaya.

The history of the derivation of the common name of mango (*Mangifera indica* L.) is as interesting as the origin of the species itself. This also gives some clues to the place of its origin. As early as in the 16th century the name 'mangas' was used for the mango in the great work 'Colloquies on Simples and Drugs of India'. It is 'mangas' (Tamil word for mango) from which the common English term and the botanical name (*Mangifera indica* L.) is said to have originated. *Mangifera indica* means 'an Indian plant bearing mangoes.'

The mango is now an important fruit throughout the tropics and into the milder subtropical regions. From India eastward to southern China and south through the Malayan

Archipelago to the warmer parts of Australia, it is commonly grown. It is one of the most important fruits of Java, and 3rd most important in the Philippine Islands. It grows well in Hawaii and other Pacific islands. It has long been grown in West Indies, and to a limited extent in Florida. Its introduction in California or the Mediterranean region has not wielded success.

Mango tree is hardy, evergreen and is grown in tropical to subtropical conditions. Tree is large, erect or spreading. Bark becomes corky in older trees and splits. Leaves are lanceolate to elliptic oblong, smooth and glabrous, simple and alternate. Young emerging leaves are yellow to green in colour. Flowers are small, numerous in large terminal panicles. Sometimes flowers are borne axillary. Flowers are red to yellow in colour. Hermaphrodite, male and female flowers are found on the same panicle. Staminate flowers have aborted pistils. Petals, sepals and stamens each are 4-5 in number. One to two stamens out of 4-5 are long and functional. Ovary is single celled with single ovule. Fruit is drupe type (a superior one celled fleshy fruit with one / two seed and does not split open), large in size and have terpenaceous flavour and taste ranges from sour to sweet in different mango varieties. Stone is large, hard, fibrous and monoembryonic in most of the cultivars.

## **2. ECOLOGY AND PHYSICO-CHEMICAL STATUS OF SOIL**

Mango is very particular to the soil and climatic conditions. Ideal soil for mango cultivation should have pH range between 5.5 and 7.5 and should not have more than 0.05 per cent water soluble salts (Singh, 1960 a). Alluvial soils have been found very suitable for mango cultivation. Bhumbla and Dhingra (1963) have described extremely sandy soils, shallow, rocky soils, water logged soils and alkaline or calcareous soils unsuitable for mango cultivation.

The well drained laterite soils of Ratnagiri and Sindhudurga districts on the west coast of Maharashtra, Karnataka and Goa, the medium black soils of Peninsular India, the soils of the delta regions and the deep red loams with a substratum of loose gravel found in Madras are almost equally suited.

### **3. CLIMATE**

Mango thrives best at around 26.7°C annual mean temperature. The optimum growth temperature for mango has been reported to be 23.9°C to 26.7°C (Woodrow, 1910). Below 1.1°C, mango plants are adversely affected by the frost. At Saharanpur, it was noted that minimum temperature of 0.6°C to 0°C for 1.25 hr for two consecutive days resulted in appreciable damage to mango trees. Differentiating and exposed fruit buds in 'bud break' and 'bud burst' stages were killed and turned blackish and dropped down (Singh and Singh, 1955). High temperature during flowering helped in increased percentage of perfect flowers (Singh *et al.*, 1966). It is noted that temperature also governs flowering time and ripening of the fruits. High temperature initiates early flowering and ripening of fruits. But in Konkan region it is observed that low temperature initiates flowering and the warm condition favors development of hermaphrodite flowers. Prolong low temperature decreases development of hermaphrodite flowers which in turn affects crop production. Mango plants can even grow up to 1400 m altitude. However, it is reported by Singh (1978) that fruiting at higher altitudes has been poor, normal fruiting is obtained below 500 m altitude.

For mango, amount of rainfall as well as its distribution, both are important. According to Singh and Jawanda (1961), it does the best in comparatively dry regions which receive good rainfall in hot weather from June to September followed by a more or less dry spell for the subsequent eight months. Rainfall of about 1250 mm during the year is very suitable along with irrigation facilities. According to Singh (1978), mango grows equally well both under low and heavy rainfall conditions ranging from 250 mm to 2500 mm annually. It can be grown with little or no irrigation above 750 mm annual rainfall. Rainfall during flowering period causes heavy losses to the crop because of washing away of the pollens resulting in poor fruit set, high incidence of mango hoppers, mealy bugs and diseases like powdery mildew and anthracnose. Excessive rainfall and high humidity during the time of fruit maturity result in high incidence of fruit fly. Persistence of high temperature, rainfall and humidity throughout the year, results in continuous vegetative growth and thus causes poor fruit bearing.

#### **4. BOTANICAL DESCRIPTION**

Botanically the mango belongs to the family Anacardiaceae to which a number of plants of horticultural interest belong.

The mango is one of the largest of fruit trees, but when planted singly it is normally spreading. Sometimes it spreads over a hundred feet, if it is raised from seedling trees. Mango trees grown from seeds are mostly erect and robust while the grafted ones are generally dwarf with spreading branches. Trees raised from seeds technically known as 'seedling' mangoes, usually live for more than hundred years whereas grafted trees are known to have shorter life of about 80 years or less.

The growth habit of the mango is also of importance as the tree is evergreen. Nonetheless, it is able to withstand all the vagaries of nature maintaining its evergreen condition. Very often it is seen standing in the evergreen situation far away in the horizon of wide barren fields stretching in several hundred thousand hectares in the plains, even in the hot scorching summer, like an oasis of the desert. This evergreen tree grows by periodic bolting where a crown of leaves emerges out. Several times in a year and only once reproductive bolting occurs. These phasic developments of vegetative and reproductive organs are appropriately called respectively vegetative flush and reproductive flush. However, reproductive flushing confines to a specific period, say November-December. If it fails to bolt reproductive flush, it invariably gives vegetative flush. This peculiarity may be with the entire tree or exhibited by branches.

Leaves are simple, alternate, exstipulate and coriaceous and crowned at the ends of the branches. The phyllotaxy is usually 3/8 but as the leaves are arranged very closely at the tips they appear to be whorled.

The time of flowering in different regions is greatly influenced by local weather conditions. In Andhra Pradesh and South Konkan and along West Coast, the mangoes may begin to bloom as early as in November, in some years though usually they start flowering in December. In most parts of the peninsular India, December-January is the usual time for mango to flower. In many parts of North India, the mango flowers late in January or in the beginning of February or even as late as March in some sub montane districts Flowering continues in 2 or 3 distinct flushes for a period of six to eight weeks on different branches of trees and it takes about five months for the fruit to mature and ripen after flowering. Certain mango types flowering on alternate branches throughout year are also not rare.

It is noted that in Konkan the weather is humid because of coastal climate. Hence, floral initiation and ripening of fruits is rather slow. There are three consecutive flowering flushes that occur during one and same flowering season.

Flower bud differentiation in mango shoots takes place during October to December. Development of different organs in mango flowers starts from calyx, corolla, stamens and then carpel and the disc. It takes about 15 days for tiny bud to develop and open into a flower. Flowering in mango remains for about 20-25 days (Singh, 1960 b).

Inflorescence in mango is terminal but axillary and multiple panicles may also arise from axillary buds. The panicle consists of a main axis having many branched secondary axes. The flowers are closely clustered towards the apex of each branch or main axis. These are either male or hermaphrodite. According to Mukherjee (1953), the total number of flowers in a panicle may vary from 1000 to 6000 depending upon the variety. Mango panicle also varies in length from 5 to 30 cm (Singh, 1978). Hermaphrodite flowers in a panicle determine the extent of initial fruit set. Hermaphrodite flowers may be early, mid or late emerging as per emergence of panicles. Studies conducted by Singh *et al.*, (1966) revealed that in cultivar Dashehari, perfect flowers in the panicles of medium and late flushes were 2 and 7 times more, respectively than panicles of early flush. Panicles in the inner portion of the tree have highest percentage of perfect flowers than those located on the periphery. Medium and late emerged panicles have higher fruit set and retention as compared to early emerged panicles. It has therefore been thought that high temperature is associated with an increased percentage of perfect flowers and low temperature with a decreased percentage of perfect flowers (Singh, 1978). Sharma and Singh (1970) have observed higher pollen production in late flush than in early flush in cvs. Dashehari, Langra and Chausa. Pollen viability has been recorded as high as 93 per cent and germination of pollen on stigma is quite normal. Stigma remains receptive up to 5 days after anthesis. Mango is a cross-pollinated type and it is done mainly by insects and house fly (*Musca domestica* L.) In self-pollinated fruitlets of mango, auxins like substances were found lesser in amount as compared to cross pollinated fruitlets (Pandey *et al.*, 1972). Therefore, cross pollinated fruitlets have better fruit retention as compared to self- pollinated ones. Pandey *et al.*, (1974) has reported that cross pollinated fruitlets act as a strong physiological sink as compared to selfed fruitlets with the higher levels of RNA and DNA.

The chief internal factor that governs and controls the entire phenomenon of flowering in mango is maturity and age of its seasonal vegetative growth (leafy shoots). In Western

India mango puts forth new leafy growth thrice in a year. The first flush is produced in the early spring (February - March), the second during March-April or later in the beginning of the monsoon and 3rd in the beginning of the winter (October - November) and there may occur some occasional growths in between these main flushes. In Uttar Pradesh, only two flushes are generally produced, in March- April and July - August. In the Punjab, as many five flushes are given out between April and August, out of which April and May flushes are heaviest. In South India, mangoes put forth two main flushes, one from February - June and the other in October - November.

Of the various flushes of the above mentioned seasonal growths, it is mostly the 8- to 10-month-old mature shoots that produce flowers. These shoots are produced in spring and early summer and cease growing at least four months prior to blossoming. Other shoots produced in subsequent flushes during late monsoon and after October rarely blossom towards the end of winter or in the beginning of spring which is the flowering time of mango throughout India.

The internal nutritional conditions of the tree favour differentiation of flower buds, if vegetative shoots produced in the spring and summer cease to grow early and accumulate sufficient food reserves in their tissues before October. The spring and summer shoots get sufficient time to grow, rest and mature for the purpose but the later formed one do not get time to do so.

Mango trees are characterized by alternate bearing or biennial bearing which means that mango bears 'fat' and 'lean' crops in alternate years. When mango bears a heavy crop, the bearing season is called the 'on' year. When it bears a poor or lean crop, the season is called the 'off' year. The habit of bearing heavy and sparse crops in alternate years is believed to be inherent in mango. However, it is based on observation and not on experimental evidences. For producing blossom, a mature shoot should have its carbohydrate content in much greater proportion to nitrogen but if nitrogen is more than carbohydrate, the shoot will produce more and more leafy growth.

## **5. NUTRITIONAL STATUS**

Mango tree has great religious significance as 'Panch Pallav', an aggregate of five springs which is used at religious functions. Dry twigs of mango are used for lighting the sacred fire for 'Havan'. Stone of mango fruits and bark of the tree have medicinal value.

### **5.1 Fruit Pulp**

Mango fruits are excellent source of vitamin A, vitamin C and sugars. Chemical composition of mango fruits based on the analysis of more than 25 cultivars has been published by the Indian Council of Medical Research in a special report (series no. 42, 1966) (C.F. Chandra & Chandra).

According to this report mango fruits contain moisture 73.0 to 86.7 %, Carbohydrates 11.6 to 24.3 %, Proteins 0.3 to 1.0 %, Fats 0.1 to 0.8 %, Minerals 0.3 to 0.7 %, Vitamin A 650 to 25940 I.U. and Vitamin C 3.0 to 83 mg/100 g.

During the ripening process the fruits are acidic, astringent and rich in ascorbic acid (vitamin C). Ripe mangoes contain moderate levels of vitamin C, but are fairly rich in provitamin A and vitamins B<sub>1</sub> and B<sub>2</sub>. Fruit acidity is primarily due to the presence of malic acid and citric acid. During ripening acidity decreases to 0.1 to 0.2 %. Following fruit set starch accumulates in the mesocarp. Free sugars, including glucose, fructose and sucrose, generally increase during ripening; however, the sucrose content increases three to fourfold due to the hydrolysis of starch.

#### **5.1.2 Chemical Status of Fruit Pulp**

The chemical composition of the fruit is very important. To know the chemical status, different constituents like citric acid, ascorbic acid, malic acid  $\beta$  - carotene, total sugars and starch and T.S.S. were estimated during the development of the fruit.

It appears from the results that moisture percentage in the fruits of Alphonso goes on decreasing with steady state from fruit setting to harvest. Gole (1986) reported decline in the moisture content in Alphonso, Pairi and Seedling mango from fruit set till maturity. In the present investigation the moisture percentage in the Alphonso fruits at 20 days after fruit set is noted to be 85.50 %. The low level of moisture is noted at harvest time (100 days after fruit set) as 83.53 %. It is significantly noted that there is drop in the moisture percentage during ripening process. A steady and slight decline in moisture content during growth of the mango fruits could be attributed to the increased rate of biosynthesis of soluble chemicals and metabolites which result in an increase in concentration of fruit

fluid. Similar observations are made by Kapur (1974); Pandey *et al.*, (1974); Dabhade and Khedkar (1980 a, b) and Naik (1985) in different varieties of mango.

Following table summarizes the results obtained from the analysis of fruit pulp of Alphonso mango.

**Table1: Chemical Status of Alphonso Mango (*Mangifera indica* L) Fruit pulp with respect to Developmental Stages**

Fruit maturity (days)	Moisture (%)	Titrateable acidity (%)	Ascorbic acid ((mg/100g)	Malic acid (mg/100g)	$\beta$ -carotene ( $\mu$ g/100g)	Reducing sugars (%)	Nonreducing sugars (%)	Total sugars (%)	Starch (%)	T.S.S. ( $^{\circ}$ Brix)
20	85.50	2.55	294.10	693.65	34.00	0.17	0.33	0.50	1.75	5.00
40	85.00	2.67	256.00	657.88	56.75	0.44	0.29	0.73	4.40	6.57
60	84.73	2.20	227.00	746.82	111.28	0.60	0.19	0.79	5.62	7.88
80	84.22	2.32	184.59	631.39	140.66	0.93	0.09	1.02	8.70	9.33
100	83.53	2.22	141.33	1417.61	250.07	1.37	1.10	2.47	11.30	9.74
Ripened	80.00	0.66	69.80	1535.44	9578.57	4.49	12.32	16.81	0.30	19.33

It is evident from the results that there is decrease in the acid content in the Alphonso mango fruits during their development. The values for titrateable acidity increase from 20 days to 40 days after fruit set and then there is slight decrease up to harvest time. Gole (1986) recorded 2.30 per cent acidity in Alphonso at maturity. Patkar (1978) while studying Alphonso reported that there was decrease in acid content in the fruits at harvest stage (2.68 g/100 g). The maintenance of higher acidity at fruit setting might be attributed to increased biosynthesis of organic acid during growth periods. It is interested to note that during ripening stage there is sudden drop in the acidity. Rodriguez *et al.*, (2012) found that stage of maturity had a great influence on total titrateable acid (TTA) content. Reduction in TTA could be due to degradation of citric acid due to increased activity of citric acid glyoxylase during ripening while reduction in acidity may be due to their conversion into sugars and their further utilization in metabolic processes like respiratory

climacteric in the fruit. The similar findings were reported by Pandey *et al.*, (1974), Muzumdar (1976); Chattopadhyaya *et al.*, (1978), Naik (1985), Doreyappa–Gowda and Huddar, (2001) and Rathore, *et al.*, (2007); in some varieties of mango.

The level of ascorbic acid in the immature fruits is quite high (294.10 mg/100g) which is gradually decreased up to maturity (141.33 mg/100g). The drop in the level of ascorbic acid during ripening process is noted to be 69.80 per cent. This drop may be because of degradation and utilization of ascorbic acid during fruit development. The decrease in the level of ascorbic acid in the fruits of mango during development is reported by different workers (Siddappa and Bhatia, 1954; Subramanyam *et al.*, 1971; Gangawar and Tripathi 1973; Rangawala, 1975; Patkar, 1978; Naik, 1985; Gole, 1986).

Ascorbic acid is highly susceptible to oxidative destruction at ambient temperatures as well as freezing temperatures; this could have contributed to the decreased trend in vitamin C with ripening and storage. (Ishtiaq *et al.*, 2010). Vitamin C is a precursor component in nutrition. It helps the body to develop resistance against infectious agents and it is an excellent antioxidant against cancerous agents. Vitamin C is an essential component in human diet required for prevention of scurvy, presents biological functions in collagen formation, inorganic iron absorption, inhibition of nitrosamine formation and immune system enhancement. It acts as an antioxidant protecting the body against oxidative stress related diseases (Padayatty *et al.*, 2003).

Malic acid is the intermediate organic acid synthesized during T.C.A. cycle. It is evident from the results that the level of malic acid goes up and down during development of the fruits but finally at harvest time and ripened stage, there is remarkable increase in the malic acid level. This increase in malic acid is twofold.

It is evident from the results that the initial level of  $\beta$ -carotene in the developing fruit is at lower order i.e. 34  $\mu\text{g}/100\text{g}$ . There is steady increase in the level of  $\beta$ -carotene up to maturity (250.07  $\mu\text{g}/100\text{g}$ ). However, there is sudden increase in the level of  $\beta$ -carotene in ripened fruits of Alphonso. This increase in the carotenoid content during later stage of development may be because of accelerated biosynthesis of carotenoids which during ripening of mango fruits imparts colour to the fruit pulp. The increase in the level of carotenoids in the Alphonso fruits was reported by different workers viz.; Lakshminarayana (1973), Mann *et al.*, (1974), Patkar (1978), Naik, (1985) and Gole (1986). High amounts of  $\beta$ -carotene in mango fruits at their ripe stage is an indication of a high nutritive value due to its antioxidant property and as a precursor of vitamin A, thus

beneficial to the consumers.

The level of reducing, nonreducing and total sugars goes on increasing during the development of fruits. There is threefold increase in the level of reducing sugars in the ripened fruits of Alphonso and there is almost tenfold increase in the level of non-reducing and total sugars. The values for reducing and nonreducing sugars showed the increasing pattern which is attributed in the values of total sugars. Hulme (1971) and Gangawar and Tripathi (1973) reported increase in the level of nonreducing sugars and total sugars in developing mango fruits, while the level of reducing sugar is noted to be increased as reported by Cheema *et al.*, (1939), Leley *et al.*, (1943), Subramanyam *et al.*, (1971) and Gangawar and Tripathi (1973). Gole (1986) reported higher reducing and total sugars throughout the growth period in Alphonso and Pairi. Similar observations were reported by Pandey *et al.*, (1974), Muzumdar (1976), Chattopadhyaya *et al.*, (1978), and Naik (1985) in different varieties of mango. The increased level of total sugars is because of higher biochemical activities and because of conversion of excess organic acid into sugar which leads to the change in taste from sour to sweet during ripening process.

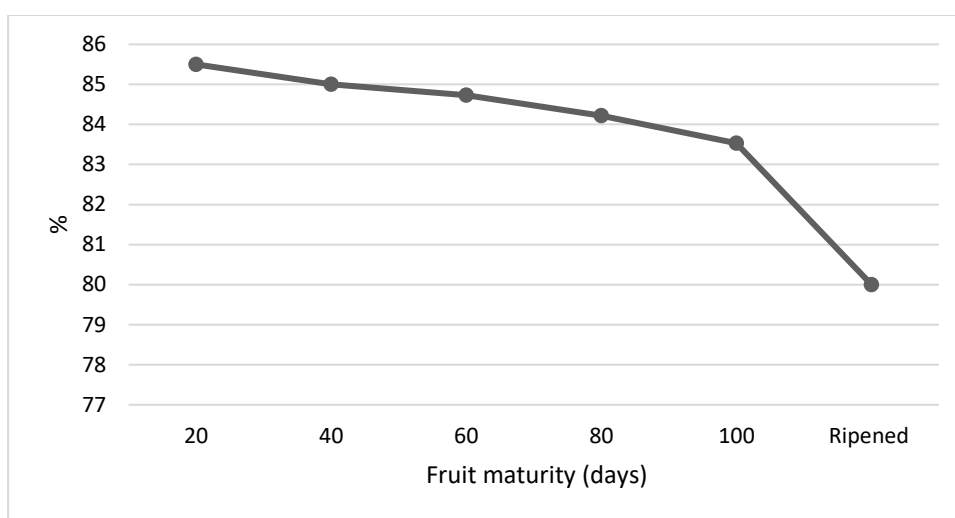
Starch content in the pulp of mango fruits attributes to the semi softness. It is evident from the results that there is steady increase in the starch content in the fruits of Alphonso during developmental stages. The level for starch increases from 1.75 % to 11.30 % up to harvest time. The increase in the starch content during the development of different mango varieties is reported by different workers viz.; Leley *et al.*, (1943), Popenoe and Long (1957-58), Mukherjee (1959), Gangawar and Tripathi (1973), Patkar (1978), Gole (1986). It is noted from the table that there is sudden drop in the level of starch in the ripened stage of fruits of Alphonso. Complete disappearance of starch during ripening of the fruits in Alphonso mango was reported by Leley *et al.*, (1943), Askar *et al.*, (1972) and Singh *et al.*, (1974). TSS in fruit juices contains different soluble solids such as acids, minerals, sugar, vitamins and proteins etc. (Khan *et al.*, 2013).

The values for Total Soluble Solids (T.S.S.) increase steadily during growth of the fruits. However, during ripening stage there is sudden increase in the level of T.S.S. to 19.33<sup>0</sup> Brix in Alphonso fruits. Decrease and increase in the level of T.S.S. in developing, matured and ripened mango fruits is reported by different workers viz.; Pandey *et al.*, (1974), Muzumdar (1976), Chattopadyaya *et al.*, (1978), Patkar (1978), Naik (1985) and Gole (1986).

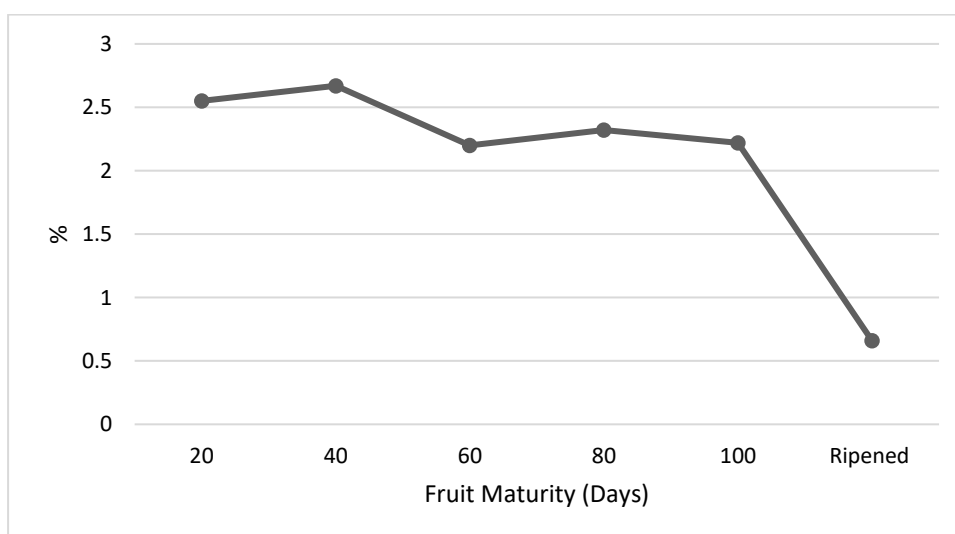
Thus, with the development and growth of the fruits of Alphonso mango till ripening, the moisture, titratable acidity, ascorbic acid and starch show decreasing trend in their

concentration in fruit pulp, on the other hand, malic acid,  $\beta$ -carotene, sugars and TSS show increasing trend. Okoth *et al.*, (2013) and Safina *et al.*, (2014) found similar trends in various varieties of mango.

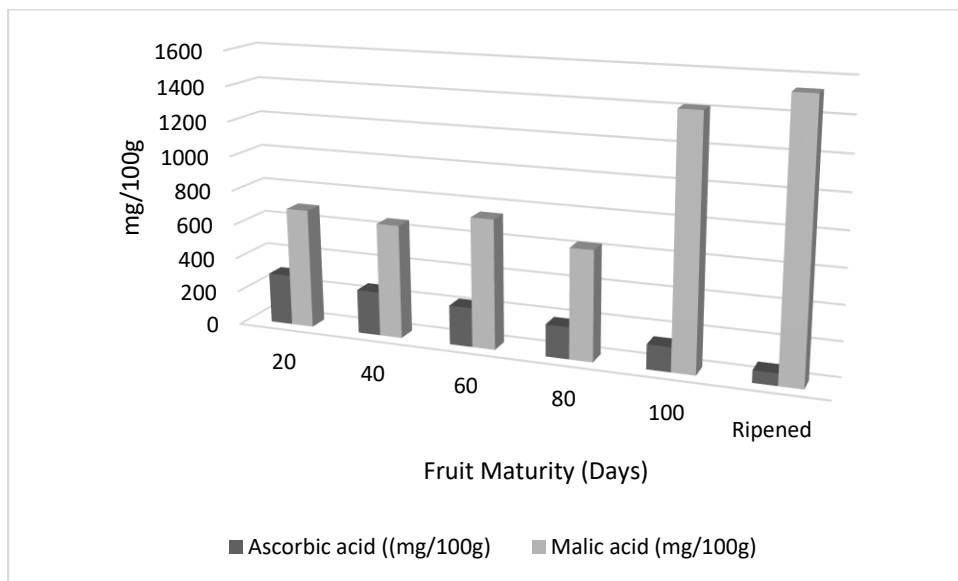
The ripening process of mango fruit involves numerous biochemical changes including increased respiration, ethylene production, fruit softening, and development of pigments, metabolic activities leading to changes in carbohydrates, organic acids, lipids, phenolics, volatile compounds, structural polysaccharides and softening of texture to acceptable quality (Lizada, 1993; Gomez-Lim, 1997). This ripening process takes place within 9-12 days postharvest at ambient temperature, depending on cultivar and stage of fruit maturity at harvest.



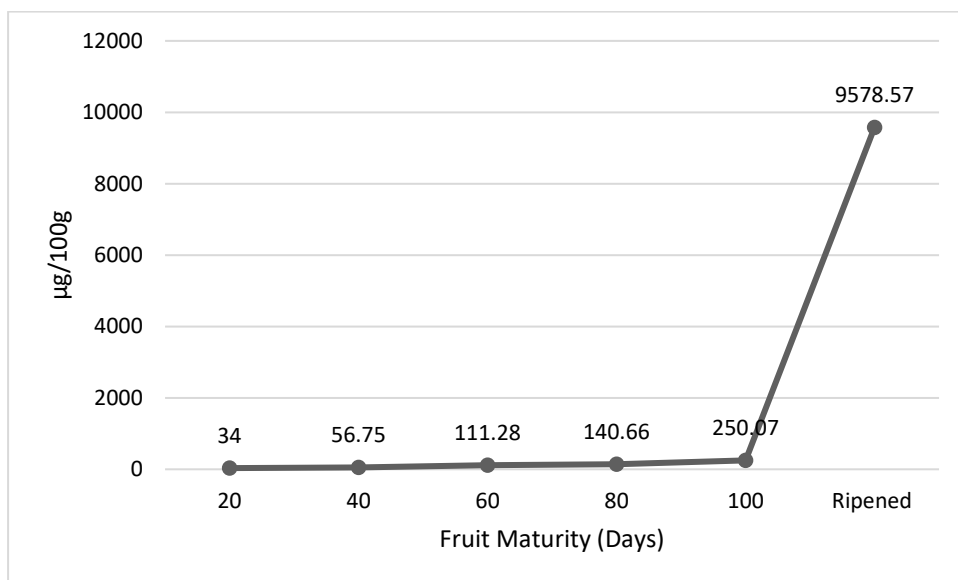
**Figure 1: Developmental change in moisture content of fruit pulp of Alphonso mango (*Mangifera indica* L)**



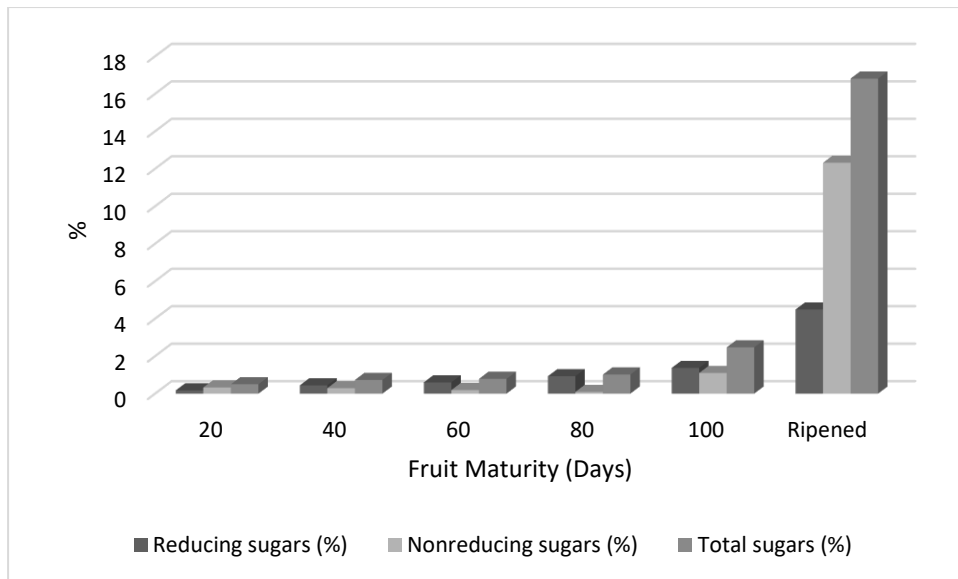
**Figure 2: Developmental change in titratable acidity of fruit pulp of Alphonso mango (*Mangifera indica* L)**



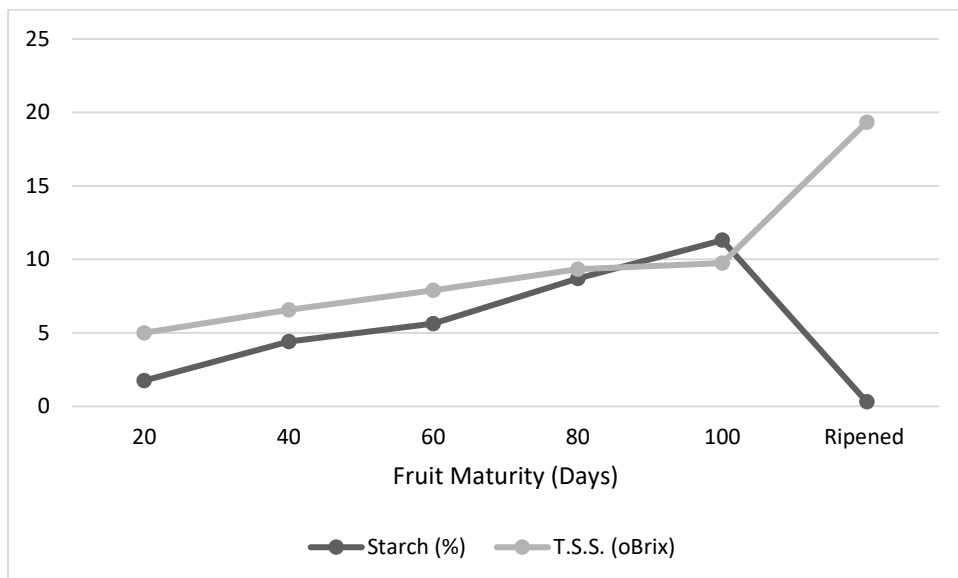
**Figure 3: Developmental change in ascorbic acid and malic acid content of fruit pulp of Alphonso mango (*Mangifera indica* L)**



**Figure 4: Developmental change in β-carotene content of fruit pulp of Alphonso mango (*Mangifera indica* L)**



**Figure 5: Developmental change in reducing, nonreducing and total sugar content of fruit pulp of Alphonso mango (*Mangifera indica* L)**



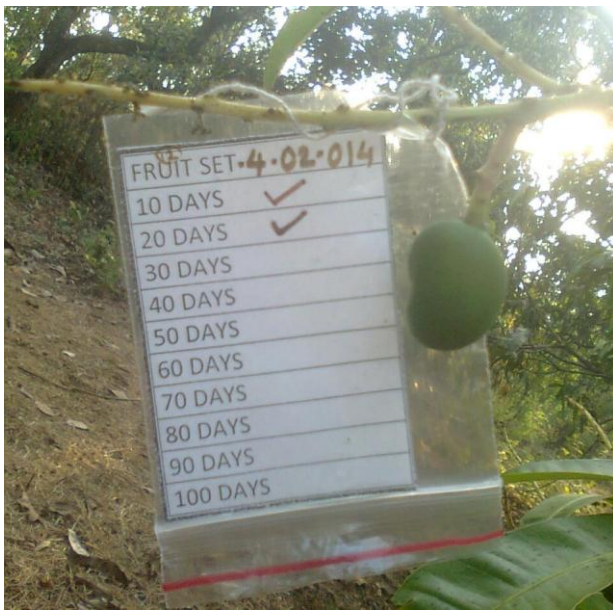
**Figure 6: Developmental change in starch and TSS content of fruit pulp of Alphonso mango (*Mangifera indica* L)**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Set**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 10 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 20 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 30 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 40 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 50 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 60 days**



**Alphonso Mango (*Mangifera indica*)**  
**Fruit Maturity 70 days**



**Alphonso Mango (*Mangifera indica*)  
Fruit Maturity 80 days**



**Alphonso Mango (*Mangifera indica*)  
Fruit Maturity 90 days**



**Alphonso Mango (*Mangifera indica*) Fruits - Maturity 20, 40, 60, 80, & 100 days**

## **5.2 Seed kernel**

Mango seeds are also nutritious, rich in proteins, carbohydrates, fats and minerals. Many researchers have analysed the mango seed kernels and trying to find out their dietary use.

Dhingra and Kapoor (1985) found that the average content of mango kernel comprises carbohydrates (69.22%-79.78%), fat (8.35%- 16.13%), protein (5.6%-9.5%), starch constitutes about 92% and a fair amount of fiber (0.14%-2.95%) and ash content from 0.35% to 3.66%.

Zein *et al.*, (2005) reported that depending on their variety, mango seed kernels contain on a dry weight average 6.0% protein, 11% fat, 77% carbohydrate, 2.0% crude fiber and 2.0% ash. Although mango seed kernels have a low content of protein, the quality of protein is good.

Nzikou *et al.*, (2010) found 45.2% moisture, 13% crude oil, 6.36% crude proteins, 32.24% carbohydrate (by difference), 2.02% crude fiber and 3.2% ash in mango seed kernels.

The results of proximate analysis carried out by M. A. Fowomola (2010) showed that mango seed contains (10.06 ± 0.12%) crude protein, (14.80 ± 0.13%) oil, (2.62 ± 0.02%) ash, (2.40 ± 0.01%) crude fibre, 70.12 ± 1.34%) carbohydrate and energy content (453.92 ± 4.32 KJ/100 g).

Dakare *et al.*, (2012) showed that mango seed kernels (MSK) contained carbohydrate (69.2 - 80%), protein (7.5 - 13%), fibre (2.0 - 4.6%), ash (2.2 - 2.6%), calcium (0.21%) and phosphorus (0.22%).

Mango seed kernels have a low content of protein but they contain the most of the essential amino acids, with highest values of leucine, valine and lysine. Mango seed kernels were shown to be a good source of polyphenols, phytosterols as campesterol, sitosterol and tocopherols. In addition, mango seed kernel could be used as a potential source for functional food ingredients, antimicrobial compounds and cosmetic due to its high quality of fat and protein as well as high levels of natural antioxidants. ( Kittiphoom, S. 2012).

### **5.2.1 Chemical Status of Seed Kernel**

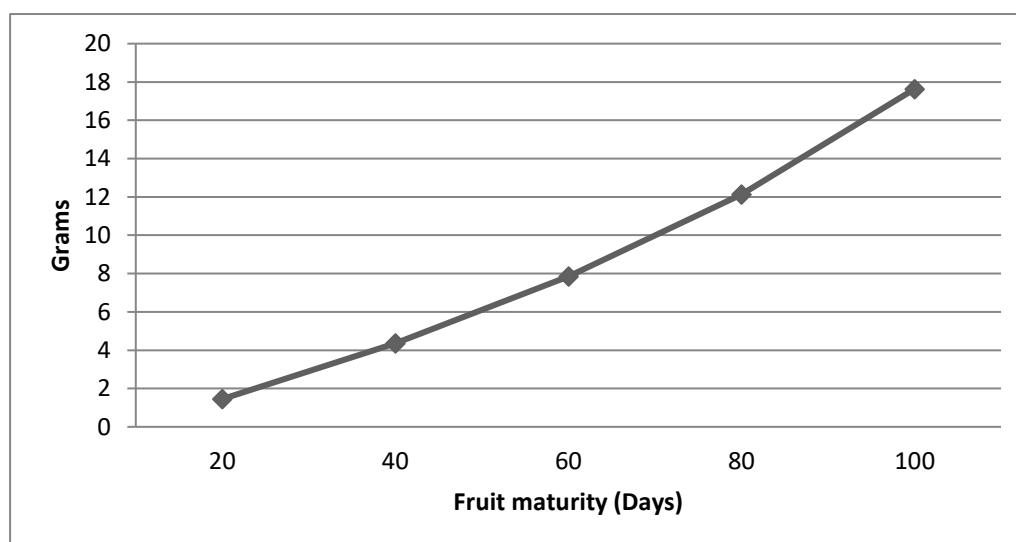
Following table summarizes the results obtained from the analysis of seed kernels of Alphonso mango.

**Table 2: Chemical Status of Alphonso Mango (*Mangifera indica* L) Seed Kernel with respect to Developmental Stages**

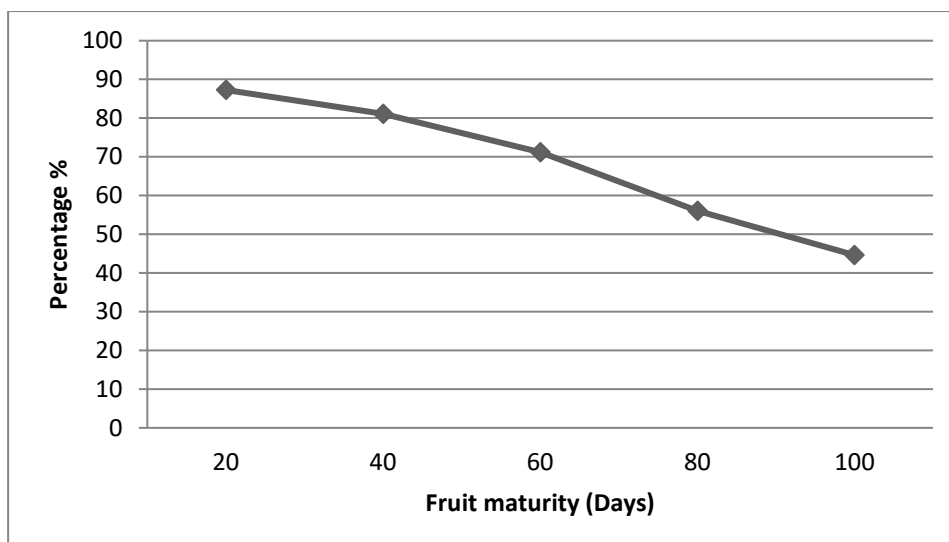
Fruit maturity (days)	Kernel weight (g)	Moisture (%)	Titratable Acidity (%)	Carbohyd rates (%)	Proteins (%)	Fats (%)
20	1.45	87.27	0.68	09.65	2.12	1.9
40	4.36	81.09	0.48	11.27	2.76	3.3
60	7.85	71.21	0.31	15.82	3.96	5.7
80	12.13	56.07	0.28	16.47	5.44	8.0
100	17.63	44.63	0.25	17.99	7.52	9.5

(The results are expressed in percentage per dry weight except moisture.)

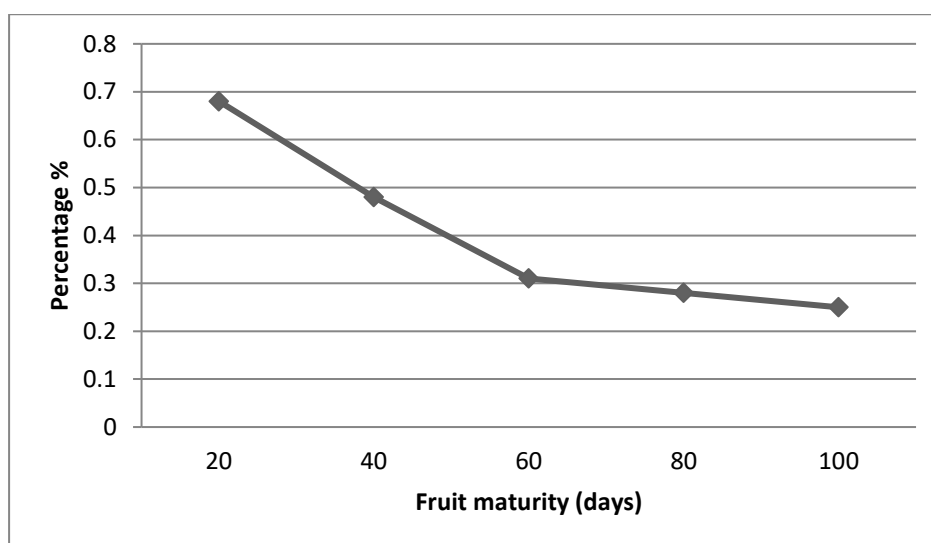
The results show that the contents go on increasing with the increasing age and weight of the seeds except moisture and acidity which are decreasing with the increasing age of the seeds. The initial 87 % moisture decreases up to 44 % at the maturity of the seeds. Titratable acidity also decreases from 0.68 % to 0.25 % with the maturity of the seeds. Carbohydrates, proteins and fat content go on increasing with the maturity of the seeds. Carbohydrate content increases from 9.65 % to 17.99 %; proteins content increases from 2.12 % to 7.52 % and fats from 1.9 % to 9.5 %.



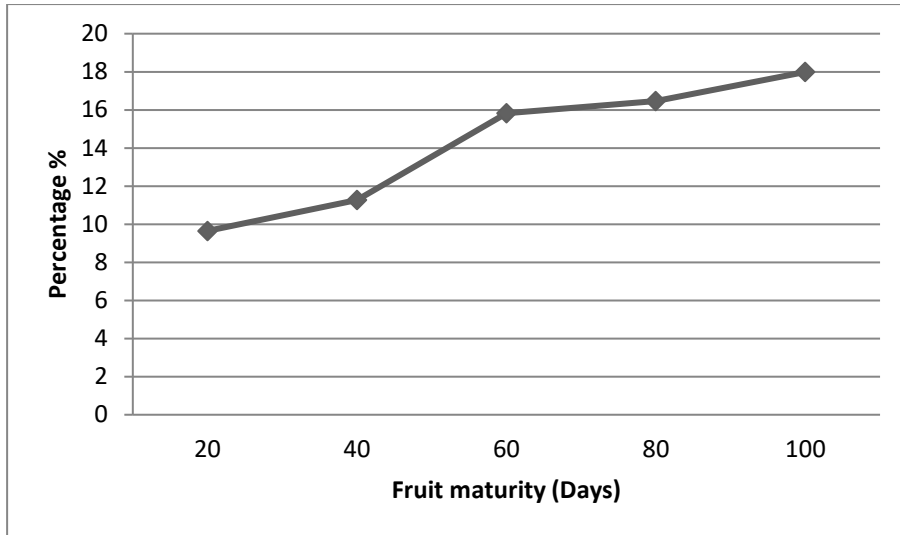
**Figure 7: Developmental change in weight of kernel of Alphonso mango (*Mangifera indica* L)**



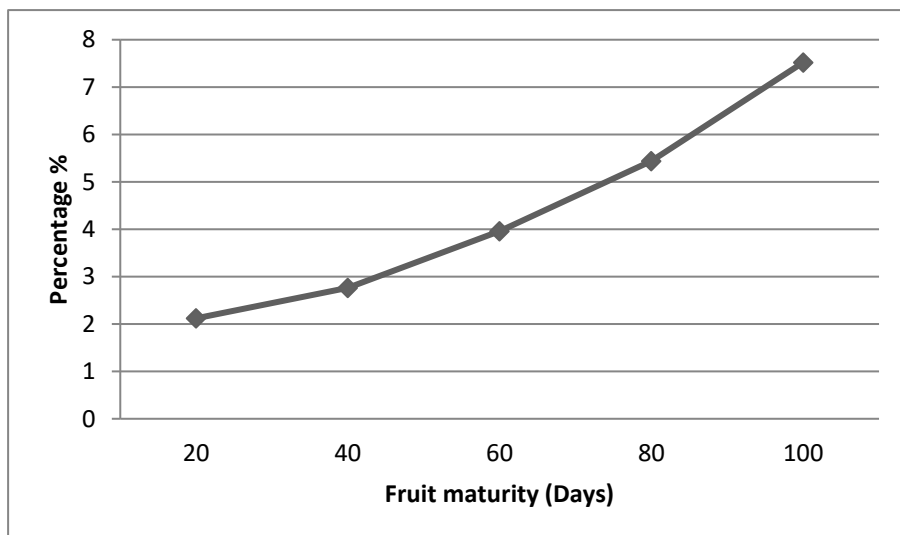
**Figure 8: Developmental change in moisture content of kernel of Alphonso mango  
(*Mangifera indica* L)**



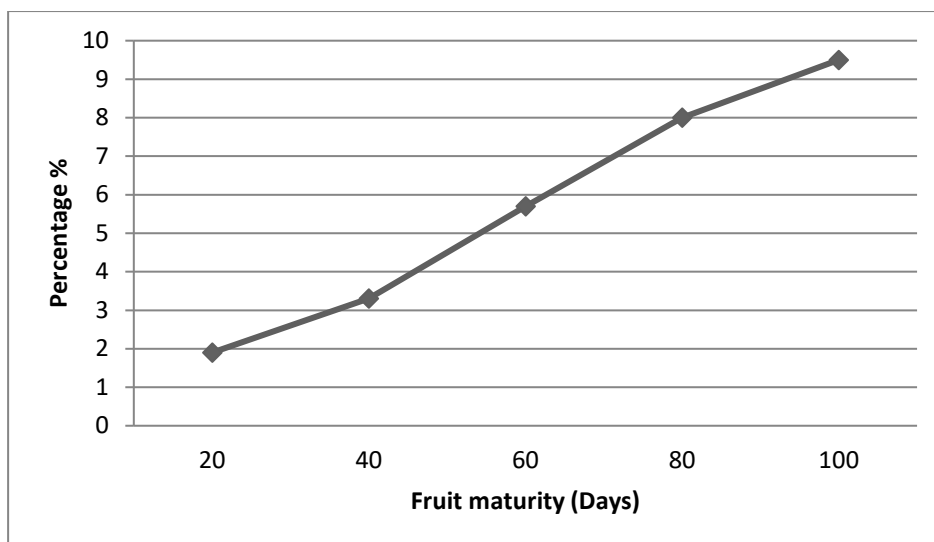
**Figure 9: Developmental change in titratable acidity of kernel of Alphonso mango  
(*Mangifera indica* L)**



**Figure 10: Developmental change in carbohydrates content of kernel of Alphonso mango (*Mangifera indica* L)**



**Figure 11: Developmental change in proteins content of kernel of Alphonso mango (*Mangifera indica* L)**



**Figure 12: Developmental change in fats content of kernel of Alphonso mango (*Mangifera indica* L)**



**Alphonso Mango (*Mangifera indica*) Fruits - Maturity 20, 40, 60, 80, & 100 days  
Sectional View**



**Alphonso Mango (*Mangifera indica*) Seeds - Maturity 20, 40, 60, 80, & 100 days**

The findings of contents of mature seed kernels match with the findings of various workers. Dhingra and Kapoor (1985) found that the average content of mango kernel comprises carbohydrates (69.22%-79.78%), fat (8.35%- 16.13%), protein (5.6%-9.5%), starch constitutes about 92% and a fair amount of fiber (0.14%-2.95%) and ash content from 0.35% to 3.66%.

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M. A. Shad *et al.*, (2001) screened four different varieties of mango viz; Maldah, Anwar Retaul, Chounsa and Dusehri for their mineral content in seed kernels and showed that they are rich in K, Ca, Na, Zn, Bi, Sr, Pb, Cd, Mn, Co, Cr, Fe, Cu and Ni. Kittiphoom (2012) showed that mango seed kernel was high in potassium, magnesium, phosphorus, calcium and sodium.

The lipid composition of mango seed kernels has attracted the attention of scientists because of their unique physical and chemical characteristics and their potential application in the confectionery industry as a source of a cocoa-butter substitute (Lakshminarayana *et al.*, 1983; Rukmini and Vijayaraghavan, 1984; Gaydou and Bouchet, 1984; A. O al., 1985; Hemavathy *et al.*, 1987). Rashwan (1990) extracted and fractionated total lipids from three different mango seed kernel varieties namely Goleck, Pairi and Hindi. On the nutritional and toxicological studies of the mango seed kernel, Rukmini *et al.*, (1984), indicated that mango seed kernel fat is promising and a safe source of edible oil and was found to be nutritious and non-toxic so that it could be substituted for any solid fat

without adverse effects. Rashwan (1990) also showed that the lipids extracted from different mango varieties were free from toxic material such as hydrocyanic acid. J. M. Nzikou *et al.*, (2010) showed that *Mangifera indica* seed kernel oil has a low content of protein and stearic and oleic acids were the principal fatty acids and the proportion of unsaturated fatty acids was greater than the saturated fatty acids. High unsaponifiable matters content (4.58%) guarantees the use the oils in cosmetics industry ( J. M. Nzikou *et al.*, 2010).

Mango seed kernels have a low content of protein but they contain the most of the essential amino acids, with highest values of leucine, valine and lysine. Mango seed kernels were shown to be a good source of polyphenols, phytosterols as campesterol, sitosterol and tocopherols. In addition, mango seed kernel could be used as a potential source for functional food ingredients, antimicrobial compounds and cosmetic due to its high quality of fat and protein as well as high levels of natural antioxidants. (Kittiphoom, S. 2012).

Gadallah and Fattach (2011) checked antimicrobial effect of mango seed kernel powder in minced beef during refrigerated storage and obtained positive results. Their results indicated that mango seed kernel was an effective inhibitor of microbial growth.

Legesse and Emire (2012) successfully utilized mango seed kernel powder in biscuit production blending with wheat flour. They showed that the processed mango seed kernel to reduce tannins can be floured and blended with wheat flour up to thirty percent for biscuit production.

However, Sandhu and Lim (2008) found unsuitability of mango seed starch for digestion. They checked digestibility of mango seed starch *in vitro* and compared with the corn starch. They found that the amounts of readily digestible starch (RDS) and slowly digestible starch (SDS) were lower for mango kernel starch than those of corn starch. Resistant starch (RS) contents in the mango kernel starches were substantially higher than those of corn starch. The glycemic index (GI) values for mango kernel starches were 48.8 and 50.9 (for Chausa and Kuppi, respectively), whereas that of corn starch was 74.8, indicating that the mango kernel starch granules were highly resistant to digestion with significant contents of RS.

El-kholy *et al.*, (2008) found suitability of mango seed kernel in fish diets while S. A. Kareem (2001) found it suitable in animal diet mixed up to 15% in the form of cake with proper detoxification.

Dakare *et al.*, (2012) showed that properly processed mango seed kernels may be suitable in diet as supplement. They observed highest reduction of anti-nutrients in mango seed

kernel treated with  $\text{Ca}(\text{OH})_2$  with percentage reduction of 95.8% for tannin, 90.6% for oxalate, 76.7% for cyanogenic glycoside, 76.2% for phytate, 95.1% for flavonoid, 65.1% for alkaloid, 59.0% for saponin and 100% for trypsin inhibitors. Treatment of soaked and boiled mango seed kernel with  $\text{Ca}(\text{OH})_2$  was found to effectively enhance the reduction of anti-nutritional factors to barest minimum. This implies that this processing method had greatly detoxified the mango seed kernel, thereby enhancing better utilization of the mango seed kernel in livestock and poultry nutrition.

The result of the phytochemical analysis shows the presence of some metabolites which confirms the usefulness of the plant in the treatment of various diseases. The high carbohydrate content of *Mangifera indica* makes it a promising raw material in the starch and allied industry and also a good source of protein in livestock feed. (Orijajogun *et al.*, 2014)

Composite flour variations prepared using mango seed kernel and protein rich sources such as soya and sprouted mung bean have been found to be comparable with wheat flour on several physico chemical aspects. Such bread preparations revealed that the presence of kernel powder and legume seed powders in lower proportions yielded breads with similar organoleptic and physical properties as refined wheat flour breads. (Lakshmi *et al.*, 2014).

MKF is good source of protein (7.53 g/100g), fat (11.45 g/100 g) and energy (421 k.cal /100g). It also contains appreciable levels of calcium (170 mg/100g), magnesium (210 mg/100g) and potassium (368 mg/100g) which are important macro minerals required for vital functions of the body. (Shilpa *et al.*, 2014).

It seems from the above discussion that the nutritional content of the seed kernel of the Alphonso mango is comparable with the nutrients of some grains but its direct utilization in diet is found to be unsafe due to presence of some anti-nutrients. However, properly processed kernels are successfully used in animal feed and even in bread and biscuit production. Thus, there is ample potential in mango seed kernels for their dietary and industrial use.

## **6. SOME CULTIVARS IN KONKAN**

### **6.1 Alphonso**

The best commercial variety, of mango, Alphonso, is widely grown in Konkan, accounting for more than 90 per cent of the area under mango cultivation. This variety is believed to have originated in Goa and it thrives best in a humid coastal climate. The tree is of medium size, suitable for spraying and other operations. Fruit of this variety has special attractive appearance having medium to large size. It develops an attractive blush when it ripens. It is fibreless and has good deal of edible matter, special luscious and sweet taste and is agreeable in flavour. It has good keeping quality and is good for pulp canning and making juice concentrates. Fruits can be stored in good condition for nearly 3 weeks at room temperature so that the shelf life of Alphonso mango fruits is about 2 to 3 weeks. All these qualities make Alphonso to become the most popular and commercial variety of mango in Konkan and in India also; and has got significant value in export market.

### **6.2 Pairi**

Pairi variety ranks second after Alphonso in popularity and commercial value in Konkan. It is a grafted, biennial, medium to heavy bearing variety. Tree size is large or medium spreading. Flowering starts in the month of November or December, full bloom is in mid-January, fruit set in first week of February and ripening from the last week of April to May. The inflorescence is yellowish green in colour, without leafy bracts having average length of 25 cm.

The fruits of this variety are very attractive in colour having beak. Pulp of the fruit is sweet and fibreless. The shelf life of the fruits is only 6 to 8 days.

### **6.3 Batalihapus**

'Hapus' is the local name for the variety Alphonso. The trees of 'Batalihapus' resemble like Alphonso trees. But its fruits are more in length giving somewhat bottle like appearance. Therefore, it is named locally as 'Batalihapus' meaning bottle like Alphonso. The tree is of medium size and spreading. Leaves are large measuring up to 30 to 50 cm in length and 5 to 8 cm in breadth. Bearing is biennial and flowering season starts late in February. Fruits are matured in May. Fruits also are large in size measuring up to 10 to 12 cm in length and 7 to 8 cm in breadth. However, pulp: stone ratio is very low. Though the pulp is sweet it has no attractive flavour. Shelf life of the fruits is 6 to 7 days only. Hence, this variety has less commercial importance.

#### **6.4 Narali**

This mango variety is grafted one. Trees are of medium size and spreading. Bearing is biennial and heavy. Comparatively number of flowers per panicle are higher if compared with other local varieties. Fruit setting is also high in percentage. Inflorescence is yellowish green in colour, some time with leafy bracts, and having 45 to 50 cm average length. Full blooming is in the month of March. Fruits are matured in the month of May. Ripened fruits are greenish yellow in colour. Skin is thick and leathery. Pulp is pale yellow coloured, fibrous and adhered to skin. Taste is sour, sweet and characteristic. Due to its strong terpenaceous flavour the unripe fruits are used for making pickles. Though it is commercially less important it is good sucking variety.

#### **6.5 Mankur**

This grafted variety is mainly cultivated in Goa and Karnataka state. The tree is of medium size and spreading. Bearing is biennial and heavy. Flowering season is late in February and fruits are matured in May. Inflorescence is yellowish green having average length of 30 cm. Fruits are large, yellowish orange in colour. Pulp is yellowish in colour, very sweet, large in quantity but not firm. Shelf life is not more than 8 days. Hence commercially it has less importance. But it is a good sucking variety as it contains considerable amount of juice.

#### **6.6 Ratna**

To overcome the major problems of Alphonso variety i.e. biennial bearing and development of spongy tissue in ripe fruits, Konkan Krishi Vidyapith, Dapoli, released a new hybrid mango variety - 'Ratna', by the crossing between Alphonso and Neelum, in the year 1981. Now a days it is widely cultivated in Konkan. The tree is semi vigorous and regular bearing. The flowering starts in the first week of December with full bloom in the month of January. Fruits are matured in the month of May. The inflorescence is pinkish in colour without leafy bracts, having average length of 25 cm. The fruits of this variety are large with greenish orange colour, oblique and slightly elongated in shape. The pulp is sweeter, orange in colour, fibreless and has good shelf life of 15 days.

## **7. YIELD, HARVESTING, POST HARVESTING OPERATIONS AND STORAGE**

Mango is cultivated in different area and more concentration is now a days given on yield which is because of economic importance of mango.

Certain mango varieties like Alphonso are now sold at international market. Grafted mango trees start commercial fruiting after five years of plantation whereas seedling mango trees bear after 8-10 years. Fruiting at early stage of establishment should be discouraged since it imparts adverse effect on the growth of mango trees and sometimes overbearing at young stage from mango plants without proper nutrition may be one of the important factors of poor vegetative growth of the trees. It is noted that there are different factors which govern the vegetative and reproductive growth of mango tree. Fruit yield in mango depends on several factors such as flowering during the season, cultivar, method of propagation (grafted/seedling), vigour of the tree, management practices adopted in the orchard including application of manure and fertilizers, irrigation scheduling and diseases and pest management. Cultivar Dashehari starts commercial bearing within 6 to 7 years after plantation, cultivar Langra takes about 20 years or more to come to full bearing (Singh, 1969). However, at this stage, Langra trees bear tremendous crop. There are certain reports regarding the bearing of fruits in mango. According Singh (1969), number of fruits per tree generally varies from about 20 fruits in fifth year to 1000 - 2000 fruits at 20th year. A grafted tree yields about 300 - 500 fruits in the tenth year, about 1000 in the 15th year and 2000 to 5000 from the 20th year onwards (Anonymous, 1980). It has been observed that good yield from mango trees can be obtained by proper maintenance of the orchard up to the age of 50 years and after that yield declines.

The studies regarding the post harvesting period in mango is also worked out. It is noted that there is difference in the period required for ripening of the mango varieties. Fruits are harvested between June and August under Northern Indian conditions. Some cultivars such as Dashehari ripen early and take about three months from the time of fruitset to ripening whereas cultivars Samar, Bahisth, Chausa takes about 3 to 4 months from fruitset to ripening. Harvesting of immature fruits results in white patches or air pockets, poor keeping life and quality. The chemical composition of the fruit is also responsible for maturity of the mango fruit. Specific gravity, acidity and starch contents of fruits have been used as a basis for predicting maturity (Teaotia *et al.*, 1968). They have reported that fruits of cultivar Langra having starch/acidity ratio of 4 or more can be considered fully mature.

Harvesting time of mango fruits has also been determined on the basis of pressure tests and TSS reading and physical appearance of fruits etc.

Mango has commercial market hence the mango fruits are packed in boxes according to gradation and these boxes are sent to the market. The traditional method of packing mango fruits utilises baskets and wooden crates. Now ventilated wooden boxes, polythene bags of 200 gauge and corrugated cardboard boxes are also in use. Padding or cushioning material used for packaging of mango fruits may be grass, paddy or wheat straw, paper shreadings, mango leaves, *Albizia lebbek* leaves, leaves of *Butea frondosa*, sugar cane leaves or newspapers as lining material. Individual fruit may also be wrapped with tissue paper. It has been reported by Srivastava (1961) that Dashehari fruits kept for a week in wooden containers and using *Albizia lebbek* leaves as cushioning material helped in proper ripening of fruits with the best appearance. However, the best flavour of fruits was obtained when ripened with mango leaves. Keeping mango fruits of cultivar Bombay Green with *Butea frondosa* and sugarcane leaves has been suggested good for ripening (Teotia *et al.*, 1964). Even immature fruits of cultivar Langra develop distinct ripe skin colour under the carbide treatment (Srivastava and Mukherjee, 1961). They found better retention of ascorbic acid (Vitamin C) in mangoes ripen under room condition (open) as compared to carbide treated fruits at all the stages of maturity. The ripening process in mango fruits is complicated one where various biochemical reaction are involved. There are certain chemicals which are used for enhancement of ripening process. There are controversial reports regarding the effect of such chemicals on taste and aroma of mango fruits after ripening.

In Konkan area mango is cultivated widely. The main and marketable varieties grown in this area are Alphonso and Pairi. Out of these Alphonso has international market. Generally after attending a particular size of mango fruits, they are harvested and graded. Then these fruits are packed in wooden boxes also with rice straw as packing or cushioning material. In this method the mango from Konkan is sent to Mumbai market or to other places. Waxing treatment of the mango fruits help in reducing respiration, delayed ripening and also improved storage life even at higher temperature of 32.2°C to 37.8°C (Agnihotri *et al.*, 1963). Addition of 1 per cent sodium orthophenylphinate (SOPP) or 0.2 per cent Flit 406 (50 per cent n-trichloromethyl thio-tetraphthamide) in wax emulsion has been found beneficial (Srivastava 1967). There has been 75 per cent and 75 to 100 per cent increase in storage life by application of 4 per cent sugarcane wax emulsion at room temperature in cultivars Chausa and Dashehari respectively (Srivastava 1967). However, per cent increase

in storage life by application of 4 per cent sugarcane wax emulsion was only 25 per cent in both the cultivars viz; Chausa and Dashehari. Under cold storage conditions, there is development of microbial infection and chilling injury to stored mango fruits. Pretreatment of mango fruits with the antibiotic aureofungin has helped in minimizing the incidence of microbial infection.

The shelf life of mango fruits varies variety to variety. If the shelf life is higher then, it is preferred by the merchants. It is noted that temperature plays very important role in ripening as in maintaining shelf life. Wrapping the fruits in polythene bags and storing them at 7.2°C showed lower physiological losses and chilling injury (Mukherjee 1956 and Singh 1960). Chausa fruits can be stored at 42-45°F temperature at 85 - 90 per cent relative humidity for 5 weeks when fruits are kept in baskets with paddings. These fruits after storage have 5 days post storage life. At the similar temperature and relative humidity, fruits of cultivars Dashehari can be stored for 4 weeks in crates having two days post storage life and Safeda for 6 weeks. Temperature below 45° F causes low temperature injury to the fruits. The optimum temperature for ripening of mango fruits varies from 67 to 70° F which minimizes wastage of fruits due to decay as compared to the ordinary temperature (75° F to 110° F). At this temperature range, ripen fruits develop a far better colour with higher TSS (Singh 1977). Fully matured and firm fruits in which the yellow colour had not yet developed were stored at room temperature using wrapping materials. Polythene wrapper showed the maximum delaying effect followed by cellophane (Deol 1985).

Some other chemicals were applied for protection against decaying of mango fruits. Calcium application has been found effective in reducing physiological loss in weight and preventing decaying of fruits. Dipping of harvested fruits in 4 per cent calcium + hot water (52°C) + 1 per cent Jakistin helped in preventing decaying of the fruits of cultivar Langra (Anonymous, 1986 a). Spray of 0.6 per cent calcium as calcium chloride has been found to reduce physiological loss in weight of mango fruits. Besides this treatment also helped in retaining the vitamin C content of mango fruits, (Anonymous, 1988). According to Chauhan *et al.*, (1987), mango fruits harvested at colour break stage and packed in wooden boxes with paper lining as cushioning material when stored at room temperature (42°C) showed minimum physiological loss in weight and decay loss which were dipped in tap water (35°C) and cold water (10°C) as compared to fruits dipped in solution of amino ethoxyl vinyl glycine (AVG) at 10 mg/L for 1/6 hour.

## **8. PROBLEMS**

### **8.1 Preharvest Fruit Drop**

This is very common problem. There are several factors causing fruit drop in mango which include deficient nutrition, lack of cross pollination, poor pollen transfer, low stigmatic receptivity, defected perfect flowers, self-incompatibility, competition between developing fruitlets, drought conditions, inadequate irrigation, occurrence of higher wind velocity, sever diseases such as anthracnose, powdery mildew and infestation of mango hopper and mango mealy bug and varietal characteristics.

### **8.2 Black Tip**

There is development of small etiolated area at the distal end of the fruit which gradually spreads, turns black and covers the tip completely. It has been attributed to the gases such as sulphur dioxide, ethylene and carbon monoxide emitted from brick kilns (Sen *et al.*, 1943).

### **8.3 Irregular or Biennial Bearing**

Biennial bearing means, if a mango tree carries a heavy load of crop in one year then the following year shows reduced yield. Most of the commercial mango cultivars show such tendency of biennial bearing.

### **8.4 Mango Malformation**

It is of two types viz. vegetative and floral. Vegetative malformation is characterized by development of abnormally compact rosette like shoot-lets from vegetative buds in the leaf axils or apical meristem of the younger plants consequent upon activation. Singh *et al.*, (1961) has called it bunchy top since such shoots form bunch. This type of malformation is more prevalent in young plants and very little in bearing trees. The floral malformation is characterized by abnormality in any part of the panicle or all parts of the panicle. Severely affected panicles look like a compact mass and appear greener and sturdier. As a result of floral malformation, the rachis and secondary branchlets become thicker and shorter. Flower parts such as bracts, sepals, petals and ovary become larger in malformed panicles compared to normal ones. These panicles have mostly male flowers (Majumdar *et al.*, 1970). Very little fruit set takes place initially in malformed panicles and finally fruits drop before maturity from such panicles. Malformed panicles remain on the trees for several months as black masses of tissues.

Mango malformation is a serious problem under north Indian plains and is comparatively more as compared to western and southern parts of the country.

Malformation in mango has been attributed to several reasons such as cultural practices, nutritional disorder (Tripathi 1955, Chema and Malhi 1986), mites, viruses, fungus – *Fusarium maliformae* (Summanwar *et al.*, 1966).

### **8.5 Scorching of Leaves**

Scorched leaves have brick red colour towards the tip, along with margins of old leaves. It is mainly due to chloride ion toxicity (Pandey *et al.*, 1971).

### **8.6 Fruit Cracking**

The affected fruits develop crack longitudinally deep up to fleshy mesocarp. It might be due to sharp fluctuations in day and night temperature during fruit development, heavy irrigation after dry spell, deficiency of essential nutrients such as boron and potassium and hailstorm during active fruit development causing injury to the fruit skin (Chandra and Singh 1985).

## **9. DISEASES**

### **9.1 Powdery Mildew**

It is a fungal disease caused by *Albugo*, during the period between panicle development and fruitset, high relative humidity up to 91% in cloudy weather coupled with low night temperature has been found as most congenial for development of this disease (Gupta 1979). Rainfall during this period help in high intensity of powdery mildew. This disease is characterized by greyish white powdery bloom on the flower buds and fruitlets which may gradually affect the entire panicle and consequently panicles get dry and turn black. Incidence of this disease causes heavy premature fruit drop.

### **9.2 Anthracnose**

The disease is caused by *Colletotrichum gloeosporioides*. There is appearance of black necrotic area on the affected parts i.e. stem, leaves, twigs and fruits. Under severe attack, the entire surface of leaves may be covered with necrotic areas. Young leaves are more susceptible than the older ones. The young fruits under the attack are dropped down and black spots develop on the older fruits. This disease is more common in humid and high rainfall areas.

### **9.3 Black Mould Rot**

It is incited by *Aspergillus* sp. and is common both in field and storage conditions on the fruits. The fungus causes premature fruit drop. Initially, on the affected region of mango fruits, appears a yellow discoloration and later irregular greyish spots. These spots coalesce to form dark brown or black spots. The fruits collected at early stage of maturity are more susceptible to decay during storage than collected at late stage of maturity.

### **9.4 Leaf Blight**

It is caused by *Macrophoma mangiferae* and is prevalent in Punjab, Delhi and Uttar Pradesh. Initially symptoms appear as round, light brown spots on the leaves which later on are enlarged, become irregular and dark brown and cover the large marginal surface of the leaves. In the ripened fruits dark brown lesions develop.

### **9.5 Bacterial Blight**

It is mainly due to *Pseudomonas mangiferae indicae* bacteria. It occurs in tarai region of Uttar Pradesh. Both the leaves and fruits are attacked. Dark green water-soaked spots appear on the apical portion and in between the veins of the leaves, panicles and fruits. Later on, the spots become dark brown, increase in area and become rough and slightly raised due to bacterial ooze. The leaves fall off in serious attack. The affected tissues exhibit

deep longitudinal cracks exuding gum and such fruits drop down and become unfit for human consumption.

### **9.6 Sooty Mould**

This disease is common in the areas where incidence of hoppers and scale insects are severe. The fungus *Capnodium sp.* Develops on the honey dew secreted by hoppers on the leaves, twigs and inflorescence. It hampers photosynthetic activity of affected leaves.

## **10. INSECTS PESTS**

Mango hopper, mango mealy bug, mango fruit fly, mango shoot gall maker, bark eating caterpillar, scale insects and termites are major insect pests of mango.

### **10.1 Mango Hopper (*Idiocerus sp.*)**

The mango hoppers are the most destructive pests as the nymphs and adults cause injury to the inflorescence and young shoots. It sucks the sap from tender plant parts such as young shoots and panicles causing withering away of panicles, lower fruit set and premature fruit drop. They also excrete honeydew which results in growth of sooty mould on dorsal surface of leaves, branches and even on fruits.

### **10.2 Mango Thrips (*Scirtothrips spp.*)**

Mango thrips are microscopic, slender insects that cause significant damage to mango trees by sucking sap from tender leaves, flowers, and developing fruits. Infestations often peak during the flowering stage (January–March), potentially leading to total fruit loss if untreated.

### **10.3 Mango Mealy Bug (*Drosicha mangiferae* Green)**

It causes considerable damage to mango fruit trees. The nymphs emerge in December – January and crawl up the tree trunk and cluster together and suck the vital sap from tender parts of stem, leaves and inflorescence, thus causing drying of shoots resulting in decline of fruit set and falling of immature fruits. The black sooty mould develops due to honey dew secretion of mealy bugs which interferes in the photosynthetic activity of the leaves.

### **10.4 Shoot Gall (*Apsylla cistellata*)**

The whitish eggs are laid on new leaves during February – April which hatch from August to October. There are 6 nymphal instars, each moulting after 3 – 5 weeks to the next stage. The adults are formed within the galls. The nymphs soon after hatching show an instinct to migrate leaf bud and enter the adjacent buds. Usually, the upper two whorls of an opening bud are preferred. After entering, the nymphs induce multiplication of bud tissue and result in gall formation. The growing buds turn into cone shaped galls due to some sort of secretion by the nymphs. As a result of gall formation, growth of shoot and inflorescence is adversely affected. The nymphs overwinter inside the adults emerge from the galls.

### **10.5 Bark Eating Caterpillar (*Indarbela sp.*)**

Its presence in the trees can be detected by brownish ribbon like loose masses of the excreta which remains attached with the main branches at the point of injury. The caterpillar makes tunnels inside the stem and enters deep into it. This interrupts with translocation of cell sap arresting growth and fruiting capacity of the tree.

### **10.6 Mango Fruit Fly (*Bactrocera dorsalis*)**

This pest hibernates during November – March in pupal stage. It is polyphagous. The female lays eggs just below the epidermis of ripening fruits. The eggs hatch out in 2 – 3 days. On hatching, the maggots of the fruit fly feed on the pulp by forming tunnels. Affected fruits drop prematurely and maggots come out from the fruits for pupation in soil. The adult flies are 7 mm long with hyaline wings and are dark brown in colour. The maggots make the fruit unfit for human consumption. The infested fruits do not show any external sign of attack but the appearance is sickly. On cutting the fruit, the wriggling maggots can be seen inside the fruit.

### **10.7 Scale Insect (*Aspidiotus destructor*)**

The insect infests the tender parts of the tree by sucking their vital cell sap. There is infection of sooty mould due to secretion of honey dew by scale insect.

### **10.8 Termite (*Odontotermes obesus*)**

Many species of termites are found attacking mango tree. They damage all plant parts but the bark is worst affected. Some time they may damage roots causing death of the plants in initial stage.

### **10.9 Stem Borer (*Batocera* sp.)**

The pest makes zigzag tunnels into the trunks of main stems moving upwards feeding on internal tissues. The attacked stem dies and wither away.

### **10.10 Mango Gall Midges**

It has been found that *Procontarinia matteiana* Keiiter is an important insect that causes galls to form on the dorsal surface of the mango leaf (Rao and Verghese, 1984). Grey, green and brown coloured, round and raised galls are developed on the leaves. The leaves are rendered useless by continuous draining of sap by the larvae feeding inside the gall. The leaves under severe infestation, turn yellow, shrivel and drop off prematurely.

### **10.11 Mango Leaf Webber (*Orthaga euadrusalis*)**

The eggs are laid on leaves. The first instar larvae feed on leaf chlorophyll. From second instar, the larvae start webbing on the leaves and feed on entire leaf leaving the midrib and veins.

Besides, few more insects such as leaf cutting weevil (*Deporus marginatus*), field crickets, leaf miner (*Acrocercops syngramma*), beetles, thrips, caterpillars, white flies and other sucking bugs, fruit borers and fruit sucking moths also damage mango trees but are of minor importance.

## 11. USE OF PESTICIDES

Pesticides are the chemicals used to kill or control the growth of pests and diseases of plants animals and human beings, to eradicate weeds and to control pests and microorganisms that spoil agricultural products.

Pesticides are classified in various ways as follows:

On the basis of types of pests they control, pesticides are classified into following groups:

- i. Fungicides, controlling fungal pathogens,
- ii. Bactericides, controlling pathogenic bacteria,
- iii. Insecticides, controlling insect pests,
- iv. Herbicides, controlling weeds,
- v. Nematicides, controlling nematodes,
- vi. Rodenticides, controlling rodents,
- vii. Acaricides, controlling harmful mites.

On the basis of their chemical nature, pesticides are classified as follows:

- i. Organochlorines: These are chlorinated hydrocarbons, e.g. DDT, BHC (Benzene hexachloride), dieldrin, lindane.
- ii. Organophosphates: These consist of phosphorus bonded to carbon atoms of organic radical e.g. parathion, melathion.
- iii. Carbamates: These are N-methyl and N, N-dimethyl carbamic esters of phenols and heterocyclic enols e.g. carbaryl, pirimicarb.
- iv. Pyrethroids: Pyrethrum is a natural organic plant product having wide range of insecticidal activity due to presence of 5 esters in it. It was extracted from *Chrysanthemum* sp., but recently it is being produced synthetically to provide new group of insecticides called synthetic pyrethroids.
- v. Triazines: These are the isomeric compounds each having a ring of three carbon atoms and three nitrogen atoms. Most of them are herbicides and antifeedents (i.e. inhibiting the feeding) e. g. atrazine, ametryn.

On the basis of their mode of action, pesticides are classified as follows:

- i. Stomach pesticides: These poison the harmful pests when they enter their stomach along with food material. Hence these are applied to plant parts which serve as food for the pests. E.g. lead arsenate, Paris green.
- ii. Contact pesticides: these kill the pests upon physical contact with them. They directly penetrate the body and act in various ways. E.g. DDT, Pyrethrum.

- iii. Systemic pesticides: These are applied or sprayed to one part of the crop plant from where they are translocated throughout the plant body and make the whole plant toxic to the pests. e.g. thimathion, chlorpyrifos.
- iv. Fumigants: These act when in the form of a gas or fumes and enter the respiratory tract of insects. These are sprayed in closed rooms or green houses. E.g. carbon tetrachloride (gas), hydrogen cyanide (gas), ethylene dichloride (vapour).

Use of pesticides becomes obligatory to face diseases and pests. To minimize the economic loss caused by the noxious insects, fungi and weeds, farmers rely on pesticides such as, atrazine, carbofenthiuron, chlorpyrifos, malathion, methidathion, monocrotophos, phosphamidon, etc. (M. Bujagendra Raju 2011). When applied improperly, residues of some of these pesticides can remain as such and can pose a significant hazard to human health. In India 54 pesticides are regularly monitored in exportable mangoes (APEDA, 2008). The mango fruit is perishable in nature and there are many occasions for it to get spoiled till the fruit reaches to consumer's table. It is estimated that the total loss due to spoilage may be ranging from 30 to 40 per cent (Salunkhe and Desai, 1984). Therefore, the fungicidal dip treatment to the mango fruits is a widely applied practice to increase shelf life of the mango fruits.

Very few mango growers, who export their mangoes, follow good agricultural practices to maintain maximum residual limit (MRL). Only exporting mangoes are checked for MRL. Today's market demands not only the quality of agricultural produce but also safety and environment-friendly production practices.

Many workers have checked mangoes from local market for pesticides residue and found below maximum residual limit thus safe for consumption. Hussain *et al.* (2002) studied different varieties of mango fruits for pesticide residue and found all the samples contaminated but within permissible limits being set by FAO/WHO with reference to public health. Kumar *et al.* (2010) estimated organochlorine pesticide residues in mango fruits and found below MRL. Waskar *et al.* (2004) studied the residue levels of carbendazim and captan in peel and pulp of Kesar mango and found it below detectable limit.

Bempah *et al.* (2011) assessed the concentration of pesticide residue in fruits and vegetables and showed that 37.5% of the fruit and vegetable samples analyzed contained no detectable level of the monitored pesticides, 19.0% of the samples gave results with levels of insecticides residues above the MRL, while 43.5% of the samples showed results below the MRL. Tahir *et al.* (2009) analysed some fruits and vegetables for the levels of nine pesticide residues and found that most of the samples did not contain any residues and only two samples had detectable residue but below MRL.

Shah *et al.* (2007) assessed three different varieties of mango for the residues of commonly used pesticides viz Cypermethrin, Methamedophos, Monocrotophos, Cyfluthrin, Dieldrin and Methyl Parathian, and found all the samples to be contaminated with a degree of variation of pesticides residue studied. However, all the samples were within permissible limits, set by FAO/WHO with reference to public health.

### **11.1 Pesticide Residue in Fruit Pulp**

A number of chemicals are in use today in the production of agricultural commodities. They are essential to modern agriculture. Prevention of health risks, including toxicological risks, due to food intake is central in food safety policy (Miller, 1987).

For most of us the primary source of pesticide exposure is what we eat and drink. Maximum Residue Levels (MRLs) and Acceptable Daily Intake (ADIs) are measures set by government to assure us that the human exposure to pesticides is limited.

But there is no full proof way to ensure a safe universal ADI because of the diversity of food we eat and because some people are more vulnerable than others – especially young children and the malnourished. MRLs and ADIs also do not take into account the effects of combinations of pesticides or pesticide breakdown products. (Mahindru 2009)

Despite a very low pesticide consumption, Indian food products, mainly fruits and agriculture crops have far more pesticide residue because other countries use degradable pesticides while in India there is more use of persistent pesticides hence their residues remain in food products. (Mahindru 2009).

Pesticides are chemical substances used to kill animal, insect, plant and fungal pests in agricultural, domestic and institutional settings. (Sanborn et.al. 2002) Interest on pesticide toxicity has particularly increased over the past years owing to increasing evidence of carcinogenic, mutagenic and teratogenic effects in experimental animals and exposed humans. (Hrelia et.al. 1996). They constitute a very important group of chemical compounds that have to be controlled due to their very high toxicity and their widespread use in agricultural practice for field and post-harvest protection. (Ortelli et.al. 2004). The general population is mainly exposed to pesticides through the ingestion of contaminated foods (such as cereals, vegetables and fruits), which are directly treated with these pesticides or are grown in contaminated fields. Diet is one potentially significant source of pesticide exposure considered in aggregate and cumulative risk models. (Fenske *et al.*, 2002). The organophosphate, organochlorine and related pesticides act by binding to the enzyme acetyl cholinesterase, disrupting nerve function, resulting in paralysis and may cause death. (Bai et.al. 2006). They may produce acute and chronic toxicity. The acute effects manifesting as miosis, urination, diarrhoea, diaphoresis, lacrimation, excitation of

CNS and salivation. The chronic exposure involves neurotoxic and behavioural effects. Specific effects of pesticides can include cancer, allergies and hypersensitivities, damage to the central and peripheral nervous systems, reproductive disorders and disruption of the immune system. (Robert et.al. 2005). Recent studies have shown that exposures to contaminants in food may pose a public health risk. (Rene and Zoonen 1999). Children may be more susceptible to the effects of these exposures, as they have higher rates of metabolism, less mature immune systems and different patterns of activity and behaviour than adults. (Morasso 2001). Pesticides can also interfere with drug metabolizing enzymes especially Cytochrome P450 leading to drug interactions. (Hodgson and Patrica 1996). However, it is now an established fact that pesticides have greatly altered our capacity to protect our crops. They are essential part of modern life. It is estimated that India approximately loses 18% of the crop yield valued at Rs. 900 bn due to pest attack each year. The use of pesticide helps to reduce the crop losses; provide economic benefits to farmers and help in ensuring food safety and security of the Indian nation (Mahindru 2009).

Pesticides are widely used in fruits and vegetables because of their susceptibility to insect and diseases attack. Consequently, food safety is a major public concern worldwide. During the last decades, the increasing demand of food safety has stimulated research regarding the risk associated with consumption of fruits and vegetables as they constitute major part of human diet contributing nutrients and vitamins. Therefore, residues of pesticides could affect the ultimate consumers especially when these commodities are freshly consumed. The total dietary intake of pesticides residues that remain on agricultural commodities are known as carcinogens/or toxins and therefore it is desirable to reduce these residues (Zawiyah *et al.*, 2007).

According to the World Health Organization (WHO, 2003), food consumption consists on averaged for 30% (Based on mass) of fruits and vegetables, and fruits and vegetables are the most frequently consumed food group (WHO, 2003). Fruits and vegetables are essential to a nutritious and healthy diet; however, the health benefits are compromised by consistent contamination with pesticide residues. At the international level, the Codex Alimentarius Commission of the United Nation's Food and Agriculture Organization and the World Health Organization has established maximum residue limit (MRL) for pesticides in a variety of foods. (Ahmed 2001). Furthermore, because fruit and vegetables are mainly consumed raw or semi-processed, it is expected that they contain higher pesticides residue levels compared to other food groups of plant origin, such as bread and other foodstuffs bases on cereal processing (Claeys *et al.*, 2011).

In the present investigation an attempt has been made to determine the pesticide residues in ripened Alphonso mango fruits samples purchased from the local market from Devgad and Vengurle region of the Sindhudurg district. The analysis was carried out from a commercial laboratory 'TUV India Private Limited', Pune. The samples were tested for ninety-eight different pesticides from twenty-four chemical groups such as Organochlorines, Organophosphorus, Synthetic Pyrethroids, Triazines, Pyrimidines, Triazoles, Imidazole, Oxazole, Pthalimide, Benzimidazole, Nicotinoids, Aliphatic Nitrogen Fungicides, Morpholine, Natural Product Derivatives, Substituted Thiouria, Benzoylphenyl Urea, Strobilurin, Phenyl Pyrazole, Pyrazole, Nitrophenyl Ether, Dithiocarbamates and others.

The result shows (Appendix - I) that almost for all the pesticides, their residue level in the pulp of Alphonso mango is below limit of quantification except Carbendazim which is 0.13 mg/Kg but still below MRL i.e. 0.5 mg/Kg. This shows that pesticide residues in ripened Alphonso mango pulp from Devgad and Vengurle region are in very traces and are below MRL, therefore the fruits are safe for consumption.

Similar kind of results are noted by different workers. Hussain *et al.* (2002) studied different varieties of mango fruits for pesticide residue and found all the samples contaminated but within permissible limits being set by FAO/WHO with reference to public health.

Waskar *et al.* (2004) studied the residue levels of carbendazim and captan in peel and pulp of Kesar mango and found it below detectable limit. Shah *et al.* (2007) assessed three different varieties of mango for the residues of commonly used pesticides viz Cypermethrin, Methamedophos, Monocrotophos, Cyfluthrin, Dieldrin and Methyl Parathian, and found all the samples to be contaminated with a degree of variation of pesticides residue studied. However, all the samples were within permissible limits, set by FAO/WHO with reference to public health.

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Kumar *et al.* (2010) estimated organochlorine pesticide residues in mango fruits and found below MRL. Bempah *et al.* (2011) assessed the concentration of pesticide residue in 350 locally produced fruits and vegetables and showed that 37.5% of the fruit and vegetable samples analyzed contained no detectable level of the monitored pesticides, 19.0% of the samples gave results with levels of insecticides residues above the MRL, while 43.5% of the samples showed results below the MRL.

Based on these observations it may be assumed that the Alphonso mango fruits are within the permissible range of MRLs proposed by FAO/WHO and may not pose a serious threat to public health.

But the various studies disclose that even a low-level exposure to pesticide residues puts consumers, especially children on risk in a cumulative manner. So, an analysis showing the residues in undetectable or safe range does not essentially mean that it is absolutely safe and free of any untoward effects. More over as mentioned earlier, MRLs and ADIs do not take into account the effects of combinations of pesticides or pesticide breakdown products.

Besides direct threat to human health, pesticides cause major loss to biodiversity affecting ecosystems. Because most of the pesticides contaminate ecosystems by accumulating in soil and waterbodies. Sindhudurg district is situated on west coast of Maharashtra having great slope from the Sayhyadri range (Western Ghat) to the Arabian see. As a result, most of the rain water get mixed to the Arabian see as surface run off. Therefore, a large quantity of pesticides sprayed must have get mixed with potable water bodies and see water contaminating marine ecosystem every year, affecting marine life. And most of the population in Sindhudurg is dependent on marine food.

It is studied that, Organochlorine insecticides like DDT accumulate in the food chain because they build up in the fatty tissue of organisms that are then eaten in quantity by higher organisms, thus moving up the food chain and threatening fish, birds and higher animals like humans. Through such an ecological multiplier effect, far away in Antarctica, penguins, have been found to have enough accumulated pesticides residue to cause their egg shells to be soft and break. There are many examples of even wild life dying or suffering disrupted reproduction because of pesticides used to kill other organisms.

Honey bees, which are vital for successful cropping, are often accidental victims of sprays aimed at harmful insects like grubs and beetles on food crops.

This shows that though there may not be any direct harm to the human being from pesticide residues in fruits and other crops, their indirect effects are also of major concern.

## **12. SUMMARY AND CONCLUSION**

Mango (*Mangifera indica* L.) is the premier fruit of India. Among the important fruit crops of the world, it is greatly relished for succulence, exotic flavour and delicious taste.

Mango deserves to be the national fruit of India. In the area, the production, the nutritive value and the popularity of appeal, no other fruit can compete with it. It is the favourite fruit of all parts of India and has been repeatedly acclaimed as the "King of fruits".

In Maharashtra mango is cultivated in various districts like Pune, Solapur, Akola, Jalgaon, Nagpur, Kolhapur etc. However, Konkan area is very much popular for growing mango, where Alphonso variety is grown prominently. The mango, which has wide varietal differences, grows in longer range of ecogeographical regions. There are different varieties in Konkan with wide range of popularity in common peoples. These varieties are Alphonso, Pairi, Ratna, Mankur, Batalihapus, Narali, Totapuri, Raiwal etc. Out of these mango varieties, Alphonso is very much popular, in the national as well as in the international market because of its aroma and taste. Other varieties, Pairi and Mankur, are next to it.

The range for coastal region is 760 km in Konkan where climatic conditions are varying at different districts like Thane, Raigad, Ratnagiri and Sindhudurga. Alphonso mango is grown in all areas in these four districts. However, more cultivation is in Ratnagiri and Sindhudurga districts. The spread area in the coastal belt in Konkan could be divided broadly into two parts - North Konkan and South Konkan. Sindhudurga district is placed in south Konkan while Ratnagiri district is at the central part of North and South Konkan. Fruits of Alphonso mango from both Ratnagiri and Sindhudurga district are popular in national and international market. However, Alphonso from Sindhudurga district, particularly from Devgad, is more famous for its taste and aroma and also has greater demand in the national and international market.

Economically and nutritionally Alphonso mango is very important. In Sindhudurg district, the area under Alphonso mango cultivation is approximately 27000 hectares producing 3000 kg mangoes per hectare. It plays major role in the economy of Sindhudurg district.

Physiologically it is important and interesting to see compositional changes with the maturation and ripening process of the fruits.

Beside diseases and pests, the mango crop has to face natural odds. The production of mangoes is totally dependent on natural conditions. Midterm rain, cyclones, heat shock etc. cause premature fruit fall that adds to the loss which affects average 10000 hectares area

per year in the Sindhudurg district. It becomes necessary for value addition of mango fruits which may compensate pre mature fruit loss.

Use of pesticides also becomes obligatory to face diseases and pests. To minimize the economic loss caused by the noxious insects, fungi and weeds, farmers rely on pesticides such as, atrazine, cartap, chlorfenvinphos, malathion, methamidophos, monocrotophos, phosphamidon, etc. (M. Bujagendra Raju *et al.*, 2011). When applied improperly, residues of some of these pesticides can remain as such and can pose a significant hazard to human health. In India 54 pesticides are regularly monitored in exportable mangoes (APEDA, 2008).

The mango fruit is perishable in nature and there are many occasions for it to get spoiled till the fruit reaches to consumer's table. It is estimated that the total loss due to spoilage may be ranging from 30 to 40 per cent (Salunkhe and Desai,1984). Therefore, the fungicidal dip treatment to the mango fruits is a widely applied practice to increase shelf life of the mango fruits.

Very few mango growers, who export their mangoes, follow good agricultural practices (GAP) to maintain maximum residual limit (MRL). Only exporting mangoes are checked for MRL. Today's market demands not only the quality of agricultural produce but also safety and environment-friendly production practices. Thus, it becomes necessary to check mangoes in local market for MRL of pesticides to find out their safety for consumption.

With this context, in present research work an attempt has been made to study physiological changes in the pulp during age wise maturation and ripening process of the Alphonso mango fruits.

Seed kernels of the Alphonso mango were analyzed to see the changes in proximate constituent of the seed kernel with increasing maturity of the fruits.

The pulp of ripened Alphonso mango fruits collected from local market was analysed for maximum residual limit of pesticides.

Some of the important findings in the present research work are as follows.

- i. The moisture percentage in the fruits of Alphonso goes on decreasing with steady state from fruit setting to harvest.
- ii. It is significantly noted that there is drop in the moisture percentage during ripening process.

- iii. There is decrease in the acid content in the Alphonso mango fruits during their development. The values for titratable acidity increase from 20 days to 40 days after fruit set and then there is slight decrease up to harvest time.
- iv. It is interested to note that during ripening stage there is sudden drop in the acidity.
- v. The level of ascorbic acid in the immature fruits is quite high (294.10 mg/100g) which is gradually decreased up to maturity (141.33 mg/100g) and finally dropped to 69.80 mg/100g at ripened stage.
- vi. The level of malic acid goes up and down during development of the fruits but finally at harvest time and ripened stage there is remarkable increase in the malic acid level. This increase in malic acid is twofold.
- vii. The initial level of  $\beta$ -carotene in the developing fruit is at lower order i.e. 34  $\mu\text{g}/100\text{g}$ . There is steady increase in the level of  $\beta$ -carotene up to maturity (250.07  $\mu\text{g}/100\text{g}$ ). However, there is sudden increase in the level of  $\beta$ -carotene in ripened fruits of Alphonso (9578.57  $\mu\text{g}/100\text{g}$ ).
- viii. The level of reducing, nonreducing and total sugars goes on increasing during the development of fruits. There is almost four fold increase in the level of total sugars at maturity. The values for reducing and nonreducing sugars showed the increasing pattern which is attributed in the values of total sugars.
- ix. There is threefold increase in the level of reducing sugars in the ripened fruits of Alphonso and there is almost tenfold increase in the level of non-reducing and total sugars at ripened stage.
- x. There is steady increase in the starch content in the fruits of Alphonso during developmental stages. The level for starch increases from 1.75 % to 11.30 % up to harvest time.
- xi. However, there is sudden drop in the level of starch in the ripened stage of fruits of Alphonso.
- xii. The values for T.S.S. increase steadily during growth of the fruits. However, during ripening stage there is sudden increase in the level of T.S.S. to 19.33<sup>0</sup> Brix in Alphonso fruits.
- xiii. The contents of seed kernel go on increasing with the increasing age and weight of the seeds except moisture and acidity which are decreasing with the increasing age of the seeds.
- xiv. The initial 87 % moisture decreases up to 44 % at the maturity of the seeds.

- xv. Titratable acidity also decreases from 0.68 % to 0.25 % with the maturity of the seeds.
- xvi. Carbohydrates, proteins and fat content of seed kernel go on increasing with the maturity of the seeds. Carbohydrate content increases from 9.65 % to 17.99 %; proteins content increases from 2.12 % to 7.52 % and fats from 1.9 % to 9.5 %.
- xvii. Residues of various pesticides in the pulp of ripened fruits were found below maximum residual limits.

Thus, with the development and growth of the fruits of Alphonso mango till ripening, the moisture, titratable acidity, ascorbic acid and starch show decreasing trend in their concentration in fruit pulp, on the other hand, malic acid,  $\beta$ -carotene, sugars and TSS show increasing trend.

The nutritional content of the seed kernel of the Alphonso mango is comparable with the nutrients of some grains but its direct utilization in diet is found to be unsafe due to presence of some anti-nutrients. However, properly processed kernels are successfully used in animal feed and even in bread and biscuit production. Thus, there is ample potential in mango seed kernels for their dietary and industrial use.

Based on the pesticide analysis from fruit pulp, it may be assumed that the Alphonso mango fruits are within the permissible range of MRLs proposed by FAO/WHO and may not pose a serious threat to public health.

But, the various studies disclose that even a low-level exposure to pesticide residues puts consumers, especially children on risk in a cumulative manner. So, an analysis showing the residues in undetectable or safe range does not essentially mean that it is absolutely safe and free of any untoward effects. Moreover, MRLs and ADIs do not take into account the effects of combinations of pesticides or pesticide breakdown products.

Besides direct threat to human health, pesticides cause major loss to biodiversity affecting ecosystems. Because most of the pesticides contaminate ecosystems by accumulating in soil and waterbodies. Sindhudurg district is situated on west coast of Maharashtra having great slope from the Sayhyadri ranges (Western Ghat) to the Arabian sea. As a result, most of the rain water get mixed to the Arabian sea as surface run off. Therefore, a large quantity of pesticides sprayed must have get mixed with sea water contaminating marine ecosystem every year, affecting marine life. And most of the population in Sindhudurg is dependent on marine food.

It is studied that, Organochlorine insecticides like DDT accumulate in the food chain because they build up in the fatty tissue of organisms that are then eaten in quantity by higher organisms, thus moving up the food chain and threatening fish, birds and higher animals like humans. Through such an ecological multiplier effect, far away in Antarctica, penguins, have been found to have enough accumulated pesticides residue to cause their egg shells to be soft and break. There are many examples of even wild life dying or suffering disrupted reproduction because of pesticides used to kill other organisms.

Honey bees, which are vital for successful cropping, are often accidental victims of sprays aimed at harmful insects like grubs and beetles on food crops.

This shows that though there may not be any direct harm to the human being from pesticide residues in fruits and other crops, their indirect effects are also of major concern.

Thus, it can be concluded that at any stage of maturity not only pulp but seed kernels also of Alphonso mango fruits are nutritious but more and more ways of their industrial and dietary utilization are to be found out so as to add value to the premature fruit loss.

Besides, though pesticide residues in the Alphonso mango fruits are at permissible level, it is necessary to use organic farming practice or biodegradable pesticides not only for public health but for biodiversity conservation also.

## REFERENCES

- Ahmed, F. E. (2001). Analyses of pesticides and their metabolites in foods and drinks. *Trends in Analytical Chemistry*, 20, 49.
- Ali, M. A., Gafur, M. A., Rahman, M. S., & Ahmed, G. M. (1985). Variations in fat content and lipid class composition in ten different varieties. *Journal of the American Oil Chemists' Society*, 62(3), 520–523.
- Anonymous. (1980). *Handbook of agriculture*. ICAR, New Delhi.
- APEDA. (2008). Regulation of export of fresh mango India through monitoring of pesticide residues. [www.apeda.com](http://www.apeda.com)
- Askar, A., El-Tamimi, A., & Raouf, M. (1972). The chemical constituents of mango fruits and their behaviour during growth and ripening. *J. Mitteilungen Rebe abnd Wein, Obstbau and Fruchteverwertung*, 22(2), 120–125.
- Bai, Y., Zhou, L., & Wang, J. (2006). Organophosphorous pesticide residues in market foods in Shaanxi area, China. *Food Chemistry*, 98, 240–242.
- Bempah, C. K., Buah-Kwofie, A., Denutsui, D., Asomaning, J., & Osei Tutu, A. (2011). Monitoring of pesticide residues in fruits and vegetables and related health risk assessment in Kumasi metropolis. *Research Journal of Environmental and Earth Sciences*, 3(6), 761–771.
- Bhumbla, D. R., & Dhingra, D. R. (1963). *Punjab Horticulture Journal*, 3, 134–137.
- Chandra, A., & Chandra, A. (n.d.). *Mango research in India*. Alfa Publishers and Distributors, Bikaner.
- Chandra, A., & Singh, D. (1985). *Haryana Farming*, 14, 11.
- Chattopadhyaya, P. K., Sadhukhan, S. K., Sadhy, M. K., & Bose, T. K. (1978). Studies on physiology of fruit growth in mango. *Indian Agriculturist*, 22(4), 199–206.
- Cheema, G. S., Karmarkar, D. V., & Joshi, B. M. (1939). *Imperial Council of Agricultural Research India Miscellaneous Bulletin*, 21. (As cited in Jain, N. L., 1961).
- Cheema, S. S., & Malhi, C. S. (1986). *Punjab Horticulture Journal*, 26, 6–7.
- Claeys, W. L., Jean-Francois, S., Bragard, C., Maghuin-Rogister, G., Luc, P., & Schiffers, B. (2011). Exposure of several Belgian consumer groups to pesticide residues through fresh fruit and vegetable consumption. *Food Control*, 22, 508–516.
- Dabhade, R. S., & Khedkar, D. M. (1980a). Studies on drying and dehydration of raw mangoes for preparation of mango powder (amchur). Part I. *Indian Food Packer*, 34(3), 3–17.

- Dabhade, R. S., & Khedkar, D. M. (1980b). Studies on drying and dehydration of raw mangoes for preparation of mango powder (amchur). Part II. *Indian Food Packer*, 34(3), 18–31.
- Dakare, M. A., Ameh, D. A., Agbaji, A. S., & Atawodi, S. E. (2012). Effects of processing techniques on the nutritional and antinutritional contents of mango (*Mangifera indica*) seed kernel. *World Journal of Young Researchers*, 2(3), 78.
- Deol, I. S. (1985). A study on chemical changes during the storage life of Samar, Bahisht Chausa mango (*Mangifera indica* L.). *Punjab Journal of Horticulture*, 25(1–4), 5–11.
- Dhingra, S., & Kapoor, A. C. (1985). Nutritive value of mango seed kernel. *Journal of the Science of Food and Agriculture*, 6, 752–756.
- Doreyappa-Gowda, L. N. D., & Huddar, A. G. (2001). Studies on ripening changes in mango (*Mangifera indica* L.) fruits. *Journal of Food Science and Technology*, 38, 135–137.
- El-Kholy, K. H. F., Solta, M. E., Abd El Rahman, S. A. E., El-Saidy, D. M., & Foda, D. S. H. (2008). Use of some agro-industrial by-products in Nile tilapia fish diets. In *Proceedings of the 8th International Symposium on Tilapia in Aquaculture* (pp. 933–947).
- Fenske, R. A., Kedan, G., Lu, C., Fisker-Andersen, J. A., & Curl, C. L. (2002). Assessment of organophosphorous pesticide exposures in the diets of preschool children in Washington State. *Journal of Exposure Analysis and Environmental Epidemiology*, 12, 21–28.
- Gadallah, M. G. E., & Abdel Fattach, A. A. (2011). The antibacterial effect of mango seed kernel powder in minced beef during refrigerated storage. *World Journal of Dairy and Food Sciences*, 6(2), 219–228.
- Gangawar, B. M., & Tripathi, R. S. (1973). A study on physico-chemical changes during growth, maturity and ripening in mango. *Punjab Horticulture Journal*, 13(4), 230–237.
- Gaydou, E. M., & Bouchet, P. (1984). Sterols, methyl sterols, triterpene alcohols and fatty acids of the kernel fat of different Malagasy mango (*Mangifera indica*) varieties. *Journal of the American Oil Chemists' Society*, 61(10), 1589–1593.
- Gole, R. S. (1986). *Studies on fruit development and post-harvest handling of mango (Mangifera indica L.) fruits* (Master's thesis). Konkan Krishi Vidyapeeth, Dapoli.
- Gomez-Lim, M. A. (1997). Postharvest physiology. In R. E. Litz (Ed.), *The mango: Botany, production and uses* (pp. 425–445). CAB International.
- Gupta, J. H. (1979). *Indian Journal of Horticulture*, 36, 96–98.
- Hodgson, E., & Patrica, E. (1996). Pesticides: An important but underused model for the environmental health sciences. *Environmental Health Perspectives*, 104, 97–106.

- Hrelia, P., Maffei, F., Fimognari, C., Vigagni, F., & Cantelli-Forti, G. (1996). Cytogenic effects of metalaxyl on human and animal chromosomes. *Mutation Research*, 369, 81–86.
- Hulme, A. C. (1971). Mango. In A. C. Hulme (Ed.), *The biochemistry of fruits and their products* (Vol. 2, pp. 233–253). Academic Press.
- Hussain, S., Masud, T., & Ahad, K. (2002). Determination of pesticide residues in selected varieties of mango. *Pakistan Journal of Nutrition*, 1(1), 41–42.
- Ishtiaq, A. R., Aman, U. M., Ahmed, S. K., Basharat, A. S., & Saeed, A. M. (2010). A new mango hybrid shows better shelf life and fruit quality. *Pakistan Journal of Botany*, 42(4), 2512.
- Nzikou, J. M., Kimbonguila, A., Matos, L., Loumouamou, B., Pambou-Tobi, N. P. G., Ndangui, C. B., *et al.*, (2010). Extraction and characteristics of seed kernel oil from mango (*Mangifera indica*). *Research Journal of Environmental and Earth Sciences*, 2(1), 31–35.
- Kapur, K. B. (1974). Studies on biochemical changes in mango during growth and ripening. *Indian Food Packer*, 28(6), 10–16.
- Khan, A. S., Khan, M. R. G., Malik, A. U., Rajwana, I. A., Shaheen, T., & Bakhsh, A. (2013). Influence of defoliation and deblossoming on fruit quality of guava (*Psidium guajava* L.) cv. Gola. *Pakistan Journal of Botany*, 45(2), 563–570.
- Kittiphoom, S. (2012). Utilization of mango seed. *International Food Research Journal*, 19(4), 1325–1335.
- Kumar, S., Kumar, V., Upadhyay, R., Kumar, M., Puri, S., & Tripathi, M. R. (2010). Estimation of persistent organochlorine pesticide residues in selected fruit. *Global Journal of Science Frontier Research*, 10(4).
- Lakshmi, M., Majumdar, S. D., & Ravi, U. (2014). Mango (*Mangifera indica* L.) kernel flour as a potential ingredient in the development of composite flour bread. *Indian Journal of Natural Products and Resources*, 5(1), 75–82.
- Lakshminarayana, S. (1973). Respiration and ripening pattern in the life cycle of mango fruit. *Journal of Horticultural Science*, 48(3), 227–233.
- Lakshminarayana, G., Rao, T. C., Ramalingaswamy, P. A., & Chandrasekhara Rao, T. (1983). Varietal variations in content, characteristics and composition of mango seeds and fat. *Journal of the American Oil Chemists' Society*, 60(1), 88–89.
- Legesse, M. B., & Emire, S. A. (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. *African Journal of Food Science and Technology*, 3(9), 193–203.

- Leley, V. K., Narayana, N., & Daji, J. A. (1943). Biochemical studies in the growth and ripening of Alphonso mango. *Indian Journal of Agricultural Sciences*, 13, 291–299.
- Lizada, M. C. C. (1993). Mango. In G. Seymour, J. Taylor, & G. Tucker (Eds.), *Biochemistry of fruit ripening* (pp. 255–271). Chapman & Hall.
- Lowry, O. H., Rosenbrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Follin phenol reagent. *Journal of Biological Chemistry*, 193, 262–275.
- Fowomola, M. A. (2010). Some nutrients and antinutrients contents of mango (*Mangifera indica*) seed. *African Journal of Food Science*, 4(8), 472–476.
- Shad, M. A., Rehman, A., & Daud, K. (2001). Mineral contents of mango seed kernels. *Online Journal of Biological Sciences*, 1(4), 195–197.
- Raju, M. B., Rao, C. N., Kumar, G. V. R., Rao, B. T., Krishna, P. M., Prasad, K., & Venkateswarlu, P. (2011). Determination of multiclass pesticide residues in mangoes by liquid chromatography–tandem mass spectrometry. *International Journal of Applied Biology and Pharmaceutical Technology*, 2(2).
- Mahindru, S. N. (2009). *Food safety and pesticides*. APH Publishing Corporation, New Delhi.
- Majumdar, P. K., Sinha, G. C., & Singh, R. N. (1970). *Indian Journal of Horticulture*, 18, 167.
- Mann, S. S., Singh, R. N., & Pandey, R. M. (1974). Maturity studies in Dashehari and Langra cultivars of mango (*Mangifera indica* L.). *Haryana Journal of Horticultural Sciences*, 3(3–4), 97–105.
- Miller, K. (1987). *Toxicological aspects of food*. Elsevier Applied Science.
- Morasso, G., *et al.*, (2001). Pesticides as food contaminants: A pilot project for correct public information. *Trends in Food Science and Technology*, 11, 379–382.
- Mukherjee, S. K. (1953). Mango—its botany, cultivation, uses and future improvements, especially as observed in India. *Economic Botany*, 7, 130–162.
- Mukherjee, P. K. (1956). *Annual report, Fruit Research Station, Saharanpur*.
- Mukherjee, S. K. (1974). Origin of mango (*Mangifera indica*). *Economic Botany*, 26, 260–264.
- Muzumdar, B. C. (1976). Comparative fruit development of three mango (*Mangifera indica* L.) varieties in West Bengal. *Indian Agriculturist*, 20(3), 163–168.
- Naik, S. R. (1985). *Studies on physico-chemical changes in Alphonso and Ratna mango (Mangifera indica L.) fruits during growth, development and storage* (Master's thesis). Konkan Krishi Vidyapeeth, Dapoli.
- Nzikou, J. M., Kimbonguila, A., Matos, L., Loumouamou, B., Pambou-Tobi, N. P. G., Ndangui, C. B., *et al.*, (2010). Extraction and characteristics of seed kernel oil from mango (*Mangifera indica*). *Research Journal of Environmental and Earth Sciences*, 2(1), 31–35.

- Okoth, E. M., Sila, D. N., Onyango, C. A., Owino, W. O., Musyimi, S. M., & Mathooko, F. M. (2013). Evaluation of chemical and nutritional quality attributes of selected mango varieties at three stages of ripeness. *Journal of Animal & Plant Sciences*, 17(3), 2619–2630.
- Orijajogun, O. J., Latayo, M. B., & Onyinye, C. A. (2014). Chemical composition and phytochemical properties of mango (*Mangifera indica*) seed kernel. *International Journal of Advanced Chemistry*, 2(2), 185–187.
- Ortelli, D., Edder, P., & Corvi, C. (2004). Multi-residue analysis of 74 pesticides in fruits and vegetables by liquid chromatography electrospray-tandem mass spectrometry. *Analytica Chimica Acta*, 520, 33–34.
- Padayatty, S. J., Katz, A., Wang, Y., Eck, P., Kwon, O., Lee, J., *et al.*, (2003). Vitamin C as an antioxidant: Evaluation of its role in disease prevention. *Journal of the American College of Nutrition*, 22(1), 18–35.
- Pandey, R. M., Sinha, G. C., Majumdar, P. K., & Singh, R. M. (1971). *Current Science*, 40, 356–357.
- Pandey, R. M., Rathore, D. S., & Singh, R. N. (1972). *Incompatibility Newsletter*, 1, 22–24.
- Pandey, R. M., Rao, M. M., & Singh, R. N. (1974). Biochemical changes in developing mango fruit (*Mangifera indica* L.) cv. Dashehari. *Progressive Horticulture*, 5(4), 47–59.
- Patkar, V. R. (1978). *Studies on chemical composition during growth and development and effect of growth regulators on ripening of Alphonso mango fruits* (Master's thesis). Konkan Krishi Vidyapeeth, Dapoli.
- Popenoe, J., & Long, W. G. (1957–1958). Evaluation of starch content and specific gravity as measures of maturity of Florida mangoes. *Proceedings of the Florida State Horticultural Society*, 70, 272–274.
- Rangawala, A. D. (1975). *Changes in chemical composition of Alphonso mango fruits during ripening with particular reference to spongy tissue* (Master's thesis). Konkan Krishi Vidyapeeth, Dapoli.
- Rathore, H. A., Masud, S., & Soomro, H. A. (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) var. Dosehari. *Pakistan Journal of Nutrition*, 6, 143–148.
- Rodriguez Plequezuelo, C. R., Duran, Z. V. H., Muriel Fernandez, J. L., & Franco, T. D. (2012). Physico-chemical quality parameters of mango (*Mangifera indica* L.) fruits grown in Mediterranean subtropical climate (SE Spain). *Journal of Agricultural Science and Technology*, 14, 365–374.

- Prasada Rao, G. S., & Verghese, A. (1984). *ICAR fruit research workshop*. Lucknow.
- Rashwan, M. R. A. (1990). Fatty acids composition, neutral lipids and phospholipids fractionation in the kernel lipids of mango varieties. *Assiut Journal of Agricultural Sciences*, 21(1), 105–117.
- Vanderhoff, G. R., & Zoonen, P. V. (1999). Trace analysis of pesticides by gas chromatography. *Journal of Chromatography A*, 843, 301–322.
- Van Steenwyk, R. A., & Zalom, F. G. (2005). Food quality protection act launches search for pest management alternatives. *California Agriculture*, 59, 7–11.
- Rukmini, C., & Vijayaraghavan, M. (1984). Nutritional and toxicological evaluation of mango kernel oil. *Journal of the American Oil Chemists' Society*, 61(4), 780–792.
- Kareem, S. A. (2001). Response of albino rats to dietary levels of mango seed cake. *Journal of Agricultural Research and Development*, 1, 31–38.
- Naz, S., Anjum, M. A., Chohan, S., Akhtar, S., & Siddique, B. (2014). Physico-chemical and sensory profiling of promising mango. *Pakistan Journal of Botany*, 46(1), 191–198.
- Salunkhe, D. K., & Desai, B. B. (1984). *Post-harvest biotechnology of fruits* (Vol. 1). CRC Press.
- Sanborn, M. D., Cole, D., Abelsohn, A., & Weir, E. (2002). Identifying and managing adverse environmental health effects: Pesticides. *CMAJ*, 166, 1431–1436.
- Sandhu, K. S., & Lim, S. T. (2008). Structural characteristics and in vitro digestibility of mango kernel starches (*Mangifera indica* L.). *Food Chemistry*, 107, 92–97.
- Sen, P. K., Malik, P. C., & Roy, P. K. (1943). *Science and Culture*, 9, 87–88.
- Shah, H., Ahmad, M. N., Saleemullah, Suleman, M., & Saljoqi, A. U. R. (2007). Determination of pesticide residues in selected mango available at local markets in Peshawar. *Sarhad Journal of Agriculture*, 23(3).
- Yatnatti, S., Vijayalakshmi, D., & Chandru, R. (2014). Processing and nutritive value of mango seed kernel flour. *Current Research in Nutrition and Food Science*, 2(3), 170–175.
- Siddappa, G. S., & Bhatia, B. S. (1954). The identification of sugars in fruit by paper chromatography. *Indian Journal of Horticulture*, 11(1), 20.
- Singh, R. N. (1960). *Horticulture Advances*, 4, 48.
- Singh, K. K. (1977). *Punjab Horticulture Journal*, 17, 6–13.
- Singh, A. R. (1978). *Haryana Journal of Horticultural Sciences*, 7, 144–147.
- Singh, K. K., & Jawanda, J. S. (1961). *Punjab Horticulture Journal*, 1, 79–88.
- Singh, L. B., & Singh, R. N. (1955). *Indian Journal of Horticulture*, 12, 108.

- Singh, R. N., Majumdar, P. K., & Sharma, D. K. (1966). *Proceedings of the American Society for Horticultural Science*, 89, 228–230.
- Singh, G., Kumar, A., & Pathak, P. K. (1974). *Indian Journal of Horticulture*, 31, 283–285.
- Singh, R. N. (1958). *Horticulture Advances*, 2, 37.
- Singh, L. B. (1960a). *The mango: Botany, cultivation and utilization*. Leonard Hill.
- Singh, L. B. (1960b). *Horticulture Advances*, 4, 38.
- Srivastava, R. P. (1961). *Allahabad Farmer*, 35, 61.
- Srivastava, H. C. (1967). *Grading, storage and marketing: The mango—A handbook*. ICAR, New Delhi.
- Srivastava, L. N., & Mukherjee, P. K. (1961). *Annual report, Horticultural Research Institute, Saharanpur*, 81.
- Subramanyam, H., Krishnamurthy, S., Subhadra, N. V., Dalal, V. B., Randhawa, G. S., & Chacko, E. K. (1971). Studies on internal breakdown, a physiological ripening disorder in Alphonso mangoes (*Mangifera indica* L.). *Tropical Science*, 13(3), 203–210.
- Summanwar, A. S., Raychaudhuri, S. P., & Pathak, S. C. (1966). *Indian Phytopathology*, 19, 227.
- Tahir, M. U., Naik, S. I., Rehman, S., & Shahzad, M. (2009). A quantitative analysis for the toxic pesticide residues in marketed fruits and vegetables in Lahore, Pakistan. *Biomedica*, 25, 171–174.
- Tripathi, R. D. (1955). *Indian Journal of Horticulture*, 12, 173.
- Vavilov, N. I. (1949–1950). The origin, variation, immunity and breeding of cultivated plants. *Chronica Botanica*, 13, 26.
- Waskar, D. P., Dhemre, J. K., & Dethé, M. D. (2004). Residue implications of use of carbendazim and captan on Kesar mango fruits. *Agricultural Science Digest*, 24(2), 151–152.
- Woodrow, G. M. (1910). *Gardening in tropics*. Alexander Gardener.
- Zawiyah, S., Che Man, Y. B., Nazimah, S. A. H., Chin, C. K., Tsukamoto, I., Hamanyza, A. H., & Norhaizan, I. (2007). Determination of organochlorine and pyrethroid pesticides in fruit and vegetables using SAX/PSA clean-up column. *Food Chemistry*, 102, 98–103.
- Zein, R. E., El-Bagoury, A. A., & Kassab, H. E. (2005). Chemical and nutritional studies on mango seed kernels. *Journal of Agricultural Science (Mansoura University)*, 30, 3285–3299.



# Physiological and Nutritional Dynamics of Alphonso Mango

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