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Srinivas T
M.Sc., Department of Food Science and Technology, Lovely Professional University, Phagwara, Punjab, India

Darshan G
M.Sc., Department of Food Science and Technology, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Srinivas T
M.Sc., Department of Food Science and Technology, Lovely Professional University, Phagwara, Punjab, India

Preparation, packing, sensory effect and physico-chemical qualities of fruit leather: A review

Srinivas T and Darshan G

Abstract
In this 21st century world the most significant portion of diet is fruits. Phytocompounds, minerals, proteins, Vitamin and other vital components are abundant in them, and also they play an important part in the development of immunity. Despite India's status as the world's second-largest fruit producer, it suffers from 15-20 percent post-harvest losses. As a result, substantially value addition of fruits and more processing is required to avert this losses Jellies, juices, jams, wine, nectar, leather, and some other important items are made from fruits. Leather is the most popular snack products of all ages. Leathers were manufactured from a specific fruit or combination of fruits for different flavors. Amla, Apricot, Banana, Papaya, Apple, Pineapple, Mango, Grapes, Pomegranate, Blue berry, Strawberry and other fruits are also used for leather manufacturing. The leathers are dried using various ways, resulting in differences in the nature of the leather. Various researchers conducted different studies on best combination in blending of different fruits in processing of blended leather, and also the impacts of temperatures and various drying methods on and physiochemical attributes and organoleptic of the fruit leather, and the storage capability and impacts of various packaging materials were reviewed in work.

Keywords: Fruit leather, nutrition content, drying methods

Introduction
Fruits are regarded the most significant nutritional component due to higher quantities of fiber, vitamins, minerals, particularly electrolytes, antioxidants, and phytochemicals found in them (Slavin and Lloyd, 2012) [38]. Because fruits have larger levels of anthocyanins, flavanols, and procynadins, they give the majority of the health benefits. Fruits like grapes, berries, and pomegranate aid to reduce cardiovascular issues, while citrus and apple have quite a modest influence on blood pressure and blood cholesterol levels (Habauzit *et al*., 2013) [13]. India is known as "World's Fruit Basket." India is second only to China in fruit output. Approximately 6506 thousand MT of fruits were grown in India. The total area for fruit cultivation is around 97358 ha (Aman, A. *et al.* 2018) [47]. The abundant production in fruits such as mangoes, grapes, bananas, oranges, and pomegranates created more prospects for exports to nations such as Bangladesh, United Arab Emirates, Nepal, Malaysia, Netherlands, the United Kingdom, Sri Lanka, and Oman. Post-harvest waste in fruits and vegetables cost India Rs. 25289-28464 crs per year. Damage due to lossage in, banana, mango, and grapes equal to 1.2 percent of agricultural GDP (Murthy *et al*., 2007) [48]. According to research conducted under Indo-US project involving post-harvest losses assessment of fruits and vegetables (1986-1991), post-harvest losses in mango ranged from 5- 36.7 percent, 11-14 percent in banana, 16-23 percent in citrus, and 2-12 percent in guava. Those losses can be reduced by processing and storing the fruits into various value-added goods such as leather, juices, nectar, jam, jellies, wine, toffee, pulp, puree, sliced products, canned products, and so on. Fruits have a greater moisture levels and are often acidic. They are easy to digest and add a diversity of scent, flavour, texture, and colours to our diet. Fruit processed goods have a high export potential.
The primary goals of processing are to maintain flavour, colour, consistency, and nutrition, hence extending the product shelf life of delicate fruits. Due to lack of competent labour, inadequate cold storage facilities, ineffective post-harvest handling, and little technology innovations, India provides just 1% of the worldwide market for fruit processing. A few of the elements that have a detrimental impact on fruits having a lower economic worth since they have shorter lifespan. The action of the bacteria resulted in loss of 20-25 percent of the collected fruits (Droby, 2006) [46]. Fruits are frequently contaminated by microorganisms when they come into touch with dust, dirt, or water, as well as during the storage, harvesting, and post-harvest processes.

This leads in the harbouring of a diverse spectrum of microorganisms, including human and plant diseases (Eni *et al*., 2010) [9].

The greatest technique to preserve the fruits is to turn them into leathers. Fruit leather was said to have originated in the Persian Empire. 'The initial contribution on preparation of fruit leather was made by extension services of various colleges in the United States. The first scientific investigation on this issue was launched in 1978 and since then leather has gotten a lot of interest in the research world. Fruit leathers are reformed fruits created from concentrations of fruit liquids or fruit pulp and many other ingredients after drying. Fruit leathers composed of pulp are still the most popular among customers because they include a high concentration of carbs, fibres, antioxidants, vitamins, and minerals. Fruit leathers are desiccated and dried fruits. These chewy, delectable dried fruit products are chewy and flavorful. These are created by distributing pulp on stainless metal or aluminium trays, then dried or dehydrating them at a certain temperature till the moisture level is between 15-20%. Hot air drying, solar drying, microwave oven drying, cabinet drying, vacuum drying, and freeze drying are some of the options for drying. The leather is then removed off the trays and packaged when it has dried. After that, the leather is removed from trays and packaged. Because of its freshness and more appealing appearance, as well as the fact that it doesn't require refrigeration, it is often regarded as the greatest method for incorporating fruit solids and chosen by people of all ages, particularly children and adults. Remaining ripe fruits were used to make the leathers. Fruit leather is just fruit that has lost its moisture content. Many dehydration procedures remove the moisture content from fruit pulp, extending the shelf life of the product. It is cost-effective since it allows you to buy fruits in excess and assures that they do not spoil.

Reference fruit: Amla (*Emblica officinalis*)

Anti-oxidant property of amla fruit: Antioxidants of amla have also been linked to improvements in human antioxidant status. The amla fruit is a viable choice of natural antioxidants, according to a recent clinical trial with smokers. In this study, subjects who took 250 mg (twice daily) for 60 days showed significantly lower levels of peroxidation and higher antioxidant status. Another clinical experiment with patients who had been diagnosed with metabolic syndrome revealed that taking either 250 or 500 mg capsules (two times a daily) for 12 weeks lowered the levels of lipid peroxidation and increased GSH levels. In contrast, the antioxidant level of healthy patients was unaffected by the use of 125 mg capsules. Recent studies on animals have shown that amla fruit components have a preventive effect against oxidative damage. In this instance, GSH, CAT, and SOD activity in the mouse thymus was stimulated by daily treatment of 500 mg/kg body weight of amla fruit extract for 28 days. As a result, these scientists also noted a decrease in the levels of lipid peroxidation and reactive oxygen species (ROS). Similar research using amla fruit extract showed a substantial drop in the levels of lipid peroxidation, concurrent drops in the levels of conjugated dienes and CAT, and amelioration of the arsenic-induced reduction in SOD levels in the liver of mice. A different investigation found that the amla fruit extract increased CAT and SOD activity and decreased lipid peroxidation in the kidneys of mice.

According to these research, amla phytochemicals can serve as antioxidants by preventing the production of oxidation products, boosting antioxidant status, and activating the body's own antioxidant protective mechanism. The result is promising for managing illnesses or decreasing oxidative stress brought on by lifestyle choices like smoking, especially in clinical studies (metabolic syndrome).

One of the main causes of cardiovascular problems is hyperlipidaemia, however amla bioactive substances may help regulate this condition. Numerous studies have demonstrated the prevention of cardiovascular problems by amla and/or its compounds. At the human level, a 500 mg dosage of P. emblica L. extract given twice daily for three months lowered the levels of total cholesterol, LDL, and high-sensitive C-reactive protein (CRP) in Class I obese people. Gopa *et al.* investigated the impact of amla fruit capsules and found that participants with hyperlipidaemia had appreciable decreases. These authors claim that at the conclusion of the study period, substantial decreases in total cholesterol, LDL, and VLDL levels as well as a significant rise in blood HDL levels were also seen. Furthermore, several investigations found that the fruit and extract of P. emblica L. decreased VLDL, cholesterol, and LDL levels in both hyperlipidaemic patients and healthy individuals. The extract reduced the amount of significant inflammatory markers when given over a period of 2 to 6 months. Marker CRP, leading to an increased HDL level and defence against atherosclerosis.

The P. emblica L. plant's natural constituents have been linked to anti-diabetic properties. According to *in vitro* research, the primary phytochemicals in amla, such as ellagic acid and ascorbic acid, inhibit the essential enzymes responsible for breaking down glucose (especially amylase and glucosidase). The health advantages of amla phytochemicals for diabetic people are also supported by clinical investigations. For instance, after 21 days of the research, diabetic patients who received daily dosages of up to 3 g of P. emblica L. powder extract had lower blood glucose levels. Walia *et al*. obtained a similar result, finding that diabetic patients' blood glucose levels significantly decreased after ingesting 10 g of amla powder once day for 90 days. Additionally, P. emblica L. extract with high flavonoid content decreased diabetes patients' risk of neuropathy. Amla's bioactive components appear to be crucial in the treatment of diabetes, notably in helping to restore insulin and glucose levels.

Although there is currently little data, amla phytochemistry appears to support a positive impact in the setting of inflammation. Li *et al.* work's is one illustration of the anti-inflammatory efficacy in cell models. According to these authors, when an inflammatory response was induced by exposure to lipopolysaccharides, RAW 264.7 cells treated with amla extract—which is rich in gallic acid, corilagin, and ellagic acid—displayed lower levels of inflammatory markers (NO release and production of tumour necrosis factor (TNF-), interleukin-1 (IL-1), and interleukin-6 (IL-6)). (Li *et al.*).

Human studies have shown that P. emblica L. fruit extract (500 mg/day; containing punigluconin, emblicanin-A, emblicanin-B, and peduculagin) reduces platelet aggregation in both single and repeated dosage regimens. This was shown in a randomised crossover clinical trial with type-2 diabetes subjects.

Table 1: Health benefits of fruit used for fruit leather

Fruit	Part used	Utilization in Food	Effect on health	Supportive evidence
Amla	Fruit	Fruit pulp as dried sheets	Antioxidant	Jeevangi *et al*., (2013) [16], studied the presence of dismutase, catalase, glutathione, GSH, peroxidase, reductase, Vitamin E, Vitamin C and containing high level of ascorbic acid (ranging from 1150 to 1750 mg/100gms of fruit) Which increases the blood plasma level.
			Anti-inflammatory	TNF- and IL-6 levels in serum were considerably reduced by amla fruit extract (50 mg/kg body weight). These findings show that amla fruit extract may be an efficient anticoagulant and anti-inflammatory drug. (Theertham Pradyumna Rao *et al*., (2013)) [31].
			Cardioc protective effect	Emblicanin A, B showed antioxidant effect *in vitro* and *in vivo* like ascorbic acid (cardio protective). (Patel *et al*., 2011) [41]
			Anti-diabetic effect	Study was performed in mice with arsenic induced hyperglycemia to explore the efficacy of amla. Result showed that exposure of arsenic alters the glucose homeostasis and significantly declines hepatic glucose regulatory enzyme, pancreatic inflammation markers such as IL1β, TNF-α. (Singh *et al*., 2020) [42].
			Anti-microbial activity	Significant reduction in the mean colony count of Escherichia coli, Staphylococcus aureus, *Klebsiella pneumoniae* and *Pasteurella multocida* in rats by tube dilution method. (Bhadra *et al*., 2020) [43].
			Nephroprotective effect	Amla leaf ethanolic extract significantly decreases serum creatinine as well as blood urea nitrogen, so preserving the kidneys from injury, as well as increasing antioxidant enzyme activities and lowering renal MDA levels. Furthermore, oral treatment of Amla leaf extract heals morphological, anatomical, and morphological abnormalities in red blood cells. (Bhandari *et al*., 2018) [5].
			Anti-amnesiac (memory loss)	Elevated plus-maze and passive avoidance tests in Swiss Albino mice; showed memory enhancing, antioxidant and anti-cholinesterase activity (M Golechha *et al*., 2012) [40].

Table 2: Test module

Sr. No.	Property	Test module	Dose/concentration/method	Mechanism of action and Potential findings	References
1.	Antigout activity	Sprague-Dawley Rats	Potassium oxonate at 250 mg used for inducing of Hyperuricemia and allopurinol at 5 mg/kg dissolved in 0.9% saline solution	There was significant Increase in platelet count (<0.05%) in rats which was given a standard treatment induced rats. Other Hematological parameters did not reveal any other changes in this experiment.	Sarvaiya *et al*., 2006 [33]
2.	Anti-Diabetic	Male wistar rats of 200-250 mg	Dried amla extract of 200-250 mg/kg and injected with streptozotocin at 70 mg/kg	After 5 days of injection there were found no significant changes in rats and later they injected double dose of 400 mg/kg and they showed a controlled glucose and diabetic level in rats.	Mai Elobeid *et al*., 2015 [8]
3.	Anti-inflammatory	Male and female rats	0.1ml of carrageenan (1% saline) locally injected to right hind pawn of a rat at 700 mg/kg of HAEEO	After multiple trials on rats it shown significant anti-inflammatory activity with 70% inhibition of paw edema.	Santosh kumar *et al*., 2014 [32]
4.	Hepato-Protective	Male Sprague-Dawley rats	Berberine at doses of 80, 120, & 160 mg/kg was administered orally twice daily for 2 days to rats after/before 6 hours of CCl_4 therapy	Berberine substantially reduced serum alanine transaminase (ALT) and aspartate aminotransferase (AST) activity in pre and after treatment groups in a dose-dependent manner. It also raises the levels of superoxide dismutase (SOD) in the liver. This might be because it reduces the leakage of lactate dehydrogenase and alanine transaminase (ALT) and prevents the synthesis of malondialdehyde produced by t-BHP, as described by Hwang *et al*., 2002 [49].	Naaz *et al*., 2010 [28]

Reference Fruit: AMLA

Antioxidants, particularly Vitamin C, are abundant in amla (478 mg for 100 grams). Additionally, it contains a variety of polyphenols (gallic acid, ellagic acid, corilagin etc). Antioxidants like polyphenols protect the body from free radical damage and combat many cancers and cardiovascular conditions. It has a lot of nutrients and fibre. Overall, this little fruit improves health and shields the body from a host of diseases. More than double the adult daily recommended dose of 300 mg of vitamin C is found in one 100g serving of amla berries, or roughly a half cup. Alkaloids, flavonoids, and polyphenols are also present in significant quantities. Amla contains anti-inflammatory and antibacterial effects.

Amla contains 3.4% of fibre. Fibre makes stools more voluminous, speeds up the passage of food through the intestines, and maintains regular bowel motions. This lowers the likelihood of constipation. Additionally, fibre helps thicken loose stools and lessen diarrhoea. Additionally, it promotes the release of gastric and digestive fluids, resulting in effective food digestion and optimal nutritional absorption.

Amla contains 290IU of Vitamin A, which is essential to enhancing eye health, is abundant in amla berries. In addition to enhancing eyesight, vitamin A may help reduce the risk of age-related macular degeneration. The vitamin C in amla promotes eye health by preventing the growth of germs, so reducing your risk of conjunctivitis (pink eye) and other diseases.

Amla contains 1 mg mineral iron our body needs the iron to create the proteins myoglobin and haemoglobin. Red blood cells use hemoglobin to transport oxygen from the lungs to the rest of the body. Your muscles receive oxygen thanks to myoglobin. Along with tendons, ligaments, and other connective tissue, iron is essential for the production of hormones.

Amla contains fat less than 1% so it helps in reduce body fat and lower the risk of heart disease and even cancer.
Amla contains 0.16 mg of vitamin E which helps in Strong immunity, good skin, and healthy eyes. Vitamin E pills have gained popularity as antioxidants recently. These chemicals guard against cell damage.
Amla contains various other vitamin s and minerals which helps in maintaining good skin and hair growth and act as anti-microbial agent and has certain more health benefits.

Table 3: Nutrient and Minerals content table

Nutrients and minerals	Content				References
Moisture	Tray drying	Dry basis	50celcius	2.38%	Pankaj minj *et al*., 2018 [22]
	Sun drying		30celcius	3.72%	
Protein	< 1 gram				Mishra *et al*., 2014 [23]
	Calories – 33				
Fat	<1%				Rishika Tiwari *et al*., 2019 [44]
Ash content	2.08 to 2.97%				
Mineral water	0.7%				Mishra *et al*., 2009 [24]
Carbohydrates	14.2%				
Fibre	3.4%				
Iron	1mg				
Calories	33				
Flavonoids	Quercetin				Habib-ur-Rahman *et al*., 2007 [14]
	Kaempferol Rhamnopyranoside		6” methyl		
	Kaempferol Rhamnopyranoside		6” ethyl		

Amla could be an excellent source of vitamin C. It has therapeutic qualities and the potential to be processed into different juice drinks and jam. Amla juice has demonstrated cardio-protective effects and is high in antioxidants. Due to its high nutritional and medicinal qualities, it has a great deal of promise for the creation of numerous products. Because it contains nutraceutical ingredients, it is extensively employed in the pharmaceutical and food processing sectors. Amla is also a good source of vitamins E. It boosts immunity and fends off free radicals and it also contains good amount of vitamin A. It helps avoid aging, cancer, and cell damage. This fruit has a little acidic flavour, but when eaten raw, it leaves a pleasant aftertaste.

Table 4: Vitamins content table

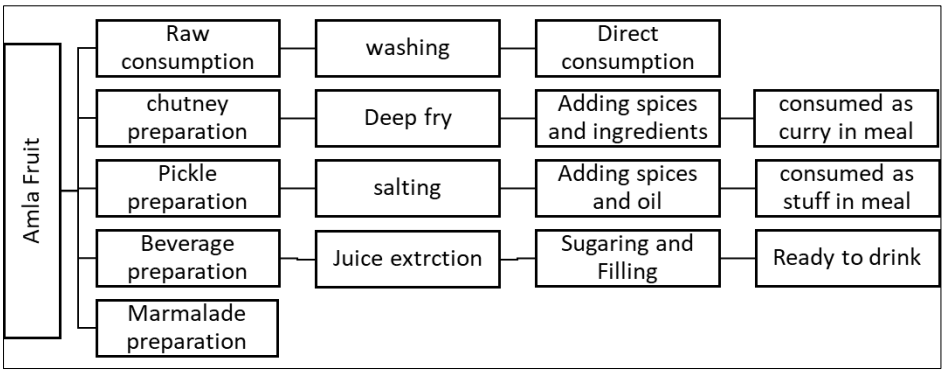
Vitamins	Value per 100 grams	%RDA	Reference
Vitamin A	290 IU	6%	Singh, D. J. (2020) [42]
Vitamin C	478 mg	800%	
Vitamin D	-	-	
Vitamin E (alfa tocopherol)	0.16±0.05 mg	-	
Vitamin K	-	-	
Thiamin	-	3%	
Riboflavin	-	2%	
Niacin	0.3 mg	1%	
Vitamin B6	0.1 mg	4%	
Folate	6 mcg	1%	
Vitamin B12	-	-	
Pantothenic acid	0.3 mg	3%	

The naturally occurring inorganic nutrient that is required for the healthy operation of an animal or plant's body is known as mineral nutrition. It can be found in food and soil. The body needs minerals because they are essential elements. Minerals are generally needed by both plants and animals. Amla contains maximum essential micronutrients which are required for human health in good amounts and which are matching the RDA allowances for human daily life.

Table 5: Minerals content table

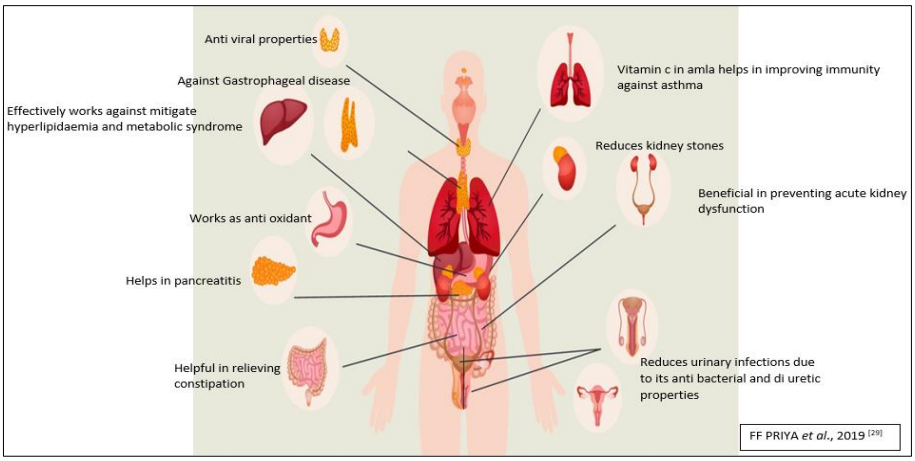
Minerals	Value per 100 g	% RDA	References
Calcium	25 mg (42+/-12 mg)	3%	Singh, D. J. (2020) [42]
Magnesium	10 mg (13+/-2 mg)	2%	
Phosphorous	21+/-5 mg	3%	
Potassium	198 mg (151+/-37 mg)	6%	
Sodium	13+/-4 mg	0%	
Zinc	012 mg (0.14+/-0.08 mg)	1%	
Copper	0.1 mg (0.04+/-0.03 mg)	4%	
Manganese	0.1 mg (0.71+/-0.06 mg)	7%	
Selenium	0.6 mcg	1%	

Chloride	25.6+/-2.3 mg	-	
Iron	1 mg	-	



Joshi *et al.* 2017 [17]
Mishra *et al.* 2012 [25]

Flow Chart 1: Showing Amla usage in consumption



Picture 1: Showing Uses of amla

Preparing Fruit Leather

Apples, apricots, pineapples, strawberries, mango, cherries, nectarines, amla, peaches, pears, plums, and berries were all deemed excellent for leather manufacturing. Other fruits, such as blueberries and cranberries, can have an excellent final result when combined. The leathers can be produced either with or without the inclusion of additives.

Additives

Due to presence of the pulp contains smaller molecular weight substances such as organic acids and sugars, the leathers are sticky to fingers, palate, teeth and packing material. To address this issue, larger molecular weight ingredients such as maltodextrin, starch, gums and pectin are included. When maltodextrin is added to pulp, it minimises stickiness while processing and packing (Valenzuela and Aguilera 2015) [15]. As seen in the scenario of Apple, the presence of maltodextrin leads in the retention of adhesive force between leather and packaging material. Another advantage of adding maltodextrin changes the hygroscopicity of apple leather. Maltodextrin-containing fruit leather absorbs less water (Valenzuela and Aguilera 2015) [15]. Most gelling agents, such as pectin, gelatin, starch and alginate, are commonly applied to leather, which enhances the texture while also slowing the drying process. The use of gelling ingredients such as carboxymethyl cellulose, pectin, guar gum and guar acacia reduces the drying rate while simultaneously increasing the product rupture energy and shelf life (Gujral and Brar 2003) [36]. Browning of leather had been serious issue in fruit leather manufacturing process. Fruit leathers have been reported to brown only after few hours of preparing fruit leather. Browning inhibitors such as citric acid, sulfite, and maquiberry extract reduced browning processes in quince, papaya, and apple leathers. In certain circumstances, smaller molecular mass compounds such as glucose, sucrose, syrups and probiotics such as oligo fructose, fructans, polydextrose, and so on, which promote stickiness, are employed to improve sweetness. Gonzalez Herrera investigated the effects of agave fructans, insulin, oligo fructose, as well as their combinations on the sensory and physiochemical qualities of apple leather. The use of agave fructans produced leather with low hardness, probiotical potential, and increased customer appeal.

Fruit Concentrate/Pulp

Fruit concentrate or pulp is the primary component in the production of leather. Leathers can also be made from the juice content of one fruit nor by combining the two kinds of fruits in varying concentrations.

Apple and Black current Leather

Apple and Black currant are temperate crop that is a good provider of vitamins & iron. Apples have a place in regular prescribed diet, and there is a popular saying linked with them: "an apple a day keeps the doctor away." Similarly, black

currant & apples is high in antioxidants and beneficial to one's health. These leathers may be effectively made by combining apple juice, pulp and black currant concentrate in various amounts with adding ingredients (L.M Diamante 2013) [6] Fruit leather can be made by combining apple juice, pulp, & black currant concentrate in ratio of 30: 6: 2 and drying it in hot air dryer at 70 ℃ temperature with an air velocity of 0.2 m/s was found to be the most appropriate to costumers on physiochemical properties & organoleptic evaluation.

Grape Leather

Maskan *et al*. 2002 [21] has dried the grape leather in sun as well as in a hot air oven. The fresh grapes are cleaned first, and the seeds and skins were removed. A 70 percent CaCO3 solution was added to it. The mixture is then heated for a short period of time to produce enzyme deactivation, resulting in a colour shift. Filtration and separation of the calcium tartarate provide clarified juice. The whole amount of juice was split into two portions. To achieve the concentrated juice, the remaining 3/4 of the juice is cooked for 30 minutes with constant stirring. The remaining 1/4th of the juice is combined with the wheat starch and heated for 4 minutes, or until the concentration reaches 4 g/100 g of starch. The juice is then poured onto an 8 cm diameter disc of fabric and dried in a hot air oven or in the sunshine.

Banana Leather

Bananas are an extremely perishable fruit, turning them into leather is the most practical usage. (Ekafitri, R *et al.*, 2019) proved that banana leather was created by combining three banana varieties: raja sereh (A), muli (B), and white kapok (C). For 8 minutes, the bananas were cooked. It is peeled even more and mixed into the purée. The purees were separated into two sections, with one containing polysaccharide carrageenan and the other containing no carrageenan. It is then dried for 12 hours at a temperature of 60 degrees Fahrenheit. The samples were also tested for physiochemical characteristics. The inclusion of carrageenan had an effect on the texture of the leathers. The leather has been cured and packaged.

Apricot Leather

S.K. Sharma *et al.* 2013 [35] prepared the apricot leather. First, top quality apricots are picked and carefully cleaned before being cooked for 5 to 7 minutes. The pulp is next removed and cooked over a low heat until it is highly concentrated. The pulp is then treated with various sugar amounts (40 percent, 50 percent, 60 percent). Furthermore, 50g sugar was preserved and combined with pectin to guarantee even distribution. Later, the pectin amounts are weighed to (0.20 percent, 0.30 percent, 0.40 percent) and equally sprinkled and blended. The sample is then put in aluminium trays with a thickness of 4-5mm and dried for around 6 hours in a mechanical dehydrator at 552 °C.

Straw berry leather

Lee and Hsich 2008 [20] prepared the strawberry leather and carried out research on the thin layer drying kinetics. The leather was created by combining strawberry puree, corn syrup, pectin, and citric acid in the following ratios: 200:40:2:1. It was then put on aluminium trays. The layers (1.8, 2.7, and 3.6 mm) are dried in an oven at various temperatures (50 °C, 60 °C, 70 °C, and 80 °C). The drying process is repeated until the moisture level reaches 12%. Depending on the thickness and temperature of the layers, it might take anywhere from 80 to 600 minutes. It was discovered that drying rates increased when sample thickness decreased from 1.8 to 3.6 mm.

Apricot - Apple leather

Bains 1989 produced apple and apricot leather from a puree containing 82 percent apple pulp, 16.5 percent apricot puree, and 1.5 percent apple juice. The sample was then standardised on stainless steel trays and dried in the cabinet drier for about 6 hours at 85 °C and 5 percent relative humidity. A two-stage process generated high leather quality, which means the leather was dried twice, once at 102 °C for 2 hours and then again at 85 °C for 3.5 hours.

Papaya-Apple

Apple and papaya are high in vitamins and minerals. They work together to form a healthy diet. Fulchand *et al* 2015 [10] combined papaya and apple in varied percentages C0 (100:0), C1 (90:100), C2 (80:20), C3 (70:30), and C4 (60:40) with sugar (30%) and citric acid (1%), and a high-quality leather was created. After drying, the samples were examined for organoleptic and physicochemical qualities. Among all the samples examined, the sample created from the treatment C3 was deemed to be the highest quality leather and was widely accepted by consumers. Excessive mixing of apple pulp with papaya pulp was also found to be unacceptable, as it resulted in a loss in colour, flavour, and taste.

Mango Leather

Gujral & Khanna 2009 prepared mango leather also investigated the effects of soy protein concentration, skim milk powder, and sugar on drying behaviour, texture, acceptability, & colour of pestil. Fresh, wholesome fruits were chosen, rinsed, and skinned. The pulp is removed and cooked over 5 minutes around 80 °C before being chilled. The pulp is treated with 0.2 percent potassium metabisulphite before being sealed and kept in glass containers at 4 °C. The puree is laid on aluminium trays as dried in cabinet dryer at 60 °C temperature and air velocity of 3.5 m/s. The puree was fortified with, soy protein, skim milk powder and sugar. The combination of these components resulted in lower drying rate, as well as increased flexibility and energy. They discovered that the mixture containing sugar and 4.5 percent skim milk powder was largely acceptable.

Gujral and Brar 2003 [36] studied the hydrocolloids effect on the kinetics of dehydration, texture, colour of mango leather. The pulp prepared of fresh mangoes is deposited on aluminium plates & dried in cabinet drier at a temperature of 61 degrees Fahrenheit and 15% relative humidity. The inclusion of hydrocolloids led to the reduction in drying rate during the initial time period, but this was later determined to have no impact. Pushpa *et al.* 2006 [30]. Investigated the incorporation of defatted soy flour in the preparation of enhanced mango pestil by microwave drying. Initially, the pulp was removed and combined with lime juice (2 g), corn(maize) flour (5 g), sugar (50 g), and a 1:1 mixture of soy flour with 51.8 percent protein and skim milk powder in various degrees or proportions such as 10%, 15%, 20%, & 25%. The puree is microwaved at 80°C for 15 min at varied power settings until the water content reached 15%. Mir and Nath investigated the absorption isotherms of mango pestil. Fresh mangoes first cleaned, peeled, & pulped before being cooked at 93 °C. The pulp then combined with sugar, 0.6 percent citric acid, & 1734 ppm potassium metabhisulphite. The pulp was uniformly distributed

on aluminium trays and dried in a cabinet drier at 632 °C for 14-16 hours. Azerdeo *et al.* 2006 [2]. Investigated the effect of drying & storage on physiochemical properties of mango pestil. The mango leather being created using mango puree that was dried in an oven at 60-80 °C until the moisture level reached 15-18%.

Dehydration or drying

The method of removing moisture from a substance is known as dehydration or drying. High water content causes a rise of microbial activity, which leads to product deterioration. As a result, retaining moisture content through various means extends the product's storage life. Enzyme activity is slowed by drying, but it is not deactivated. Many biological and chemical interactions cause changes in product's texture, flavour, colour, odour, and physio-chemical qualities during drying. Drying causes crystallisation, puffing, and shrinking in product. On either hand, exposing the product to lengthier time of drying leads in damage.

Drying is a procedure that involves properly supplementing heat to wet substance such that moisture inside the material vaporises. There are various dryers for drying fruit leathers depending on heat requirement.

They are as follows

1. Conduction drying: Indirect dryers.
2. Convection dryers: Direct dryers
3. Radiation drying: The drying of electro-magnetic fields using a microwave or radio frequency.

Some drying methods used for leather drying include solar cabinet drying, sun drying, vacuum drying, microwave drying, freeze drying, spray drying and hot air-drying. Because of the availability of these contemporary dryers, then product may be dried at anytime, regardless of weather. The drying time is determined mostly by dehydrator used, as well as nature of product. Fruit leathers are typically dried at temperatures ranging from 30-80 degrees Celsius 24 hours, or until the moisture level reaches till 15-20 percent. Drying must be done in the proper manner. Otherwise, the damage would be irreparable and will primarily affect product quality, rendering that product as non-consumable & non-marketable. The various drying processes are detailed below.

Sun Drying

This is a natural approach that requires no electricity and is environmentally beneficial. It is the most extensively utilized since it requires relatively little expenditure. The puree prepared from various fruits placed over trays with very thin walls and placed in regions that receive direct sunshine. To prevent dust particles from settling, the trays are covered with a polythene cover on top. The puree is dried till the moisture level is between 15-20%. The sun-dried leather has a very vivid colour and an excellent look. The loss of nutrients due to sun drying is very minimal.

Solar Cabinet drying

Sun drying has been the most old technology, the most contemporary drying approach is solar cabinets drying. This is the most cost-effective method of drying because no further traditional energy is needed. Cabinet dryers are widely used in many poor nations, for example, in military foods and space formulas. The primary idea of cabinet drier is based on greenhouse effect, which traps heat from sun and causes temperature increase within the chamber, resulting in quick drying.

Vaccum Oven

It is an illustration of conduction dryer. It is made up of jacketed vessel that resists the vaccum inside the oven. They are made up of shelves that give a bigger surface during conduction heat transmission. The oven is linked to a vacuum pump by condensor & liquid receiver. Because the drying actually occurs at a moderate temperature, the danger of oxidation gets reduced, and the texture, colour and taste of leather is enhanced as compared against air dried leather. It is more effective at eliminating water from items. The temperature should be kept between 25 and 35 degrees Celsius.

Microwave oven

It has better use than rest of all. It is quickest drying process. The magnetron is an electrical device that generates microwaves radiations. Through glass, microwave radiation may be redirected into drying chamber. Heat has been produced consistently to leather and microwave penetration into leather results in rapid drying of product. Because the microwave maintains the greatest temperatures, it has a significant impact on the degradation of nutrients & colour.

Freeze Drying

The procedure of freezing the water and then removing these from sample. The primary concept of freezing is sublimation, which occurs when water moves from a solids to vapours state without going through liquid stage. The given sample is first frozen until it turns to ice, and then vacuumed to allow sublimation, and finally freeze-dried and then stored. It has a longer storage life.

Packaging Material

Packaging materials are crucial because they plays important character in storing of product and allowing these to cross easily over great distances while remaining complete until consumption. The wrapping materials must also be capable of meeting some of the criteria, such as material cost, ecological and sustainability awareness, and pollution rules, among others. HDPE, polypropylene, LDPE, butter paper, poly ester, and aluminium foil are few packaging materials utilised in packaging of leathers. Various materials have varying degrees of strength, elasticity, and storage capacity.

The Functions of Packaging Materials

The packing material prevents damage from deterioration and extends its life span by keeping its excellence and lifespan. It safeguards the material from three key threats: physical, chemical, and biological.

Chemical protection

The packing material reduces the changes of product's composition caused by environmental factors such as gas contact, moisture exposure, and light exposure, among others.

Biological protection

The packing material serves as a protection barrier, preventing illness and deterioration by blocking the entry of germs and certain other insects.

Physical Protection

It functions as a barrier, preventing mechanical harm to the goods. It also makes it impossible for the products to withstand collisions, crushing, and destruction. In this diverse climate, the novel product packaging also aids in increasing sales.

Packaging Material and Storage Effects

Irwandi *et al.* 1998 [15] studied the impact of different packaging materials also on biological, physiochemical, and sensory characteristics for durian fruits pestil during storing. The study employed four different types of packaging materials laminated aluminium foil (LAF), polypropylene (PP), low density polyethylene (LDPE), and high density polyethylene (HDPE). As well as the research was left at normal room temperature for nearly three months. They discovered that LAF had the least amount of water activity conservation and moisture levels change. As a result, the leather's intended textural properties are preserved. LDPE showed the greatest changes in moisture level and water content. The packing material & storage period had an impact on non-enzymatic browning of leather. The least amount of colour degradation was detected in LAF, whereas the most browning was recorded with LDPE. The LAF-packed samples retained the required texture, whereas LDPE-packed materials increased in hardness most over the course of 8 weeks. But both the packing material as well as the storage duration have an impact on microbial development. LAF reduced the development of moulds, bacteria and yeast strains. Microbial counts increased the most in the LDPE-packed samples. The samples packaged in LDPE seemed to have the lowest scores for organoleptic qualities, whereas samples wrapped in LAF received the greatest marks. Organoleptically, all 4 packing materials were mostly satisfactory. Kumar *et al.* 2015 [45] investigated the durability of four packing materials in guava leather. Study says that of aluminium foil (AF), butter paper (BP), Polypropylene (PP), and metalized polyester polyethylene (MPP) are the 4 types of product packaging materials employed in this investigation at low temperatures (~10 °C). It was discovered that moist content of sample decreased while held at room temp and increased when placed at low temperatures. The products packed in AF & MPP lost the least level of moisture. All through storage, the acid content of guava leather enhanced. Once stored in ambient and low temperatures, the samples packed in 4 packaging materials led to a rise in the reduction sugar content. It has been discovered that leather wrapped in MPP has a high nutritional content and a low microbial activity level. Low and ambient temperatures are both acceptable. Polypropylene is often used to extend the storage life of products by 1 to 2 months.

Azeredo *et al*., 2006 [2] prepared mango leather without adding additives and tested its storage stability & acceptance. The puree prepared from pulp of fresh mango and oven dried using central composite system with 2 independent variables: puree load (0.4-0.6 g at 80 °C) and drying temperature (60-70 °C). The taste of product was excellent, and it was decent. Later, polypropylene containers have been used to package leathers, which were kept at 25 °C. Without using of any chemical preservatives, leather with the mix of low water activity (0.62) and low ph (3.8) was microbiologically stable for roughly 6 months.

S.O. Babalola *et al*. 2002 [3] treated pawpaw as well as guava leathers and investigated in cold storage on the effect of temperature on qualitative qualities. Throughout storage, guava leather had lower water activity, total mould count, ph, and calorific content than pawpaw leather. Guava leather has a pleasant texture. The sensory characteristic scores during storage demonstrated that guava leather had acceptable results in general acceptability throughout 2 months of storage at 8 10. It also performed well in terms of scent, fruitiness, chewiness, colour, and general acceptability. It was more widely acknowledged.

Conclusion

Fruits are really an excellent source of minerals, phytochemical, vitamins, substances, and a variety of other necessary components that are an indispensable part of everyday diet. Eating fruits on regular basis leads to finest immune system & keeps illnesses at away. Among several other countries in world, India is the leading grower of vegetables and fruits. To reduce post-harvest loss, the harvested fruits have been further converted into various types of value-added consumables. Leather is also one such thing that everyone enjoys. The leather is made from a single fruit or combination of fruits. Fruits such as apple, guava, mango, banana, papaya, apicot pineapple, grapes, kiwi and strawberries are used to make leather. Leather is composed of a specific fruit or a combination of fruits. Fruits such as mango, apple, banana, apricot, peach, papaya, grapes, pineapple, kiwi and strawberries are used to make leather. Leather is prepared by peeling, washing, pulping the fruits, followed by addition of additives such as honey, sugar for flavor, citric acid, KMS to extend shelf life, wheat flour, maltodextrin, gums and pectin to avoid sticking. The pulp placed on lubricated trays or pans and dried until the moisture level is between 15-20%. Enzyme activity is slowed by drying, but it is not deactivated. Changes in biological and chemical processes cause changes in color, flavor, and texture. Sun drying, freeze drying, cabinet drying, vacuum drying, hot air drying, micro-oven drying and more procedures are utilized. According to all drying research, the quickest type of dryer is microwave-oven drying, which includes the use of high temperatures, while the shortest drying type is solar drying. The darker color of leather was acquired when dried in sun, and vacuum drying was seen to provide a nice result. It was discovered that when we dried at the greatest temperature for short time period nutrients, taste, color, and flavor were lost. After drying of leathers, they are wrapped with various kinds of packaging materials for both storage and long-distance transit. It's been noticed that the storage duration lengthens, the product's quality deteriorates. Furthermore, moisture permeability experiments on packing materials must be performed prior to storage investigations. Further research on the influence of food packaging materials on proximate composition of fruit bars can also be conducted.

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