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A study on quality analysis, value-added processing and waste utlization of Mango *(Mangifera Indica L.)*

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Abstract:

Mango is get larger covering the world in tropical as well as warm temperate region. A very important aspects of its processing and exporting in many producer countries. Friut processing is very advanced technology in many food sector countries regarding the export and also invented to advanced systems which enhance the fruit processing sale in the global market. The end products of mango implies low added value in the market and also seed kernel is one of the by-products of food processing industry is not commercially make use of but are discarded. For this region its physical and chemical properties as important aspects due to its valuable nutrient content of seed kernel. It is edible and has various utilities in the food industry. For instance, the dried mango seeds are stored and used for meals during acute food crisis in India. There are various value-added products of mango are used both ripe and unripe such as mango pulp, mango beverages, dried mango products, mango leather, mango jam, Mango candy where as unripe mangoes generally used in the form of pickles and chutneys etc. The whole part of mango content many antioxidant, antibiotic, anti-carcinogen and other relevant properties. Finally the future trends to improve its production and its development of mango based new products which changes and modified the diet as well as the lifestyle of human being and kept healthy.

Keywords: Fruit processing, by-products, nutrients, value-added products, antioxidant, antibiotic, anti-carcinogen.

Introduction:

Mango (*Mangifera indica*) is National fruit of India which have a unique popularity among the all fruits in world, due to their peculiar taste, aroma, and nutritional value and great opportunity in processing sector so it is also known as King of fruits. Fruit of mango is a rich source of vitamin A (4800IU) B and C and various micro as well as macro nutrients. It is a tropical fruit tree belongs to Anacardiaceous family and widely grown in tropical areas of world. The global production of mango was 55.85 million tonnes in financial year 2018-19 (https://www.statista.com) with 12.1kg/capita consumption (https://www. Purfresh.com).

However India is a largest mango growing country and share about 38.5% of total mango production in world and earn about Rs 400.21crores by export 49,658.68 MT fresh mango in year 2019-20 (http://apeda.gov.in). The mango production in India in financial year 2019-20 was about 20.44 million tonnes (2nd advance estimation) which was 4.36% lowest compared to year 2018-19(21.37 million tonnes https://www.nhb.gov.in). In India it is mainly grown in Uttar Pradesh, Andhra Pradesh, Karnataka and Bihar. It is such fruit which is useful from flowering to maturity, the fruit harvesting start from March to mid-August in India which is oval or kidney shaped green to yellow in colour. At peak harvesting period if mango processed in various value added products can be create new source of income with low cost by time and place utility in offseason. Mango processing has great demand at national and international market, raw green fruit is used for preparation of pickle, chutney and mango power and ripe fruit used for various type of beverages (RTS, squash, nectar etc) jam, latter apart this after processing skin and stone remain as waste which is generally discarded (40-60%-S.K.Sharma-2010) can be used to preparation of by product like mango fat, bio colour and as cattle feed. Kernel of mango have 6% protein 11% fat 77% carbohydrate 2% crude fiber and 2% ash (Deeksha and Mishra-2018) and polyphenols which can be mixed with wheat and maize flour to prepared biscuits chapattis. Since kernel has sufficient amount of oil so it can be used in cosmetic and shop industries apart this cellulose, pectinase and amylase enzyme can be obtains by peel and kernel respectively. The average nutritive value of mango fruit and kernel flour are given blow-

Table 1: The average nutritive value of mango fruit and kernel flour:

Parameters	Raw mango	Ripe mango	Kernel flour
Protein(g)	0.7	0.6	7.53
Carbohydrate(g)	10.1	16.9	69.77
Fat(g)	0.1	0.4	11.45
Fiber(g)	1.2	0.7	11.45
Energy(K.cal)	44	74	421
Vitamin C(mg)	3	16	--
Total carotene(mcg)	90	2210	--
Calcium(mg)	10	14	170
Potassium(mg)	83	205	368
Phosphorus(mg)	19	16	

Source* Yatnati *et al*., (2014), Nigam *et al*.,(2007)

Nutritional benefit of Mangos:

Since all parts of mango tree (leaves, flower, fruits, seed, bark) are known for its unique properties (nutritional, Pharmaceutical and cosmetics) some of them discussed blow-

Effect on digestion:

Fruits of mango contain many type of enzymes like as cellulose and pectinase in peel and amylase in kernel (Post harvest profile of mango-2013) which help to breakdown of complex form of nutrients into simple form. Mango contain Amylases enzymes which split starch into maltose and glucose in ripe mango these enzymes are more active, apart this it contain sufficient amount of dietary fiber which are responsible of improving digestion in alimentary canal and also help to overcome various digestive related problem such as constipation, diarrhea (Raman,MS.,RD.2018)

Anti-oxidant properties:

Various types of phytochemical compounds are present in different part of plants which have ability to scavenge of free radical. A different kind of phytochemicals (antioxidants, vitamins, pigments) are found in various part of mango plant which have antioxidants and free radical reducing ability. Afifa *et al* (2014) conducted a comparative study on five mango varieties (Langra, Himsagor, Amraupali, Fazli, Ashiwna) and revealed that Ashiwna (66.65mg/100g) and Langra (59.17mg/100g) have highest ascorbic acid content (antioxidant) but highest total phenol was reported in Langra followed by Ashiwna. Both chemical compounds protect cell to free radical and save to oxidative damages.

Mango peel, pulp and stone have lot of polyphenoliocs compound including mangiferin, catechins, anthocynins,quercetin, kaempferol etc which protect cell from free radicals.Ganogpichaygri, et al.(2017) reported that ethanolic leaf extract of mango have mangiferin polyphenols which was helpful to prevent diabetes and cancer problem. According to Khurana *et al* (2016) phytochemical mangiferin has antioxidant properties which responsible for decrease oxygen free radicals thus prevent DNA damage which induced of cancer. A lot of reactive oxygen species (ROS) such as superoxide anions, hydroxyls, and hydrogen peroxide are produced in human body during various metabolic accumulation of these chemical molecules reduced renovator ability of cell, lapse cellular function and lead various type of health problem like heart attack, aging, diabetes etc. Thambi et al.,(2016) reported that ripe mango peel have high amount of antioxidants like anthocyanins(360-365mg/1oog) and carotenoids(194-436mg/100g) compared to raw peels but raw mango peels have maximum polyphenol compare to ripe peel.

Anti-carcinogenic properties: Luricella *et al.*,(2019) conducted a study anti-cancer effect on mango peel extract and reveled that extract induced apoptosis and inhibited colony formation of tumor cells. According to Nyuyen *et al*.,(2016) reported that methanol bark extract of mango have many bioactive compound such as mangiferolate and isoambolic acid which create antagonistic effects in pancreatic carcinogenic cells..

Value added products of mangoes:

Mango is a such fruit which is useful at any stage of maturity (unripe to ripe stage) but a lot of fruits are drop due to physiological and environmental factors during maturity to ripening stage.

Ripe mango product:

Mango pulp: Mango pulp is yellow, sweet, inner part of mango which is obtained by mesocarp of ripe mango fruit. It is used for the preparation of various types of products (juice, nectars, Jams etc) in on season as well as off season. Pulp is prepared after washing (15ppm chlorine solution) blanching (75^0C for10 min), peeling, and pulping (0.5mm mesh size) standardized as 15-18 ^{0}B by adding sugar syrup and 0.1% ascorbic acid which prevent discoloration

Mango beverages: Different type of mango beverages are prepared by mango pulp such as Ready to serve (RTS), squash, nectar are prepared at commercial scale. Because pulp of mango is very viscous so for dilution and adjusting total soluble solid various amount of water are add in different type of beverages. Different type of beverages after packing in cans heated at 85^0C for 10-15minute to prevent microbial spoilages. Harsitha *et al*., (2016) prepared ready to serve and squash by Safeda variety of mango with 20% and 40%pulp respectively was found best organolepticaly . Another study conducted by Sahni and Khurdiya (1889) and state that nectar prepared with 20%mango pulp by the four cultivars (Dashehari, Chausa, Neelum and Amrapali) and it was found that nectar prepared by Amrapali was found best in overall acceptability among other variety. In another study Sahni & Khurdiya(1988) developed nectar by three hybrid mango variety and it was revealed that Amarpali variety was better in context of colour and flavor. Rabbani & Singh (1989) revealed that RTS and nectar with composition 10% juice, 14%TSS, and 0.3%acidity and 20%juice 14% TSS, and 0.3% acidity by different varieties of mangoes was found better. Mathur and purnanadam(1976) prepared mango squash with 25%juice,45%TSS,1.2-1.5% acidity and Sulphur dioxide(350ppm) as preservative and stored in glass bottles. A study conducted by Chakraborthy *et al*.,(1991) for the preparation of various mango product by different variety of mango and prepared nectar and juice and comparatively judge organolaptic characteristics(colour, aroma, taste and overall acceptability) to Alphanso mango and state Dasehri,Tamburia Dasheri were found to be good compare to Alphanso mango for preparing canned mango nectar. Sakhale *et al*., (2012) prepared Ready to serve (RTS) by blending of soyamilk and Mango pulp in different proportion and it was revealed that beverage prepared by combination of 50:50 best in different physico-chemical and organoleptic parameters among other combination.

Table-2 mango beverages with specification:

Beverages	Pulp (%)	TSS (%)	Acidity (%)	Remarks
RTS	20	13	0.24	Harsitha *et al*., (2016)
Squash	40	50	1	Harsitha *et al*., (2016
Nectar	20	20	0.3	Sahni & Khurdiya (1989), Rai *et al*.,(1972)

Dry mango products: In recent years preparation of mango juice dry powder is in trend because it is a good adjunct in various type of product like confectionary, ice-cream and bakery industry. Siddappa *et al*.,(1953) state that pulp of mango was easily dehydrated at 141^0C in 6-8 seconds by double drum drier and obtain a yellow colour material with natural flavor. Nanjundaswamy et al., (1976) sate dehydrated mango slice prepared by osmotic dehydration technique proximately same organoleptic attributes (colour ,flavor, texture) to canned slice. The best dehydrated mango slice can be prepared after submerging fresh slice at sugar syrup (70^0B) and heated for 2minute at 90^0C before drying in cabinet dryer (57 ± 2^0C) suggested by Khurdiya &Sagar(1996).They also said that addition of sugar improved slice chewing and solid content. Friday,O.A.(2013) used ripe mango to obtain flour, after cleaning ,peeling, slicing drying slice in solar dryer at 60-70^0C for 5 h for 5suny days to reduced moisture 90% of fresh slice and store for about 1 year 8 month(96 week) and revealed that there was no significant change in colour and increased trend was recorded in various physical and chemical properties like viscosity, swelling index and bulk density, total carbohydrates, crude fiber and ash.

Amchur is a fine power made from unripe sound, healthy, mangoes dry slice have vinegary,acidic taste and can be used during unavailability of fresh mango fruits foe preparation of many dishes,and have nutritious and healthy benefits like prevent scurvy, control blood pressure, improve vision etc. Krishna *et al*.,(2020) conducted a study on quality of amchur of five mango varieties(Mahabhog,Punia, Fazli, Bharathi and Ashiwna) and reported that during storage period sugar and titrable acidity was increased and also revealed that Mahabhog variety was found superior for amchur among other cultivars. A study conducted by Patil *et al*.,(2019) for preparation of amchur by keeping slice at different blanching duration, temperature and concentration of KMS and it was concluded that slice blanched for 5minute, treated 5 minute at 1.5% KMS, drying in cabinet dryer and packed in 400gauge HDPE was found better for amchur preparation.

Mango toffee: Toffee is a confectionary product which is ordinarily prepared by blending sugar, fat, and various types of synthetic colour and flavor. Which are very popular in whole world among the children. Shakhale *et al*.,(2012) prepared toffee by blending fig and mango pulp in different proportion and suggested that combination of fig and mango pulp at 80:20 ratio was found better in different organoleptic parameters. Shakele *et al*.,(2012) suggested for preparation of toffee blend pulp heated up to one third of it primal volume and sugar was added and heated up to mixture attend 65-70^0Brix at this stage butter and flavoring materials are add and cooked

mass is sifted in smooth server and form a appropriate sheet which has already daub to littlie butter. The cooled sheet cut in suitable size and wrapped in butter paper.

Mango Jam: Mango jam is a semi-solid opaque processed product prepared after cooking and blending of pulp, sugar, acid and pectin in a appropriate proportion. Abdelazim *et al*.,(2014) used three varieties of mango(Malgoa, Abusamaka and Galb Altor) for jam preparation and revealed that jam prepared by Galb Altor mango was superior in colour,teaste and overall acceptability but Abusamaka mango jam in flavor. A study conducted by Shafaly *et al*.,(2019) take beal and mango pulp in different ratio for jam preparation and it was suggested that pure pulp of mango are best for jam preparation compare to other blend combination.Safder *et al*.,(2012) selected six mango varities(Dusehri,Chaunsa, Langra, Anwar Ragtol, Malda and Fajli) and reported that and Anwar Ragtol jam hashighest total soluble solid(68.2^{0}B), reducing sugar and total sugar but to the point of organoleptically parameters Dusehri variety was superior.

Mango Yoghurt drinks: It is a fermented drink which are made after blending milk and mango pulp in reasonable amount and subjected to fermentation process. It is minerals and vitamin rich food product which have countable amount of various minerals like calcium, phosphorus, sodium and potassium and also have therapeutically properties such as reduced cholesterol level, cancer, cardiac diseases. Raut *et al*.,(2015) develop mango yoghurt drink by mixing mango pulp and yoghurt drink in different and concluded that drink prepared by 6% pulp blend was more acceptable. Sagar and Khurdiya(1996) reported that mango lassi prepared by mixing mango powder and curd at 3:10 ratio was more acceptable.

Mango Ice-cream: It is prepared by blending milk and mango powder in a appropriate proportion. Birtnell(1991) suggested icr-cream prepared by mixing mango pulp power and milk at 3:10 was appropriate.

Mango Leather: it is dehydrated flexible value added product which is prepared blending of mango puree with sugar, citric acid and preservatives and used as snack and desert**.** Azerado *et al*.,(2006) prepared mango leather by use of mango puree and shake down onto petri dishes then drying at 60-80^{0}C in oven to reduced moisture up to 15-18%. Gujral and Khanna (2002) conducted a study to review the effect of skim milk power, soy protein and sucrose on dehydration, texture and colour of mango leather and revealed that these ingredients slow drying of leather increased extensibility and improved nutrients status. They conduct drying process up to 7.60h at 60±1^{0}C to reduced moisture content up to 90 percent. Chavan *et al*.,(2016) prepared fruits bars by mixing mango and sapota pulp in different proportion and concluded that pulp combination of sapota and mango at 30:70ratio was found best among all combination.

Unripe mango products:

Mango pickle: it is preserved product of unripe mango, it is categorized different type on the basis of preservative used such as salt pickle, oil pickle, and sweet pickle. Science it is national

pickle of India and almost all Indian is familiar to this and prepared it in different ways. Sethi(1991) state that green mango slice preserve in a solution containing 5% salt and 1.25% acetic acid and 0.01%KMS have high preservative effect compare to dry salting. Saroj and Singh (2018) standardized four recipe for preparation of mango pickles which are given in table-3, and state that during storage flavor, taste, consistency, texture was improved but colour was decreased due to browning.

Table-3 Standardized recipe of mango pickle:

Ingredients	**Recipes**			
	Oil pickle	Salty water pickle	Dry pickle	Sweet pickle
Unripe mango pieces	1kg	1kg	1kg	1kg
Red chilli power	20g	20g	20g	20g
Fenugreek power	20g	20g	20g	20g
Cumin Seed	10g	10g	10g	10g
Mustard oil	500ml	250ml	50ml	--
Asafoetida	5g	5g	5g	5g
Nigella	10g	10g	10g	10g
Cardamom	15g	15g	15g	15g
Salt	150g	250g	150g	150g
Sugar				500g
Turmeric	25g	25g	25g	25g
Mustard seed	50g	50g	50g	50g
Black pepper	15g	15g	15g	15g
Ani seed	20g	20g	20g	20g
Mathi	75g	75g	75g	75g
Fennel seed	10g	10g	10g	10g

Kanekar *et al*.,(1989) work on effect of oil, salt and acidity in the preservation of mango pickle against *Aspergilus niger* and reported that mould create spoilage at 10% salt,40% oil and 4.2% acidity but 15% concentration have adverse effect against surviving of this fungus.

Mango Chutney: It is spicy, acerbic flavorful, delicious paste like condiment prepared by peeled unripe mature mangos after cooking with different ingredients including spice, salt, vinegar, jiggery, onion and garlic. As per the FPO specification minimum total soluble solid (TSS) in chutney should 50^0B, 40% fruits of final product and 2.1% acidity. Sharma *et al*.,(2019) prepared chutney by blending beal-mango pulp in variant proportion and manifest that blending combination of mango and beal at 40:60 was best among all combination. Man,D.L.,() work on mango-guava blend chutney by blending pulp of both fruits in different proportion and found that mango and guava blend in 60:40 ratio got more acceptability by judges panel and also observed that during storage period TSS, total sugar and reducing sugar was increased but acceptability decreased continues.Husa *et al*.,(2019) take three varieties of mango(Podag, Keweni, Gadung) and different concentration of apple vinegar(5%,10%,15%) for the

development of mango chutney and reported that selection of varieties affected water content and hedonic test while vinegar concentration had not significant effect on TSS, vitamin-C ,pH, crude fiber and antioxidants activity. They also recorded that chutney prepared with Gadung variety and 5% apple vinegar has more acceptability than other variety and vinegar concentration.

Waste utilization of seed and peel of mango:

About 20% of total production of mango used to develop various type of vale added product including puree, beverages, lather, pickles (Ravani & Joshi, 2013, Loelillet, 1994).After processing huge amount of waste material are remain as peel and stone which account 40-60% of total weight(Sharama,S.K.,2010) and generally discarded that create pollution problem and responsible indirectly to generate various type of health problem. These by products have accountable nutritive status and rich source of various phytochemical (polyphenols and antioxinets) which can be use in pharmaceutical industries to cure various type of chronic disease. So by the proper utilization of these wastes above problem can be solved and can be helpful to generate a revenue resource. Same value added product are discussed blow

Mango peel: It is a major by product of mango processing industries which contribute about 15-20 % (ajila and rao, 2010, Breth & Raghuramiah, 1976) of total mango weight that is generally discarded as waste. By different scientific study it has proved that mango peel have various type of phyto-chemical like polyphenols, antioxidents, carotenoids, dietary fiber, vitamin-C and E. so peel can be used in different pharmaceutical as well as nutraceutical industries to manufacture various type of nutritional and health benefit supplements and medicine respectively. Ajila *et al*.,(2010) used mango peel as a ingredients in macaroni at different proportion (2.5,5,7.5 percentage) and reported it effect on various characteristics of macaroni including firmness, sensory and nutraceutical properties. They reported that polyphenols (0.46 to 1.8mg/g), dietary fiber (8.6 to 17.87%) and antioxidants exhibit improved in macaroni with incorporation 7.5% peel power. Avhad *et al*., (2017) develop nectar by used of mango peel power in four treatments in different amount (0.5,1,1.5,2 mg/100ml) and reported that T_2(1mh/100ml) have better acceptability compare to other treatments. Ashoush and Gadallah (2011) prepared biscuits using mango peel and kernel in different level and observed physical, sensory, antioxidant and rheological properties reported that with incorporation of mango peel ash content, crude fiber and water holding capacity improved while kernel power increased fat and protein contain in biscuits than peel power. They also suggested that more acceptable biscuit was obtained by incorporation of mango peel and kernel at 10% and 40% respectively.

Mango kernel: Kernel is an important by-product of mango which comprised about 45-75% part of mango stone (Maisuthisakul and Gordon, 2009). It is rich source of various type of phyto-chemical such as polyphenols, fat and protein. Soong et al.,(2004) reported that kernel of mango have antioxidants and phenolic content. They also reported that kernel have various type of phytosterols. Shabeer *et al*.,(2016) prepared biscuits by blending wheat flour and mango kernel

powder in different proportion(5,10,15,20,25%) and reveled that biscuits prepared with 15% and 20% kernel flour was best in sensory parameters. Yantti *et al*.,(2014) analyzed nutritious value of Totapari variety of mango they said that kernel seed of this variety cantina 7.53g/100g protein,11.45g/100g fat,170mg/100g calcium, 210mg/100g magnesium, 368mg/100g potassium and 421K.cal/100g energy.Ashush and Gadallah (2011) also used mango kernel for biscuits preparation they blend mango peel and kernel flour in different proportion and finally concluded that 10% mango peel power and 40% kernel power are best for biscuits preparation with wheat flour.Khuram *et al*., (2014) also try to prepared mango and kernel blend flour biscuits by mixing at 10% and 5% peel and kernel flour respectively and said that both ingredient improve nutritious status specially dietary fiber and antioxidants contain of biscuits.

Conclusion:

Mango fruits can be process into a large number of value added products. Processing of value-added mango based products is affected by a number of factors that have prevented industry and market expansion. Mango processing waste also can be profitably converted into form of valuable products. Generally mango is being consumed for long time as fresh and also used as a raw material for pulp and also great demand in the form of value-added products such as beverages (juice and nectar), jams, chutneys, pickels, slices, flakes, mango powder etc. United efforts are therefore, needed to overcome these various constraints to the processing industry and seasonally fluctuation in price, high cost production and production glut affect the supply of mango. Though India is the major producing country of mango but still our country suffers from 20-25% losses. These losses can be controlled by improving post-harvest management and practices like better packaging and storage, preventing ripening, thermal treatment and proper marketing chain.

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