CHAPTER 1

Introduction

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Mango (*Mangifera indica* L.) is the most popular and ancient fruit of old world. It is one of the most widely known fruit in tropical and subtropical regions of the globe. Mango is one of the six major fruits of the world. It occupies relatively the same position in the tropics as is enjoyed by the apple in the temperate zones. It is the choiest of all the fruits in the world and is loved by one and all for its delicious taste, nutritive and medicinal values. No other fruit of the world excels mango fruit in deliciousness, flavour, taste and nutrition, hence it is rightly called "King of fruits". Throughout the ages it has been aknowledged as an excellent fruit by one and all. It is the national fruit of India.

Mango (*Mangifera indica* L.) belongs to the family, Anacardiaceae, the most important member of the family, followed by Cashewnut (*Anacardium accidentale* L.), another important member of the family.

Mango has originated in the Indo-Mynmar region of South East Asia (De Condalle, 1904., Poponoe, 1920., Mukherjee, 1951., Gangolly *et al* 1957). From the place of its origin, mango travelled and spread far and wide in all directions, through travelers, missionaries, traders etc. Now it is grown in more than 100 countries and in all the five continents.

Mango, thus enjoys world wide distribution. It is grown on either side of the equator, in both dry and wet tropical and subtropical low land areas up to 23^{o} North and South of the equator. Although, at present it is being cultivated in more than 100 countries, no where it achieved the same premier position as in the Indian sub-conteinent, which is the largest producer of mango in the world. Heritage and culture of the country (India) are closely associated with mango and interwoven.

Nutritive value

The mango fruit is a highly nutritious one, rich in sugars, vitamins and minerals (Table 1.1).

Table 1.1: Chemical composition of ripe mango (per 100 g pulp)

S.No.	Constituent	Measure	Quantity
1.	Protein	gram	0.6
2.	Fat	gram	0.4
3.	Fibre	gram	0.7
4.	Carbohydrates	gram	16.9
5.	Energy	Kilo calories	74.0
6.	Vitamin-A	IU	3890
7.	Vitamin-B	mg	40
8.	Riboflavin	mg	50
9.	Vitamin-C	mg	16
10.	Total carotene	mg	2210
11.	Minerals	gram	0.4
12.	Potassium	mg	205.0
13.	Sodium	mg	26.0
14.	Calcium	mg	14.0
15.	Iron	mg	1.3
16.	Phosphorus	mg	16.0

Ripe mango is the most inexpensive source providing the human body with energy and nutrition. Mango fruit provides two and half-a-time more calories per ha, than wheat. In nutritive value no other fruit can match mango. It is an outstanding sources of vitamin A and C. Besides, the mango fruits are rich source of carotenoids, specialy beta-carotene (pre-cursor of Vitamin A). Sugars constitute bulk of carbohydrates and most of the soluble solids in the ripe mango fruits. Good mango varieties contain 20% total sugars, in which non-reducing sugars are more than reducing sugars. The principal sugars are glucose and fructose. The acid content of the ripe fruit varies from 0.2 to 0.5 %. Mangoes are high in fibre content, but low in calories, fat and sodium and form a good staple food in human daily diet (Chauhan *et al* 1998). The fruit derives its characteristic taste from the blend of acid, sugar and tannins (Bhatnagar and Subramanyam, 1973).

Consumption of a medium sized mango fruit provides daily requirement of vitamin A and C and 40% of fibre.

Uses

Mango tree and its different parts such as wood, leaves, inflorescences, flowers, fruits, seeds and kernlas have several uses and have been used in several ways for the last

several millinia in India and other South East Asian countries. Fruits, in particular are put to multiferous uses right from first stage of growth and development to maturity and ripening stage. Wood of the tree is used for making doors, windows, beams, furniture etc. The leaves, inflorescences and twigs are used in various religious rituals and functions in India and other South East Asian countries.

Mango fruits are processed and preserved in many ways. Mango fruit is utilized at all stages of its growth and development both in its immature, mature and ripe stages. Raw and green immature fruits are used for making chutney, pickle, amchoor and juices like Panna. The ripe fruits besides being used as dessert are also utilized for preparing several products like squashes, syrups, nectars, jam, jellies, leather etc.

The mango seed kernel contains 8-10% good quality fat, which is used for making soaps and also as a substitute for Cola in confectionary. Seeds including kernels are used as cattle and poultry feed. Tribals make starch out of kernels at times of food scarcity and after mixing with wheat/maize flour use the mixture for making Chapaties.

The medicinal properties of mango fruits and other parts of the plant are well known and have been put to use since long throughout the world. The different medicinal uses of mango tree and its various parts were reviewed (Nair, 1995., Budhar, 2002). Almost all parts of the plant viz., roots, bark, twigs, leaves, inflorescences, fruits, seeds and kernels are used as medicines in one way or the other. Both unripe and ripe mangoes are used in treating stomach problems and to stimulate bile formation and in blood related diseases and disorders. The powder made from the skin (peel) of unripe fruit is used to cure bleeding, dysentery, diarrhoea, sore throat, cholera and in many gynecological troubles. Consumption of ripe fruit is useful to overcome nightblindness and to protect the health of the human skin. It helps to increase digestive capacity of the human body. The ripe fruit is very good for treating nervous dyspepsia and constipation. The fruit pulp is useful against haemorrhiage problem. The seed kernel is useful to control diarrhoea, dysentery, haematomesis and piles. Mango seeds, leaves and bark are used in the treatment of diarrhoea and disorders in reproduction system of women. It is also claimed that mango takes care of the sexual debility, defects of kidney, anaemia, brain weaknesses, chronic diarrhoea, dysentery and inflammation of spleen. Mango also contains an enzyme with stomach soothing properties similar to papain of papaya.

Cultivation

According to De Condalle (1884), cultivation of mango originated in India and dates back atleast 4000 years ago. However, Tjiptano *et al* (1984) stated that ASEAN countries were among the earliest of other countries to commence cultivation of mango in the world. Cultivation of mango on orchard scale in India started only during the period of Moghuls in the 15th Century AD. But till the patronage of colonial Europeans, the cultivation of mango was taken up by effluent people like Princes, Nawabs, Zameendars, Jagirdars etc. Commercial cultivation of mango started during colonial regime in India, from which

time it passed from the above elite people to the common man. Now mango growing is in the hands of common man, marginal and small farmers also.

Mango is cultivated under diverse agroclimatic conditions of the world. Different varieties of mango are cultivated in different regions. In many regions, the crop is facing with the problems of biotic and abiotic stresses. The crop faces many challenges in production, post-harvest management and supply chain management (marketing). The post-harvest behaviour of mango fruit is strongly influenced by cultivar, harvest maturity, post-harvest treatments, diseases, disorders and storage conditions. One of the impediments of mango industry is the lack of infrastructure for post-harvest management in terms of pack houses, storage, processing, waste utilization, marketing etc.

Need for post-harvest management

Efforts to enhance production of crops, including mango, by increasing the area under the crop and adoption of improved agro-techniques and plant protection measures will be futile, unless the post-harvest losses are reduced, extended the availability of fruits, through storage and value addition is made. Minimising the post-harvest losses has, therefore, been recognized as an effective means of increasing the availability of mangoes without additional inputs. Since the cost involved in preventing the losses will be less than the production, post-harvest management attains greater significance. In order to reduce the post-harvest losses there is a need to adopt proper strategies, involving new technologies in the post-harvest management. Reduction of post-harvest losses both quantitatively and qualitatively could be achieved by adoption of good pre-harvest production practices including pre-harvest fungicide spray schedules for preventing post-harvest diseases, harvesting at proper maturity, proper harvesting methods, adoption of good packhouse practices like sorting, washing, grading, packing, pre-cooling etc. and adoption of refrigerated transportation, post-harvest treatments, storage at optimum conditions and sound marketing practices. Losses can also be reduced by preservation and processing of mango fruits, which add value to the fruits and fetch higher returns. The issue of supply chain (marketing) management also needs due focus for their improved supply and profitability to the growers/traders.

Brief Account of Post-harvest Management Aspects

Post-harvest losses in mango have been estimated, as ranging from 25 to 40% from harvesting to consumption stage (FAO, 2003), due to improper handling after harvest and lack of infrastructure for carrying out various post-harvest handling operations. The main aim of post-harvest handling is to protect the fruit from both biotic and abiotic hazards, extend their storage life, and maintain quality and freshness till it reaches the consumer. Post-harvest operations include operations at harvest, packhouses, sorting, grading, pre-cooling, storage, ripening, transportation etc.

The available season of fresh fruits of mango is very short in any producing region (2-4 months), but mangoes are produced throughout the year, in one region or the other of

the world. However, there is deamand for the fruit alround the year in all regions. Further, because of rhythum of alternate bearing, in certain years, there wil be glut in the market in which case the surplus supply may go waste for want of adequate processing. Mango is highly perishable and does not keep for more than 10 days at room temperature at mature green stage. The supply throughout the year is possible by storage of fresh fruits for extended periods. Extension of storage life can be achieved by different approaches like delaying ripening and checking biochemical activity in the fruits by exposing them to low temperature, altered gaseous atmosphere around the fruit, by irradiation etc. However, each method has its own merits and demerits. For example, the chilling sensitivity of mango fruits limits its long duration storage and transportation at temperatures below 12-13 ^{o}C.

Mangoes for table as well as processing purposes are generally harvested at hard-green and unripe stage and are ripened artificially by different methods. Ripening of fruit is a dramatic event in the life of the fruit, which enables the fruit edible and also helps in the dispersal of the seed for perpetuation. Mango is classified as a climacteric fruit. Ripening is a complex phenomenon triggered by endogenous ethylene after harvest. Under tropical conditions fruit ripening is faster as compared to subtropical conditions. However, regulation of ripening (accelerating or delaying) becomes necessary at times. The fruit should remain unripe until it reaches the destination market/consumer. This needs delaying of ripening. Once it reaches, the destination market, the ripening fruit undergoes changes in its biochemical constituents and these changes render the fruit edible. Checking these changes is one way of delayng ripening of fruits.

During glut in the market, the prices decline to the disadvantage of the farmer as well as the trader and much of the produce is likely to lost due to one or other reason. Further as mentioned above, the mangoes are available for a shorter period of 2-4 months in a season. Fresh fruits are not available always and do not give much income to the grower, traders etc. To get higher income, to avoid glut in the market, and to extend the availability of mango (in a different form) value addition to them is necessary and this is possible through preservation and processing. Mangoes can be consumed raw as dessert fruit or processed into various products. However, consumption as a dessert fruit up to over 90% is very common and predominant and only 5-6% of the production is processed in India (Naidu and Hari Babu, 2009). Mango is a versatile fruit that can be utilized at different stages of its growth and development. Green and unripe mangoes are used for making different products such as amchoor, pickles, chutney, panna etc., while ripe mangoes are used for making different types of drinks, jams, jellies, bars etc. From the start, different methods like sun-drying etc. and till now several methods of preservation and processing of both raw, green, unripe and ripe mangoes were developed. Processing, however, faces many problems in procurement of raw material, suitable variety(s) for making different products, disposal of finished products, and commercilisation of the industry and market expansion. Processing provides employment, results in increase in value addition and is quite remunerative. Though there are more than 1000 named

varieties in mango, all however, are not suitable for preservation and processing into different products. A few varieties were identified for processing into different products. Despite this, Bangalora (Totapuri) is mostly used for processing.

Preserved and processed products are often spoiled by microbes, because of high sugar content, higher acidity and low pH in the products. Contamination of fruits from the field and their non-removal before processing, inadequate quantities of chemical preservatives etc. are some of the causes of spoilage of processed products. Unhyegenic conditions in the industry and storage places, lack of proper packaging also contribute to microbial spoilage of processed products. Methods of avoiding such microbial spoilage of processed products have been worked out.

Processed products are very much liable for spoilage due to microorganisms, biochemical changes and enzymatic activity. They would be on the shelf for a longer time till they are disposed off by sale. Hence, their proper storage is very much essential and is needed for profits. Besides extending the shelf life, the processed products need to retain/preserve their nutritive value and acceptability. Their storage can be achieved by packaging, thermal preservation, sulphiting and addition of preservatives etc.

Quality is a measure of the degree of excellence or a degree of consumer acceptability. The production of high quality food products has been the important goal since the start of the processing. Additionally quality control is essential. Quality standards have been laid out by different governmental organizations in each country, through enacting several Acts for the quality control of processed products. Quality standards have been laid out for each processed product at each step of its processing.

Post-harvest diseases of fruits due to microorganisms (fungi and bacteria) are responsible to a large extent for spoilage of fruits after harvest. Some of them are carried from the field as latent infections. Post-harvest diseases cause huge post-harvest losses to the great disadvantage of sellers particularly. They are serious constraints in trading, particularly in exporting mango to global markets. Diseased fruits become unfit for either table or processing purpose. Hence, their management/control, both in the field and after harvest is inevitable. The management strategies include pre-harvest as well as post-harvet ones, like cultural, physical and chemical and of late biological methods.

Mangoes also suffer from certain serious physiological disorders during their post-harvest life. Physiological disorders are mostly due to imbalances in the metabolism induced by some abiotic factor(s) in the pre-and post-harvest environments, that render the fruit unfit for consumption as well as for processing. Some of them limit the chanes of exporting mangoes to the international markets. Efforts were made to understand and elucidate the causal factors and to ward off of such disorders in the initial stages by avoiding various causal conditions.

Post-harvest losses in case of mango in India account for 25-40%. The losses may occur at any stage right from the field at harvest, till the fruit is delivered at market, in transportation, storage etc. The post-harvest losses may be due to physical, physiological

and pathological reasons. Both quantitative and qualitative losses occur at all stages in the post-harvest system. The losses will be severe in the tropical and sub-tropical production centres, where high temperatures and relative humidity prevail during the harvesting and post-harvesting periods. The post-harvest losses reduce the availability of produce to the consumer, financial loss to all the concerned in the trade. Besides these quantum losses, the quality loss before consumption is serious and enormous and can not be estimated. Therefore, the post-harvest losses have to be prevented. Preventive methods have been devised to a satisfactory level.

After consumption as dessert fruit and/or industrial processing of the fruit, large quantities of waste in the form of peels, pulp, seeds etc. get generated. Such waste accounts up to 30-35% of the fruit depending upon the variety, size of the fruit and efficiency of the processing industry. Mango waste is not used for any useful purpose even today and is largely wasted. However, this waste can be converted into food ingredients, biofuels etc. Edible products from mango waste such as jelly grade pectin, edible fibre, vinegar, citric acid, oil, butter, kernel powder, alcohol (wine) etc. can be synthesized. Kernel oil can be used in costmotics and soap industries. The kernel flour after mixing with wheat/maize flour is used for making chapaties. About 10% alcohol could be obtained from kernel by co-culture fermentation. Enzymes such as cellulase and pectinase from mango kernel could be produced by microbial fermentation. Mango waste material also provides raw material for the gas reactors, organic manures and extraction of several useful products. Left unattended, these wastes may become the source of atmospheric pollution and contamination of soil and ground water etc. Efficient disposal and/or recycling of these wastes may help in minimizing the pollution hazards, supply of vital nutritional components in our food and feeds and bringing down the cost of processing with the possibility of providing additional income.

Marketing is as important as production. The marketing system of mango is very unorganized, because of the presence of a large number of intermediaries, mainly private individuals (pre-harvest contractors, commission agents, wholesalers and retailers) and lack of efficient supervision of Government officials. At present marketing of fruits including mango is under private entrepreneurs or collectors, who buy the fruit gardens from the farmers, arrange for harvesting and transportation to suitable collection centres, where sorting and grading to their advantage are carried out, after which the fruit is consigned to domestic or global markets. About 80% of the mango growers in the country sell their orchards to pre-harvest contracters/lease them for varying periods (1-5 years). Marketing plays a key role in the post-harvest handling operations of fruits. A perfect and efficient marketing system covers all aspects of handling from the stage of harvest till the commodity reaches the consumer. However, marketing of perishable products like fruits presents more problems as compared to other non-perishable agriculture commodities like grains, pulses etc. Generally the interests of the producer and consumer are ignored/poorly served in the present marketing system. The growers get less returns for their produce and consumer has to pay more than what is necessary and justifiable. Due

to the presence of middle men, the price of the fruit is 50-100% higher at terminal markets than at farm gate. The middle men manipulate the situation by artificially creating glut/scarcity and offer low prices to growers. They often syndicate for their advantage. They also falsely reject the produce (fruits) as substandard and indulge in malpractices in weighments etc. and delay payments to the growers. The cooperative systems play a very important role in the marketing of agriculture produce, particularly fresh perishable produce.

AREA AND PRODUCTION

World

The mango is cultivated throughout the tropical and sub-tropical regions of all the 5 continents of the world. According to FAO data (FAO 2003) currently more than 100 countries grow mango in the world and the number of countries, likely to take up cultivation of mango may increase further in the future. However, the number of countries which produce more than one million metric tones of mangoes are only few during 2004 (Table 1.2).

Table 1.2 : Area and Production in major mango producing countries during 2004 (Galan Sauco, 2004)

S.No.	Country	Area (m. ha)	Production (mill. mt)
1.	India	1.600	10,800
2.	China	0.419	3,582
3.	Thailand	0.270	1,700
4.	Mexico	0.174	1,503
5.	Pakistan	0.105	1,089
6.	Indonesia	0.170	1,006
7.	Philippines	0.159	0.968
8.	Brazil	0.068	0.850
9.	Egypt	0.045	0.327

It is clear from the above data, that India is the largest producer of mango with largest area under the fruit, followed by China at a distance. India is not only the largest producer of mango, but also the largest consumer of the fruit, however, is a poor exporter. Mexico, on the other hand, stands at the 4th place in area and production, but is the largest exporter of mango to the International markets, especially to USA and continues to be so. The area under mango in the world is 4.72 million ha, with a production of 34.89 million metric tones during 2009-10 year. India was the largest producer of the fruit accounting for 49% of the area and 49.1% of the world production in the year 2009-10 (FAO). However, its share in the world area and production has been dwindling over the years.

The mango industry gained a great impetus in the past decade and continues to boom further in future, mainly due to expansion of its cultivation to newer areas of the world and the International Trade Liberalization.

India

India is the traditional grower of mango since millennia. Mango is successfully cultivated throughout the length and breadth of the country under diverse agro-climatic conditions. Each state in the country grows mango. The data on state-wise area and production of mango in the country during 2008-09 are furnished in the Table 1.3.

Table 1.3: State-wise area and production of mango in India during 2008-09

S.No.	State	Area (m. ha)	Production (m. T)
1.	Andhra Pradesh	0.498	2.522
2.	Maharashtra	0.457	0.713
3.	Uttar Pradesh	0.271	3.466
4.	Orissa	0.164	0.450
5.	Bihar	0.144	1.330
6.	Tamilnadu	0.149	0.821
7.	Karnataka	0.141	1.284
8.	Gujarat	0.166	0.300
9.	West Bengal	0.066	0.549
10.	Kerala	0.077	0.445
11.	Others	0.206	0.870
	Total	**2.309**	**12.750**

A perusal of the above state-wise area and production indicates that Andhra Pradesh stands first in area, whereas Uttar Pradesh stands first in production. Though the area under mango is highest in Andhra Pradesh, its production is less because of lower productivity (5.1 t/ha). On the other hand, Uttar Pradesh stands 3rd in area, but first in production due to highest productivity (12.8 t/ha).

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