Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 1699-1709
Received: 12-09-2020
Accepted: 18-10-2020

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Fruit Leather: Preparation, packaging and its effect on sensorial and physico-chemical properties: A review

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DOI: https://doi.org/10.22271/phyto.2020.v9.i6y.13192

Abstract
Fruits are the most important part of the diet. They are rich in vitamins, proteins, minerals, phyto-compounds and other essential components which play a major role in developing immunity. Although India being known as the second ranked country in the fruit production but results in the 15-20% of post harvest losses. And so processing and value addition of the fruits is much more necessary to prevent this loss. Fruits are processed to juices, jellies, jams, nectar, wine, leather etc and other such value added products. Leather is one of the best product which is liked by the people of all age kinds. Leathers were made either by single fruit or by blending of different fruits. Different fruits like Apple, Pineapple, Papaya, Mango, Sapota, Grapes, Strawberry, Pomegranate etc. are used in processing of leather.The leathers were dried under different drying methods which results in variations in the quality of the leather. Studies were made by different researchers on the best proportion in blending of different fruits in the processing of mixed leather as well as effects of different methods of drying and temperatures of drying on the organo leptic as well as physio chemical attributes of the leather and also the effects of different packaging materials and storage were reviewed in this work.

Keywords: Fruit, Fruit Leather, Packaging material, Sensory attributes and Quality

Introduction

Fruits are considered to be the most important dietary component because of the availability of higher concentrations of fiber, minerals, vitamins , more especially electrolytes, phyto-chemicals as well as antioxidants (Slavin and Lloyd, 2012) [41] They provide most of the health benefits as fruits contain higher amounts of anthocyanins, flavanols and procynadins. Fruits such as grapes, berries, pomegranate helps in decreasing cardiovascular problems and fruits like citrus and apple have a medium effect on blood pressure as well as blood lipid level (Habauzit *et. al*., 2013) [21]

India is referred to as the fruit basket of the world. India ranks second in the production of fruits next to China. India produced about 6506 thousand metric tonnes of fruits. The area under cultivation of fruits is about 97358 thousand hectares (Anonymous, 2018). The tremendous production of fruits like Mangoes, Grapes, Bananas, Oranges, Pomegranates etc. provided larger opportunities for exports to many of the countries like Bangladesh, UAE, Nepal, Malaysia, Netherland, U.K., Srilanka, Oman etc. India annually loses Rs.25289-28464 crores due to post harvest losses in fruits and vegetables. An amount equivalent to 1.2% of agricultural GDP goes as losses due to lossage in Mango, banana and grapes (Sreenivas Murthy *et. al*. [47, 48]. The studies under Indo-US project on post harvest lost assessment of fruits and vegetables (1986-91) reported that the post harvest loss in case of Mango ranges 5-36.7%, 11-14% in banana, 16-23% in citrus and 2-12% in guava. These losses can be minimized by processing and preserving the fruits into different value added products like leather, juice, nectar, jam, jelly, wine, toffee, puree, pulp, sliced products, canned products etc. Fruits consist of higher moisture content and are generally acidic and is easy in processing and it offers a variety of aroma, flavour, texture and colour to our diet. Processed products of fruits have a lot of export potential. The main objectives of processing are to preserve flavour, colour, texture and nutrition which prolongs the storage life of fruits which are perishable.

Due to the deficiency of the skilled manpower, poor cold storage facilities, inefficient post harvest management and minimum technological interventions, India contributes only 1 % of the global market of fruit processing industry. One of the factors that show negative effect on the economic value of fruits is that they have a shorter shelf life.

20-25% of the fruits that are harvested resulted in the lossage due to the activity of the microbes (Droby, 2006 [9]. Fruits are generally exposed to contamination by microorganisms when contact with the dust, soil, water and during the process of handling, harvesting, post harvest processing. This results in harboring of a broad range of microbes which includes human and plant pathogens (Eni *et. al*., 2010) [11].

The best way of conserving of the fruits is processing them into leathers. It was believed that Persian Empire is the origin of fruit leather. In Turkey it was termed as 'Pestil', in Armenia it was termed as 'Bastegh', in Syria as well as in Arab countries it was termed as Qama and Aldeen where as in US it is termed as 'Fruit roll or Fruit leather. The first contribution (1976) on the fruit leather preparation was first given by the extension services of different universities in USA. Scientific works on this topic was first started in the year 1978 from then the leather gained the attention from the research field.

Fruit leathers are the restructured fruit made from concentrates of mixture of fruit juices or fruit pulp and other materials after a drying process. The fruit leathers made of pulp are most widely preferred by the consumers as they consists of good quantities of carbohydrates, fibers, vitamins, antioxidants and minerals.

Fruit leathers are the dried and dehydrated products. These are chewy, tasty and dried fruit product. These are made by spreading the pulp on the stainless or aluminium trays and then drying or dehydrating them at a particular temperature such that the moisture content reaches up to 15-20%. The drying can be carried out by different methods like solar drying, cabinet drying, hot air drying, microwave oven drying, vaccum drying, freeze drying. After drying the leather is then peeled out from the trays and are then packed. Because of its novelty and being more attractive in its form and on the other hand as it does not require refrigeration and so it was considered as the best way for incorporation of fruit solids and is mostly preferred by all ages especially for kids and adults. The leathers are also prepared from the left over ripe fruits. Basically fruit leather is the fruit without moisture content in it. Many dehydrating techniques eliminates water or moisture content from the fruit pulp so that the product lasts long. It is economical that allows to buy fruits in bulk and ensures that it won't go bad.

Health Benefits of Fruit Leather

Source of nutrients

Fruit leather is the product in which all the nutrients present in the fruit are conserved for a long time. It is generally packed with the nutrients such as fiber, minerals, calcium, phosphorous and iron. The high content of nutrients ensures one's health and combat fatigue and other health problems.

Supports digestion

It comprises of numerous fibers and so they assist in easy digestion.. It cleanses the digestive system and prevents constipation and other bladder problems. It also plays a major role in flushing out of toxin from the skin and improves skin health.

Assist in losing weight

The fruit leathers are the smartest choice to shed off the weight. The fiber content present in the fruits makes one feel full for longer time period. It is also better alternative for sweet tooth crave. The effective control in intake of carbohydrates and sugars automatically supports healthy weight loss.

Fruit leather Preparation

The fruits like apples, apricots, berries, cherries, nectarines, peaches, pears, pineapples, plums and strawberries were rated excellent in leather making. Other fruits like blueberries and cranberries in combination can provide a good end product. The leathers can be made either by addition of ingredients or without the addition of ingredients.

Additives or Ingredients

Due to the presence of lower molecular weight compounds in the pulp such as sugars and organic acids, the leathers show some sticky nature to the fingers, teeth, palate and to the packaging material. So in order to overcome this problem, the compounds of higher molecular weight like maltodextrin, gums, starch and pectin are added. Maltodextrin when added to the pulp reduces the stickiness during the processing and packaging (Valenzuela and Aguilera [51] Addition of the maltodextrin results in the retention in the adhesive force between the leather and the packaging material as observed in the case of apple. One more added advantage of addition of maltodextrin is that it affects the hygroscopicity of the apple leather. Fruit leather having maltodextrin absorbs less water [51]. Most of the gelling agents like pectin, starch, gelatin, alginate are generally added to the leather which improves the texture and also results in decrease in the drying rate. Addition of gelling agents like pectin, guar, gum, carboxymethyl cellulose, guar acacia results in the reduction in the drying rate and also increases the product shelf life and rupture energy (Gujral and Brar [18]

Browning of leather is a major problem in fruit leather making process. It has been observed that fruit leathers tend to exhibit browning after few hours of leather preparation. Addition of browning inhibitors like sulfite, citric acid, extract of maqui berry resulted in decreased browning reactions in quince, papaya, apple leathers. In some cases, the compounds of lower molecular weights like glucose syrup, sucrose and pro biotics like oligo fructose, polydextrose, fructans etc., though they cause stickiness, are used in improving the sweetness. The effects of insulin, *agave fructans*, oligo fructose and their mixtures on the sensorial and physiochemical properties of apple leather were studied by Gonzalez Herrera [15] Addition of *agave fructans* resulted in the leather with probiotic potential, low hardness and higher consumer acceptability.

Fruit Pulp/concentrate

Fruit pulp or concentrate is the basic ingredient for fruit leather making. Leathers can be made either with the pulp or the juice concentrates of the single fruit or by blending the two types of fruits in different concentrations.

Flow chart for the preparation of Fruit Leather

Selection of good quality fruit
↓
Washing
↓
Peeling
↓
Cutting into small slices
↓
Stewing
↓
Blending
↓
Addition of ingredients
↓
Spreading of puree on the parachment paper
↓
Drying
↓
Cutting into slices and packing

Apple - Black current Leather

Apple is typically a temperate fruit crop which is a potential source of iron and vitamins. Apple finds its place in a standard prescribed diet and has a famous saying associated with this fruit "an apple a day keeps the doctor away". Similarly black currant is rich in antioxidants and is good for health. Apple and Black currant leather can be successfully prepared using apple pulp, juice and black current concentrate mixed in different proportions along with additives (L.M Diamante [27] Fruit leather made by addition of apple pulp, apple juice and black currant concentrate in the ratio of 30: 6: 2 and dried in hot air dryer at a temperature of 70 ℃ with the air velocity of 0.2 m/s was reported to be most acceptable to the consumers based on the organoleptic evaluations as well as physio chemical properties.

Guava -Papaya Leather

Guava and papaya, both are important tropical crops and rich sources of nutrition. Efforts were made to prepare guava and papaya fruit leather by blending the pulp in different proportions (R. Kumar [38]. Fully mature and ripe fruit from papaya variety CO-1 and guava variety Allahabad Safeda were selected. In the first two treatments papaya and plain guava were taken as a control T_1 (100:0), T_2 (0:100) and in further treatments they were blended in different proportions T_3 (80:20), T_4 (60:40), T_5 (40:60), T_6 (20:80). The KMS 0.2% is used as the preservative and further the brix and the acidity are adjusted to 25 degrees brix and 0.5%. The samples were allowed to dry in the cabinet dryer at 60℃ till the moisture reaches 15-20%.It was observed that drying rate of plain papaya was lower than the plain guava. And the plain guava leather was good in taste, texture, flavour and acceptability than plain papaya leather. It was also observed that protein content increased in the leather when blended with guava. The colour was most bright in the guava pulp than papaya. Non enzymatic browning and mould count was also higher in the papaya leather than guava. Among the entire blend made from the T_4 was reported to be the best one and is widely acceptable by the consumers. It was good in organoleptic and physiochemical properties. It was observed that there was higher increase in the appearance of the papaya blended with guava leather when compared to the plain papaya leather.

Mango - Sapota

Mango is rich source of Vitamin C, A, riboflavin, Thiamine, Iron, calcium, potassium and fibre. Sapota is the most consumed fruit worldwide. Mango -sapota leather was processed by R.F. Chavan [36]. It prevents the digestive cancer, liver and colon cancer, heart diseases etc. Both are very good fruits in the health point of view. The leather is made by blending of mango and sapota in different different concentrations C0 (0:100), C1 (10:90), C2 (20:80), C3 (30:70), C4 (40:60) in addition of sugar (20%) and citric acid (1%) to it. All the samples were subjected to drying in the hot air dryer till it losses moisture. On analyzing the leather based on the organolpetic and physiochemical properties the leather made out of C3 treatment was observed to be the best one. It is higher on colour, taste, flavour, protein content and in sensory qualities etc.

Papaya-Apple

Papaya and apple are the rich source of vitamins and minerals. They together make the good diet. The papaya and apple were blended in different concentrations C0 (100:0), C1 (90:100), C2 (80:20), C3 (70:30) and C4 (60:40) in addition of sugar (30%) and citric acid (1%) by Chavan Ramesh [6] and a good quality leather was made out of it. The samples were dried and later analysed for organoleptic and physico-chemical properties. Among all the samples analysed the sample made from the treatment C3 was considered to be the best quality leather and it was highly acceptable by the consumers. It was also observed that excessive blending of apple pulp in papaya pulp was not acceptable as it resulted in decrease in colour, flavour and taste

Apple - Apricot leather

Apple and apricot leather was processed by Bains [3] using the puree which contains apple pulp of 82%, apricot puree 16.5% and apple juice 1.5%. The sample was then standardized on the stainless steel trays and is dried in the cabinet dryer maintaining the temperature of 85 ℃ and 5% of relative humidity for about 6 hrs. A two stage operation produced good quality of leather which means the leather is dried twice initially at 102 ℃ for 2 hours and is followed by finish drying at 85 ℃ for 3.5 hrs.

Banana, Pine apple and Apple Leather

The fruits like apple, banana, pineapple have higher perishability due to the presence of the higher metabolic activity and so they are further processed to jams, juices, jellies, pulps and leathers. The mixed fruit pestil was made by the Blessing.I [21] using different proportions of Banana, Pineapple, Apple S443 (20:40:40), S314 (60:20:20), S819 (40:40:20) and other added ingredients. The samples were dried at a temperature of 60 to 80℃ for about 10 hours. It was observed that S 443 is higher in moisture content (4.14%), fat content (2.32%), acidity (5.6 g/l) and in volatile acidity (26.60 g/l). S 819 is higher in TSS (20.07 g), TTA (0.42 g/l), ash content (1.20%), protein (0.71%), CHO (84.77%), S 314 is rich in fibre content (12.47%) and is least in S 819. Appearance was recorded highest in S 314 (7.35).Texture was reported highest in S 443 and S 819.Taste was reported to be highest in S819 (7.39).

Apple Leather

The apple leather was processed by Leiva Diaz *et al.*, by using Grany smith variety. Firstly the apples were washed, peeled, sliced to 14mm dices and then blanched to 600 seconds in order to avoid enzymatic browning, for tissue softening and for equal distribution of pectins before gelation. Later 79gms of apple puree is taken and is added with 18g of sucrose and 3g of citric acid to enhance pectin-sugar acid gelation. Further the sample is taken and is placed on the acyrlic trays and is dried in a hot air dryer at 60℃for about 3 hours. The initial moisture content in the leather is 70.6% further after drying after 3 hours it reaches to 26.9%. After the product is completely dried it is then hermatically packed and stored.

The apple leathers were processed at different temperatures by Demarchi *et al*., [8] The formulation used was similar to the leather made by Leiva Diaz except in adding powder of polydextrose (9% w/w) and micronized sucralose (0.02% w/w). The other formulation was also made in addition of extra Kmno4 (0.0063% w/w). Further samples was placed with the thickness of 6mm in the stainless steel trays and dried under tray drier at different temperatures 50, 60, 70 ℃ and velocity of air of 2 m/s. The product was subjected to drying till the moisture reaches 0.3 kg water/kg dry matter.

Apricot Leather

The apricot leather was processed by S.K**.** Sharma [42]. Firstly the good quality apricot were selected and are washed thoroughly and are further heated for about 5 to 7 minutes. Later the pulp is extracted and is then boiled on a low flame till the pulp becomes much concentrated. Further the pulp is added with different proportions of sugar (40%, 50%, 60%). Further to ensure uniform distribution 50g sugar was retained and is mixed with pectin. Later the pectin quantities is weighed to (0.20%, 0.30%, 0.40%) and is sprinkled uniformly and are further mixed. The sample is then placed with a thickness of 4-5mm in the aluminium trays and is dried under mechanical dehydrator at a temperature of 55±2 ℃ for about 6 hours.

Guava Leather

The guava leather was processed by Vijayanand *et al*.**,.** Fresh guavas were selected and tare washed, peeled and are crushed for extracting the pulp. The pectolytic enzyme Rohapect D5 L at a concentration of 0.5 ml/kg was added to the puree and is then incubated at 60 ℃. The juice was extracted from the puree after 2 hours. It is then mixed with wheat starch, pectin, maltodextrin. Later the stainless steel trays are smeared with glycerol and the puree is placed on it and subjected to drying in the hot air dryer at 50 ℃, relative humidity of 12% till 14-15% of the moisture content is reached.

The cold temperature storage and its effects on the quality attributes of guava fruit leather was studied by Babalola *et al*., Firstly the fresh guavas were selected washed and peeled and then the pulp is extracted. The pulp is added with sugar of 20% and citric acid 0.2%, and sodium benzoate of 0.1% and the proportion of puree was made upto 80%. The pulp is then boiled and cooled. Later glycerol is smeared on the stainless steel trays and then the puree is placed on the trays and is subjected to drying at a temperature of 60 ℃ for 8 hours.

The stability of storage of guava pestil in packaging materials was studied by Kumar *et al*., [49]. Fresh guavas were selected washed, peeled and further the pulp is extracted. Later the pulp is heated at a temperature of 85 ℃ to inactivate enzymes and then cooled to 45 ℃. 0.2% of potassium bi sulphite is added and mixed. The mixture is poured in the stainless steel trays and is dried under cabinet dryer at a temperature of 60 ℃ till the moisture level reaches 15-20%.

Pine apple Leather

Pineapple leather was processed by Phimpharain *et al*., [7] and its physiochemical and sensory characteristics were studied. The samples were made by adding different proportions of pectin (0.5%, 1% and 1.5%) and glucose syrup (2%, 4% and 6%). firstly the fresh pineapple is selected, stalk, leafy crowns are removed, the outer rind is peeled and the fruit is rinsed under fresh water. Later the fruit is chopped into small pieces and is then made into puree. The puree can also be stored in the bags made of plastic and is stored at -18 ℃ upto 15 days till used. The puree is heated at 85 ± 5 and is stirred with automatic pot stirrer with a speed of 57rpm for 15 minutes. Later sugar, maltodextosterone, pectin were added to it and is boiled till it becomes paste. The paste is then fed into the pestil making machine. When the paste is pressed it passes to the zone of extruder with drive ram with 2 bars of pressure and is passed through a die (27mm x 2.2mm) with 50 rpm screw speed and so the rectangular paste is obtained. The flat paste is then placed on the conveyor belt and is then cut and dried under a hot air dryer at 60 for about 10 hours till the moisture content is reduced.

Straw berry leather

Lee and Hsich processed the strawberry leather and conducted the studies to investigate the thin layer drying kinetics. The leather was made by blending strawberry puree, corn syrup, pectin and citric acid (200:40:2:1) ratios and is then placed on the aluminium trays. The layers (1.8,2.7 and 3.6 mm) are subjected to drying at various temperatures (50 ℃, 60 ℃, 70 ℃ and 80 ℃) in a oven. The drying is carried out till the moisture content reaches to 12%. It takes 80 to 600 minutes of time for different layers of thickness and temperatures. It is noted that drying rates were increased when there is decrease in the sample thickness from 1.8 to 3.6mm.

Pear Leather

The pear leather was processed by Huang and Hsieh and evaluated the physical and sensory qualities and consumer acceptability of pear fruit leather. The leather was made in 18 compositions by mixing pectin homogenously (16%, 20% and 24% w/w), corn syrup (0%, 8% w/w), water (4%, 6%, 8% w/w) at varying proportions with different concentrations of juice. The distilled water and corn syrup is mixed to the preblended mixture of the pear concentrate and is then blended with the sun bean mixmaster blender for 1 minute. The pectin is further added to prevent the formation of lumps. The second batch of 400g of sample is also blended and is then poured into the flat bottom containers. The weight present in each container is 35g and so the height of the leather is 2.85mm.The containers were left undisturbed for 1 minute so that the mixture can be evenly distributed. Later the mixture is dried by placing in the convection oven at 70 ℃ for 8 hours with air velocity of 0.4m/s.

Jackfruit leather

Cheman and Sin processed the jackfruit leather by using unfertilized floral parts of jackfruit. The unfertilized floral parts were cooked for about 60 minutes and are later made into the puree. The puree was further added with 15% glucose syrup, 25% sugar, 5% water, sodium metabhisulphite and sorbic acid. The puree was blended properly and then the mixture is placed on a aluminium foil with a thickness of 2mm. The sample is further dried at a temperature of 50 and a air velocity of 1.6m/s for about 24 hours in a cabinet drier.

The jackfruit leather was processed by Okilya *et al* [46] and studied the quality and acceptability of the jackfruit leather when dried under sun. The jackfruit was pre-treated by cutting it into two equal halves longitudinally and the central sticky layers were removed. The bulbs were scooped out and the seeds were removed. To prevent the enzymatic softening and microbial growth the bulbs were chilled before they are further processed. The pulp is then blended us8ng the blender and the pulp is further boiled in the water bath at 70 ℃ for 15 minutes. As the concentration step evaporated much off the water the drying time was reduced. Later the puree is placed on the stainless steel trays. It was further dried in a solar dryer (36.7 ℃ for 3 days), convection dryer, cabinet dryer till the moisture content reduces and reaches till 18.50%, 14.79% and 18.85%.

Mango Leather

Gujral and Khanna [20] processed mango leather and conducted study on the effect of soy protein concentrate, skim milk powder as well as sucrose on the behaviour of drying, colour, acceptability and texture of the pestil. The fresh healthy fruits were selected washed and peeled. The pulp is extracted and is boiled at 80 ℃ for 5 minutes and then cooled.0.2% of potassium metabhisulphite is added to the pulp and is sealed and stored in glass jars at 4 ℃. The puree is then placed on the aluminium trays and is dried at a temperature of 60 ℃, air velocity of 3.5 m/s in the cabinet dryer. Skim milk powder, Soy protein as well as sucrose was added to the puree. Addition of these ingredients resulted in reduced drying rate and extensibility and energy. They observed that the sample which contained the sucrose and skim milk powder of 4.5% were mostly acceptable.

Effect of hydrocolloids on kinetics of dehydration, colour and texture of leather made of mango was evaluated by Gujral and Brar [18]. The pulp made from the fresh mangoes and is placed on the aluminium trays and is dried under temperature of 60± 1 and relative humidity of 15% in a cabinet dryer. Addition of hydrocolloids resulted in decrease in the drying rate during the initial time later found to no effect.

By incorporating defatted soy flour in processing of enriched mango pestil by drying in microwave was studied by Pushpa *et al*., [16] Firstly the pulp was extracted and is added with sugar (50g), lime juice (2g), corn flour (5g) and 1:1 ratio of defatted soy flour with 51.8% of protein as well as skim milk powder were blended to the pestil in various levels or proportions like 10%, 15%, 20% and 25%. The puree was heated at 80 ℃ for 15 minutes in microwave at varying levels of power till the content of moisture reaches 15%.

Mir and Nath conducted studies on the sorption isotherms of mango pestil. The fresh mangoes were washed, peeled, pulped and later the puree is boiled at 93 ℃. The pulp was then mixed with sugar, citric acid of 0.6% and potassium metabhisulphite of 1734 ppm. The pulp was then spreaded evenly on the aluminium trays and is subjected to drying in a cabinet dryer at 63±2 ℃ for about 14-16 hours.

The impact of storage and drying on physio chemical attributes of mango pestil were studied by Azerdeo *et al*., [1]. The mango leather was made with the mango puree which was dried under oven at 60-80 ℃ till the content of moisture reaches 15-18%.

Papaya Leather

Chan Jr. And Cavaletto conducted study on the dehydration and storage stability of papaya leather. The leather was prepared by selecting the fresh papaya and boiling it for about 1 minute. Later it is peeled, skin and seeds are removed. The pulp was acidified until the pH was 3.5.The puree is heated so that the enzymes get inactivated. Later the puree is stored at -18 ℃. The puree is added with 10% sugar at 4.9 kg/㎡.The puree was then placed evenly on the Teflon coated pans. Sodium bisulfite was added to it. The puree was dried in the oven till it reaches moisture content 12-13%.

Babalola *et al* [45] processed pawpaw (papaya) leather. The fresh fruits were selected washed and peeled. The pulp is extracted and sugar of 20%, citric acid of 0.2% and sodium benzoate of 0.1%. Puree is then boiled and is cooled. Later it is placed on the trays and then dried at -60 ℃ for 8 hours.

Grape Leather

Maskan *et al.*, [2] processed the grape leather by drying it under sun as well as in hot air oven. Firstly the fresh grapes were washed and then seeds and peels were removed. $CaCO_3$ of about 70% was added to it. Then it is heated for some time as it causes inactivation of enzymes which results in change in colour. Clarified juice is formed by filtration and separation of the calcium tartarate. The total juice was divided into two parts. The 3/4 th part of the juice is again boiled for 30 minutes by continues stirring to obtain the concentrated juice. Remaining 1/4th part of the juice is added with the wheat starch and is boiled for 4 minutes till it reaches concentration of 4g/100g of starch. Juice is further placed on the 8cm diameter disk of cloth and is dried under hot air oven or direct sunlight. The product is dried for about 14 hours till the product is completely dried.

Banana Leather

Banana is a highly perishable fruit and so processing it into leather is the most useful way. W. Setia *et al* [53] Processed the banana leather by using three varieties of bananas raja sereh (A), muli (B) and white kapok (C). The bananas were boiled for 8 minutes. It is peeled further and is then blended into the puree. The purees were divided into two parts and in one part polysaccharide carrageenan are added and the other part is left without adding carrageenan. It is then dried under a temperature of 60 for 12 hours. And the samples were analyzed for physio chemical properties. It was observed that addition of carraageenan affected the texture of the leathers. The leather was dried and is packed.

Drying or Dehydration

Drying or dehydration is the process of removal of moisture from the product. Presence of higher moisture content results in increase in the microbial activity and results in spoilage of the product. And so the retention of the moisture content by various methods results in increasing the shelf life of the product. Drying slows down the activation of enzymes but does not deactivate them. The changes in the colour, texture, flavour, odour and physio-chemical properties of the product during drying is due to many chemical and biochemical reactions. The product subjected to drying results in crystallization, puffing and shrinkage. On the other hand exposure of the product to longer period of drying also results in the damage of the product.

Drying is the technique in which proper supplementation of the heat takes place to the wet material so that the moisture in the material undergoes vaporization. There are varied dryers based on supplementation of the heat for drying of fruit leathers. They are -

1. Conduction drying - Indirect dryers.
2. Convection drying - Direct dryers

3. Radiation drying - Micro wave or radio frequency of electro-magnetic fields.

Sun drying, Solar cabinet drying, Vaccum drying, Microwave oven drying, Spray drying, Freeze drying, Hot air drying are some of the types of drying used in drying of leather. Due to the presence of these modern dryers it is possible to dry the product at any time without being dependent on the climate conditions. The duration of the drying is mainly based on the type of the dryer or dehydrator and on the nature of the product. Mostly the fruit leathers are dried at a temperature of 30 to 80 °C for upto 24 hrs till the moisture content reaches to a level of 15-20%.

Drying should be carried out in a appropriate manner. If not the damage caused will be irreversible and mainly effects the product quality which results in non consumable and non marketable of the product.

The different methods involved in drying are listed below

Sun drying

This the natural method which requires zero power supply and is eco friendly. It requires very low investment and so it is most widely used. The puree made from the different fruits is placed on trays with the very low thickness and is placed in the areas which receive direct sunlight. The trays are covered with the polythene cover on the top in order to prevent the settlement of the dust particles. The puree is dried till the moisture content reaches 15-20%. The leather made out of sun drying have a very bright colour and good appearance. The loss of nutrients through sun drying is also very less.

Solar Cabinet drying

As sun drying is the most ancient technique the drying technique developed in today's modern world is solar cabinet drying. It is the most economic way of drying as no other source of conventional energy is required. The cabinet dryer is of great use in many of developing countries such as military feeding and space formulations. The main principle of cabinet dryer is based on the green house effect where the heat from the sun is trapped and results in increase in the temperature inside the chamber which results in fast drying.

Vaccum Oven

It is the example of conduction drier. It consists of the jacketed vessel to resist the vaccum within the oven. It consists of shelves which provide larger area for conduction heat transfer. The oven is connected through the condensor and liquid reciever to a vaccum pump. The drying takes place at a low temperature and so the risk of oxidation is less and so colour, texture and flavour of the leather are more improved compared to air dried leather. It acts more efficiently in removing water from the products. The temperature can be maintained to 25-35 °C.

Microwave oven

It is more efficiently used. It is the most rapid method of drying. Microwaves are produced by the electronic device known as magnetron. Microwave energy can be reflected into a drying chamber through the window. The heat is distributed uniformly on to the leather and the penetration of microwaves into the leather results quick drying of the product. The highest temperatures are maintained in the microwave and so it shows much affect on loss of the colour and nutrients.

Freeze drying

It is the process in which the water is frozen followed by its removal from the sample. The main principle of freeze drying is the process called sublimation where the water passes from solid state to vapour state without passing through the liquid state. Firstly the sample is subjected to freezing till it becomes ice and then it is subjected to the vaccum so that sublimation takes place and then later the samples are freeze -dried and is stored. It provides longer shelf life.

Hot Air drying

The trays are filled with the samples and are exposed to the circulated hot air in the cabinet. The movement of the air over the product is with higher velocities so that the heat and mass transfer will proceed more efficiently. The hot air removes the moisture from the leather and results in drying of the sample.

The different methods following different temperatures shows different effects on the physio chemical as well as organoleptic properties of the leather.

Senem Suna *et al* [39] processed apricot leather and made their studies on the changes in the organoleptic as well as physio-chemical properties of the leather which is dried under different methods like sun drying, Vaccum oven (55 °C) and Microwave oven (90 W). The drying time of microwave oven was 55 mins and is observed to be the fastest drying method which is then followed by sun drying of about 345 min and then vaccum oven drying which took 450 mins. The moisture content of the leather dried under different methods was noted to be in between 13.12±1.35 - 14.39±0.41 gm/100 gm. At the end of the drying period remaining weight of the samples was 51.1, 53.3, 52.2 for sun dried, vaccum oven dried and microwave. The hydroxymethyl furfural (HMF) of micro wave, vacuum and sun drying is noted to be 13.62 ± 0.78,19.39±0.26 and 45.64±1.29 mg/kg. Total phenolic content was of the samples lies in between 110.03±0.72 - 121.2 ±6.19mg GAE/100gm.The decrease in the antioxidant activity of sun dried, microwaveoven and vaccum oven dried samples are noted to be 59.80%, 39.23% and 19.15%. Colour is the most important parameter which determines the preference of the consumer. Yellowish orange is the colour of the pestil. Values of L*, a* and b* after the three drying methods were in between 44.37±0.85 - 49.06 ± 0.38, 16.22 ± 0.52 - 20.81±1.07 and 33.81±1.64 - 41.76 ± 1.22.Among all the drying methods the sun dried sample showed good results in sensorial as well as physio chemical analysis.

Senem suna [40] studied the effects of microwave (90 W and 180 W) for about 16 and 60 mins, Vaccum (60 and 70°C with 200 and 300mbar) for about 85 and 230 min and hot air drying with a temperature of 60 and 70°C and relative humidity of 20% and for a time period of 116 and 175 mins on different characteristics of leather like total phenolic content, antioxidant capacity and colour. Vaccum drying was observed to be the longest time taken process while microwave takes the shortest time. The drying rates ranges from 0.01g water/g dry matter at 60°C-200 mbar vaccum. In a micro wave power level of 90 W drying a constant rate period varied from 0.6 to 1.4 g water/g dry matter and there is decrease in the drying rate for power level of 180 W. Chroma value is used to predict the intensity of colour. The highest result was noticed in the vaccum dried sample (24.48 ± 1.19) and the lowest value (24.48 ± 1.19) was noticed in the hot air at 60°C. The initial total phenolic content of the sample before the drying was noted to be the highest 396.62 mg GAE/100g dw ($p<0.05$) and the phenolic content after drying was noted to be 50.59% as of hot air and 60.65% by micro wave. The antioxidant capacity was measured by three methods namely 2-diphenyl-1-picrylhydrazyl (DPPH), Copper reducing antioxidant capacity (CUPRAC) and Ferric Reducing Antioxidant Power (FRAP). Microwave 180 W (125.77±6.00) was found higher than the other samples in CUPRAC asay. DPPH analysis of pestils was found to (6.87 ± 0.01) in micro wave 90W,Vaccum 70 - 300 mbar (6.81 ± 0.07) and vaccum 60 - 300 mbar (6.78 ± 0.01) revealed highest results. In FRAP analysis microwave 90W (23.19 ± 0.54) was significantly higher. Overall acceptance of the leather was found best in the vaccum treatment followed by microwave.

Ghada. H. Abdal Rehman *et al*., [13] carried out quality and sensory characteristics of tamarind leather which is dried under different methods like cabinet drier (70 °C) and solar drier (54±4°C). The results showed that the moisture content of the sample dried in the cabinet dryer was lower (52.2%) than the solar drier (7.95%). The leather dried by cabinet dryer was darker (0.138 ± 0.01) than the sample dried by solar drying (0.043 ± 0.03). The rehydration values of the samples was (1.78) and (1.44) for solar and cabinet dryers. The drying ratios was 3.5 and 3.25 for the leathers dried by cabinet and solar driers. The ph values of samples dried by cabinet and solar driers were 2.78 ± 0.03 and 2.81±0.03. The titrable acidity values for cabinet and solar dried leathers were 6.86 ±0.03 and 7.83 ± 0.39.Overall the solar dried leathers gained highest scores than the cabinet dryer.

Chavan Ramesh Fulchand *et al*., processed papaya-apple leather and further carried out his study to evaluate the vitamin C retention in the pestil at different temperatures (55 °C, 65 °C, 75 °C) and different duration (14-16 hrs, 10-12 hrs and 8-10 hrs) Results were noted that the apple papaya puree was initially 31.23 mg/100gm and later it reduced when dried under different temperatures. The vitamin C retention decreased after drying at different temperatures are noted as (23. 42, 21.86, 17.18mg/100gm).

Demarchi *et al*., conducted his studies on effect of different drying temperatures 50 °C, 60 °C, 70 °C in the hot air drying on the retention and rate of drying of the antioxidannts in pestil. The results showed that the lower retention (6-16%) of capacity of antioxidant in the apple leathers was noted and then gradually reduced with the rise in the air temperatures though during the shorter periods of drying. The higher activation energy for the losses of antioxidant (above 31kj/mol) when compared to drying was evaluated mathematically.

The acceptability and physiochemical characteristics of durian leather when dried under different dryers and different drying methods as well as their effects on the leather was studied by Che Man *et al*.,. It was noted that the most acceptable taste was attained in the oven drying when dried at 52.24°C for 11.63 hours, and good texture was attained at 52.5 °C for about 9 hours. Good appearance and aroma and was attained at 50.63 °C for 12 hours and 51.7 °C for 12.58 hours. The overall acceptability was attained at 50°C for 12.75 hours. In the cabinet dryer it was noted that most favourable conditions was 47.50 °C for 10 hours,49.71°C for 13.50 hrs and 52.42°C for 10.42 hours helps in attaining most acceptable texture, aroma and taste. The better conditions like 52.50 °C for 10 hours and 53.81°C for 7.71 hours helps in attaining good appearance as well as overall acceptability. It was also observed that the cabinet dryer took less time in drying.

S.M. Roknul Azam *et al*., [44] conducted their studies on the quality attributes of peach leather dried under different drying methods. The four drying methods like hot air drying, micro wave-assisted hot air drying, infrared drying, hot air assisted radio frequency drying and their effects on the peach leather quality were evaluated. The drying was conducted at a temperature of 70, air velocity of 1.0m/s and at fixed power level pf 4w/g for RFD, IRD and MWD. Some of the quality parameters like Moisture distribution, colour, texture, re hydration ratio, micro structure of leather were analyzed. The results stated that the samples dried under MWD took the shortest time to dry (180 mins) which is then followed by IRD (210 mins), RFD (210 mins) and AD (300mins). The sample dried under IRD gave the best results in flavour and microstructure. The taste and odour were analyzed by the sensory tests using electronic tongue and electronic nose. The tests revealed that the samples dried under IRD produced the best quality among all.

Fatih Mehmet *et al*., [12] Conducted their studies on pomegranate leather dried under vaccum, cabinet and open drying conditions to monitor the drying kinetics together with bionutrient degradation of the leather. Drying conditions, thickness of the product and temperature had influence on the drying rate and final quality of the product. In terms of the drying kinetics and quality of the product vaccum drying has highest drying rate with higher conservation of anthocyanin, ascorbic acid and phenolic content that is connected to faster drying condition and oxygen deficient medium.

Guine [17] worked on pear leather drying under different drying conditions i.e. by direct sun exposure and in a ventilated drying chamber at a constant temperature of 30 degree Celsius. Bulk and the particle density as well as porosity variations during different drying conditions were identified. The model parameters were very similar in the two situations and the evaluation of the porosity was also similar. Further, it was possible to conclude that the pear leather developed relatively low porosity during drying as a consequence of the slow drying rates used in both situations and high degree of shrinkage was observed. The porosity of the food changes during drying which depends on the composition and in particular the initial moisture content as well as size and drying conditions used. It was concluded that two drying methods tested were considerably equivalent related to leather structure development, instead of being different. The estimated parameters was same in both the dryings as well as in porosity. Further it was able to conclude the pear leather showed low porosity during the process of drying and as the consequence of drying rates was slow the degree of shrinkage was high.

Packaging Material

Packaging material play an important role as it plays a main role in storing the product and to travel safely for long distances and still be complete till the consumption time The covering materials should also be able to need some of the requirements like cost of material, environmental and social consciousness and regulations on pollutants etc. High density polyethylene, Polypropylene, Low density polyethylene, Poly ester, Butter paper, Aluminium foil are some types of the packaging materials used in the packing of the leathers. Different materials have different degrees of strength and elastic properties and different storage abilities.

Roles of Packaging material

The packaging material prevents the product from getting deteriorated and also increases the shelf life of the product by maintaining its quality as well as shelf life. It protects the product from three major effects namely chemical, physical and biological.

Chemical protection: The packaging material minimizes the changes in the composition of the product which is effected by the influences of environment like exposure to gases exposure, moisture or light exposure etc.

Biological protection: The packaging material provides a barrier to prevent the entry of microbes and other insects, thereby preventing disease and spoilage.

Physical protection

It acts as a shield and protects the product from the mechanical damage. It also prevents the product to resist impacts, crushing and damages.

The innovative packaging material also helps in boosting up of the sales in this competitive environment.

Effects of Packaging Material and Storage

Irwandi *et al*., [26] evaluated the effects of types of materials for packaging and their effects on physio chemical, biological and sensory attributes of durian fruit pestil during the period of storage. Four types of materials used for packaging in the study -laminated aluminum foil (LAF), low density polyethyelene (LDPE), Polypropylene (PP), High density polyethylene (HDPE). And the experiment was taken out for about 3 months at the room temperature. They observed that the lowest retention in the water activity and change in the moisture content was found in LAF. And so it maintains the desired textural characteristics of the leather. The highest change in the moisture and water activity was found in LDPE. The non enzymatic browning of the leather was affected by the packaging material and storage time. The lowest decrease in the colour quality was found in LAF and the highest degree of browning was found in LDPE. The samples packed by LAF maintained the well desired texture while the LDPE packed samples has highest increment in hardness upto 8 weeks. The microbial growth is affected by both packaging material and storage time. The growth of bacteria, moulds, yeasts were inhibited by LAF.LDPE packed sample resulted in highest increase in microbial counts. The organoleptic properties was given lowest score to the samples packed in LDPE and the highest scores was given to samples packed by LAF. Overall the four packaging materials were acceptable organoleptically.

The storage stability of four packaging material in guava leather were studied by Kumar *et al*.The four types of packaging materials used in this study are-Polypropylene (PP), butter paper (BP), Aluminium foil (AF) and Metalized polyester polyethylene (MPP) under the low temperature (10℃± 1℃). It was observed that the content of moisture in the sample reduced when stored under ambient situation, and increases when stored under least temperatures. Minimum loss of moisture was observed in the samples packed in MPP and AF. Acidity content increased in the guava leather during storage. The samples packed in four packaging materials resulted in increase in the reduced content of sugar when stored under ambient and low temperature conditions. It is observed that leather packed in MPP contains high nutrients and reduced count of microbial activity. Under both low and ambient temperatures. Polypropylene is used in increasing the storage life for 1 to 2 months. Packing in aluminium foil was easy for usage but during handling the pin hole formation made it not suitable for leather packing.

The material of packaging as well as stability of storage of guava fruit leather were studied by Vijayanand *et al*. And for comparison mango fruit pestil was made. The leather was covered with BOPP (biaxially oriented polypropylene) and PP (polypropylene). The water vapour transmission rate of polypropylene is 6×10^{-3} kg/m2/dat, 90%RH, 38∘C whereas 35×10^{-3} L/m2/d is the oxygen transmission rate (OTR) at atmosphere 25ºC. The water vapor transmission rate of polypropylene oriented biaxially is 4×10^{-3} kg/m2/dat, 90%RH, 38∘C and 2.5L/m2/d is the oxygen transmission rate at atmosphere 25ºC with 90% relative humidity. The textural characteristics are similar in both guava and mango bars during initially and after storage at 25. After 60 days of storage the non enzymatic browning increased in both the bars. The overall acceptability of mango and guava samples stored in PP and BOPP reduced by the end of 60 days of storaging. However mango and guava samples stored in PP and BOPP were accepted sensorily when stored at 27℃ and relative humidity of 65% for about 90 days and when stored at temperature of 38℃ and 92% RH for about 30 days.

Pawase *et al*., [32] processed the mixed fruit bar using Fig, mango and papaya with addition of other ingredients like sugar and citric acid and studied the storage period of the fruit bar which is packed by using different packaging materials like HDPE, LDPE, Aluminium foil and PET jars which leads to some physical and chemical changes. It was noted that the leather covered in HDPE and LDPE resulted reduction in the colour from the start to 60 days when compared to aluminum foil and PET jars. The intensity of the change in the flavour and taste was more higher in LDPE and HDPE on comparision with PET jar and foil. The textural changes was less in aluminium foil when compared to LDPE and HDPE. The minimum reduction in overall acceptability during the 60 days of storage was observed in aluminium foil and PET jar. Hence it was later decided to wrap the leather in aluminium foil inorder to maintain colour, texture, flavour and taste of the product.

MBAEYI-NWAOHA IE *et al*., [29] blended African bush Mango and sour sop fruit in different proportions by mixing different ingredients like honey and citric acid. It was heated under the temperature of 70-80 inn a water bath till it solidifies and later it was poured in the greased tray and is heated upto 60 for 8 hours in the oven. It was later packed in different packaging materials like LDPE, HDPE and Aluminium foil and was later evaluated for organo leptic. micro nutrients and microbial count. It was observed that the microbial count increased during the storage. The highest was noted in HDPE and the least was noted in LDP. After 4 weeks of storage it was observed that the titrable acidity increased in the samples packed in LDP marking the highest and least in HDP. The ph of the samples decreased, when packed in LDP having the highest and HDP having the least. The sugar level was reported to be highest in the samples stored in LDP and least in HDP.

Henriette MC Azeredo *et al*. processed the mango leather with no added preservatives and evaluated the stability of storage and acceptability. The puree was made from the fresh mango pulp and is placed on the petri dishes and is dried in the oven based on the central composite design with two independent variables: drying temperature (60-70 ℃) and puree load (0.4-0.6g at 80℃). The product was very good in flavour and was acceptable. Later polypropylene buckets were used for packaging of leathers and is then stored at 25℃. The leather with the combination of low water activity (0.62) and low ph (3.8)without adding any chemical preservatives was stable microbiologically for about 6 months

S.O. Babalola [45] processed pawpaw and guava leathers and evaluated the impact of temperature in cold storage on the attributes of quality. The guava leather was lower than the pawpaw leather in water activity, calorific content, total mould count and ph during the storage period. Good texture was observed in guava leather. The scores of sensory attributes during storage revealed that the good results in overall acceptability was found in guava leather during 2 months of storage at 8± 10. The better results in smell, fruitiness, colour, chewiness and overall acceptability in it also showed good results. It was better accepted.

Quintero Ruiz *et al*., [35] studied the apple leather quality with and without metabisulphite (KMBS) during the period of storage. The apple leather without development of microbes for about 7 months period were developed by adding the formulation of KMBS. It was observed that when stored under 20℃ the browning index increased. The best fit for browning data was given by first order kinetic model. The activity of antioxidants which is determined over storage period is represented as chlorogenic acid equivalents,which decreases to 47% in the period of 7 months when stored under 20℃ in the control formulation, whereas in the formulation which is added by KMBS the losses were lower, 15.9% of the intial. The experiment for storage period of the formulation which is added with KMBS under 30℃ allowed to estimate the effect of temperature for storage by using coefficient Q10 of 16.3 for A A and 2.55 for BI. Based on the values of Q10 the storage limiting parameter at or below 20℃ will leads to browning.

Conclusion

Fruits are the good source of minerals, vitamins, phytochemical compounds and many other such essential components which are major part of our daily diet. Consuming fruits daily results in building up of the best immune system and keeps the diseases at a distance. India is the major producer of the fruits and vegetables among the other countries. In order to avoid the post harvest losses the produced fruits are further processed into different type of value added products. Leather is one such product which is liked by everyone. The leather is prepared by single fruit or by blending of different fruits. Leathers are made by using different types of fruits like Guava, Apple, Mango, Banana, Apricot, Papaya, Pineapple, Kiwi, Grapes, Strawberry etc. The leather is made by washing, peeling and pulping of the fruits and then addition of ingredients like sugar, honey for taste KMS, citric acid to prolong the shelf life, maltodextrin, wheat starch, pectin and gums to prevent the stickiness of the leather. The pulp is then placed on the greased trays and is then dried till the moisture content reaches till 15-20%. Drying slows down the activation of enzymes but does not deactivate them. The change in the colour, texture and flavour is due to changes in the chemical and biochemical reactions. Many types of drying methods are used like Sun drying, Cabinet drying, Freeze drying, Vaccum drying, Micro oven drying, Hot air drying etc. From all the studies made on drying it was noted that the fastest type of drying is the Microwave oven drying which involves the usage of high temperature and the slowest type of drying is the sun drying. The brighter colour of the leather was obtained when dried under sun and Vaccum drying was noted to give the good product. It was observed that when dried under the highest temperature for the short time loss of nutrients, colour, taste and flavour was observed. After the leathers are dried they are further packed with different types of packaging materials for storing and for the safe transport for long distances. It has been observed that the quality of the product decreases when there is increase in the period of storage. Some of the materials used for packaging are PET jars, Low density polyethylene, aluminium foil, High density polyethylene, Butter paper, Polyester etc are used. Among all the lossage of nutrients and overall acceptability is less when packed in aluminium foil and PET jars when compared to LDP and HDP. And so it is better to pack in foil and PET Jars. More over moisture permeability studies has to be carried on packaging material before the storage studies. Further studies on storage also can be worked on the effect of materials of packaging on the proximate composition of the fruit bars.

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