The Pharma Innovation Journal 2022; SP-11(6): 1620-1626

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 1620-1626

www.thepharmajournal.com
Received: 07-03-2022
Accepted: 10-04-2022

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Fortification of fruit leathers

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Abstract
Fruits play a major role in human diet. They are sources of vitamins, minerals and fibres. Fruit leathers are tasty and convenient on the go snacks with high level acceptability. They are food products consisting of fruit pulp, sugars, pectin and preservatives which are dehydrated at a temperature of 50 degrees. Here *Garcinia indica* (kokum) and *Mangifera indica* (mango) is chosen as a basic ingredient of the leather. *Moringa oleifera* tree is called as miracle tree as it is a rich source of certain macro and micro nutrients which holds great importance to human health. Some nutritional evaluation has been carried forward in leaves and stems. An important factor that accounts for the medicinal uses of *Moringa oleifera* is its very wide range of vital antioxidants, antibiotics and nutrients including vitamins and minerals. Due to these benefits, *Moringa oleifera* has been chosen as a fortifying agent. By incorporating this fortificant into fruit leathers, it improved the nutritional profile of the product. In the article elaborates all about kokum fruit leather fortification with *Moringa oleifera*.

Fruit leathers are dehydrated fruit products which are eaten as snacks or desserts. They are flexible sheets that have a concentrated fruit flavour and nutritional aspects. Most fruit leathers are prepared by mixing fruit puree and other additives like sugar, pectin, acid, glucose syrup, colour, and potassium metabisulphite and then dehydrating them under specific conditions. Various drying systems including combined convective and far-infrared drying, hot air drying, microwave drying, solar drying, and sun drying have been used to make fruit leathers. Most fruit leathers are dried at 30 to 80 ^{0}C for up to 24 hours until the target final moisture content (12–20%) has been reached. Research about fruit leathers began in the 1970s. This work has reviewed published papers on fruit leathers in order to summarize useful information about fruit leathers on methods of preparation, effects of drying condition, and effects of packaging and storage, which will be useful to many in the food industry and consumers who are health- conscious.

Keywords: Fortification, fruit leathers, health benefits, apple, banana, mango, peach

Introduction

Fruit leathers are made by drying a very thin layer of fruit puree to produce a product with a texture similar to soft leather. Fruit leather is the product prepared by blending fruit purees or pulp extracted from ripe pulpy fruit, sugar or other nutritive sweeteners and other ingredients and additives desired for product and dehydrated to form sheet which can be cut to desired shape and size. The preservation of fruit leathers depends on their low moisture content, the natural acidity of the fruit used and high sugar contents.

Fruits have been used by humans as food and medicine since prehistoric times. Although, fruits are highly nutritious and widely available all over the world. Fruits are rich in a variety of nutrients, vitamins and minerals, consumption of which reduces nutritional deficiency disorders. Fruits have very short harvest season, so preparation of fruit leathers/bars from fruits is an effective method to preserve and future use without major nutritional changes.

All fresh fruits are highly susceptible to high degree of damage due to a variety of factors and developing a fruit leather is an effective method of preservation of its nutrients. They are high calorie food.

These leathers are firm in texture but highly malleable in nature. Fortification is the process of value addition in food, wherein particular nutrients are supplemented into the diet in order to meet the nutritional requirements and to prevent nutritional deficiency diseases or illness. Fortifying agents are compounds that are added to food carriers in order to supplement the carrier with one or more necessary target nutrients. In this study, the dried leaves of *Moringa oleifera* are chosen as the fortificant. *Moringa oleifera* is considered as the modern-day super food because of its plethora of valuable nutrients. It is universally known as the miracle plant or the tree of life.

Moringa trees have been used to treat malnutrition among children and nursing mothers. Moringa leaves have been proposed as an iron-rich, calcium rich food source to medication in iron and calcium deficiencies. In addition to that *Moringa oleifera* was reported to have higher antioxidant content. *Moringa oleifera* tree is a plant rich in a number of nutrients such as proteins, fibre and minerals that are essential for a healthy human diet.

Fig 1: Different fruit leathers

The general process of making fruit leather involves the preparation of the fruit puree, with or without addition of other ingredients before mixing and then drying. These processes may vary depending on the fruit used, the nature of the additional ingredients, and the drying method and technology.

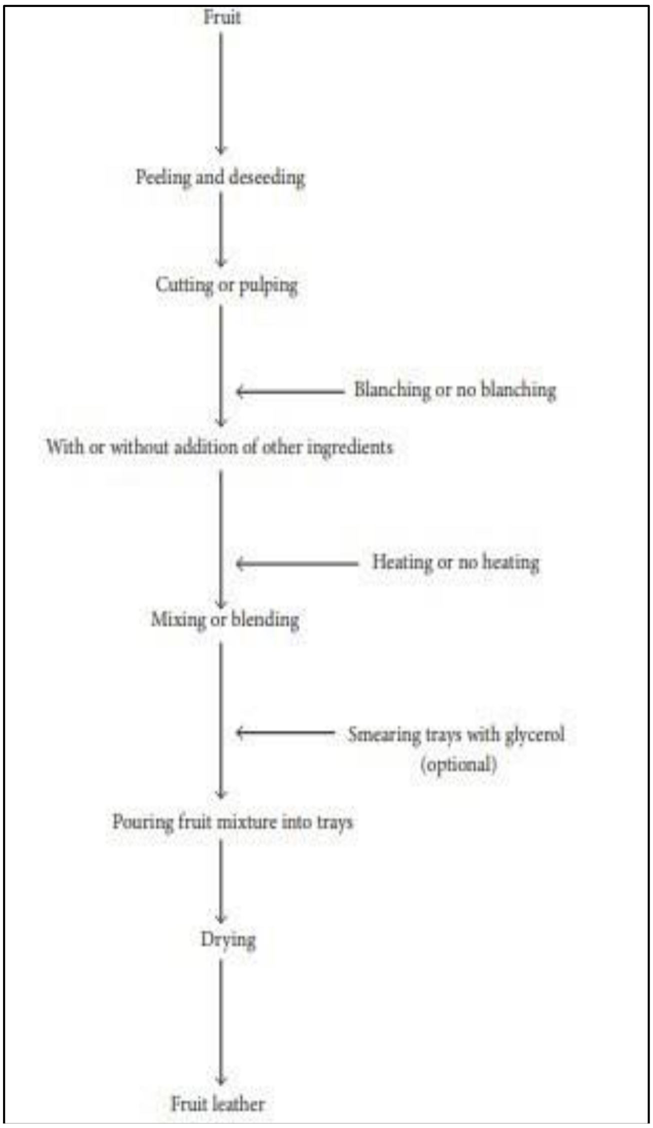

Fig 2: Schematic diagram of the general process for the production of fruit leather

Literally, fruit leather is the fruit with no water content. This process is carried out with the use of food dehydrator. It eliminates water from fruit so that the fruit lasts long. It is economical that allows to buy fruits in bulk and ensures that it won't go bad. Listed below are some of the health benefits discussed on Fruit Leather:

1. Abundant nutrients

Fruit leather or dry fruits is the process in which fruit is dried and the nutrients found in fruit are conserved. Basically, dried fruits are packed with nutrients such as fiber, minerals, phosphorus, calcium and iron. The high content of nutrients ensures one's health and combat fatigue and other health problems.

2. Supports digestion

Fruit leather comprises of natural fibers that provides numerous health benefits. Fibers found in it assist the process of digestion. Additionally, it cleanses digestive system and prevents the condition such as constipation and other bladder problems. It has positive effect on skin as flushing out toxins from the body improves skin health.

3. Assist in losing weight

Dried fruits are smartest choice to shed off some weight. The fiber content found in some fruits makes one feel full for longer time period. Fruit leather is also a better alternative for sweet to crave. The effective control in intake of carbs and sugars automatically supports healthy weight loss.

Fortification of Jamun Leather with iron

Jamun is seasonal, perishable and underutilized indigenous fruits with a lot of medicinal benefits. The fruit contains a varying amount of minerals, vitamin C, phenolic compounds, sugars and antioxidant components investigated by Prabhakaran *et al*. (2011). Mainly, jamun fruit is processed to prepare vinegar, squash, jam and jellies. Jamun product is attractive to consumers due to the eye-appealing purple colour contributed by anthocyanins pigments. Moreover, the jamun flavonoids act as both antioxidants and colorant (Bukya and Madane, 2018). Most fruits have a short harvest season and such fruits are sensitive to the deterioration even these are stored in the refrigerator in favourable condition. Fruit leathers are the dehydrated and concentrated fruit based flexible sheet that are consumed as a dessert or snack with rich nutritional profile (Khanum *et al*., 2018). Thus, fruit leather is the most effective way to preserve fruit pulp. Moreover, it is the best way to give fruit solid to children and adolescents. Fruit leathers can be stored for a longer period of time without any undesirable change in texture and the flavour (Basha *et al*., 2018).

Procurement of raw material and sample preparation: The two varieties of Jamun (Syzygiumcumin), Ra and Desi, were purchased from Ayub Agriculture Research Institute, Faisalabad keeping in view the quality traits for example size uniformity, shape and color followed by washing and grading. The seed was separated from the pulp for the analysis. The fruit pulp samples were preceded for the proximate and mineral analysis. Nutritional profiling of Jamun varieties pulp Proximate and mineral analysis: The proximate analysis of jamun varieties including ash, moisture, crude fat, crude fiber and crude protein were carried out according to the standard method of AOAC (2016). Minerals such as K and Na of jamun pulp were quantified by Flame Photometer whilst Ca, Fe and Zn were determined using the Atomic Absorption Spectrophotometer technique (AOAC, 2016). All the tests were performed in triplicates. Preparation of fortified jamun leather: Jamun varieties were passed through the pulper for the pulp that was further used for the preparation of jamun leather. The jamun pulp was homogenized using the lab homogenizer. During the homogenization, the other ingredients such as pectin, citric acid and sugar were added to the mixture. After homogenization, the mixture was pasteurized and followed by the addition of iron salt and mixed thoroughly to avoid any precipitation of salt. The ferrous sulphate was added in samples to yield 7.2 mg (40% of Recommended Daily Allowance (RDA)) and 10.7 mg/100g (60% of RDA) of jamun leather according to the treatments separately. The mixture was taken in aluminium trays and a thin layer of vegetable oil was smeared in the aluminium trays to avoid sticking of leather. The process of dehydration was done in the cabinet dryer at a temperature of 60 °C and the air velocity was set at 3.5 m/sec in cabinet dryer for about 7 to 8 hours. The leather was cut into desired shapes weighing 10g. The jamun leather was wrapped in butter paper and then stored in the polythene bags that were labelled according to the treatments prepared. Fortified jamun leather was prepared using both of the varieties separately using ferrous sulfate as a fortificant. Physicochemical analysis: The physicochemical analysis including the pH, total soluble solids (TSS), acidity, reducing sugars and ascorbic acid were analyzed by Kaleem *et al*. (2017). Mineral analysis/Iron determination: Fe level of the fortified jamun leather was determined by using an atomic absorption spectrophotometer as mentioned by AOAC (2016). Total Phenolic content: The total phenolic content of iron fortified jamun leather were determined by using the method of Phuong *et al*. (2017). DPPH radical scavenging activity: The *in vitro* antioxidant activity was assessed by using DPPH assay according to the method mentioned by Ahmad *et al*. (2018). Sensory evaluation: The sensory properties of iron-fortified leather including taste, flavor, color and overall acceptability were assessed by the 20 volunteers by using a 9-point hedonic scale. Statistical Analysis: The data obtained were subjected to statistical analysis using a two-way factorial completely randomized design (CRD) and the means were compared using LSD (least significant difference) test at 0.05% significant level using the Statistix software and following the methods explicated by Montgomery (2008).

Protein Fortification of Mango and Banana fruit leather

Mango and banana is the major fruits crop and occupies vast area for production worldwide, but post harvest losses have been reported to be very high (Srinivas *et al*., 1997). These losses can be minimized from the value addition of these fruits into the products of great importance to the society and industry. Mango and banana bars are important products, prepared traditionally from unmarketable, but sound ripe fruits. Traditionally, sun drying technique is employed for preparing mango bar results into the dark brown product due to the unhygienic and lengthy process and coincidence of rainy season (Rameshwar, 1979) with the ripening of mango fruits. Cabinet drying process was optimized for the plain mango bar (Heikal *et al*., 1972 and Mir and Nath, 1995a). Blended mango pulp with other fruits like banana, guava, papaya, jamun or pineapple was used (Mathur *et al*., 1972). Mango-pineapple bar has been reported to be superior to other samples.

Fruit bars were prepared from pulp of soft ripe fruits. The mango and banana were washed, peeled, pulped. The pulps were acidified to 0.3% CA, heated for 5min. at 85 OC to destroy enzymes, cooled, sulphited with 1000 ppm of SO2 and stored in 5 Kg glass containers at 11±1 OC for its further use. A portion of unsulphited but pasteurized pulp was packed in polyethylene sherephthalate (PET) containers at –18 OC. The different proportions of RBF and SMP (0, 5 and 10%) were incorporated for the optimization of the respective level of RBF and SMP usage in the bar preparations. Total soluble solids of pulps were raised to different levels (20, 25and30%) using powdered cane sugar. Acidity were adjusted (0.30, 0.45 and 0.6%) using citric acid to the pulps and blends which were spread uniformly on stainless steel trays (tray load 12.5 kg/m2), and dried in a cross flow cabinet drier at 70 for a prescribed interval of time (14-16 hrs for mango bars and 18 hrs for banana bars) as optimized by Prasad *et al*., (2002). Dried sheets were cut into rectangular (3.5×10 cm2) bars, packed in poly propylene (PP) pouches and stored at refrigerated temperature (11±1 OC) till subjected to sensory and chemical evaluation. Samples were analyzed for moisture by using vacuum oven method, protein by micro-Kjeldahl method, fat by Soxhlet extraction method and sugars by Lane and Eynonmethod (Ranganna, 1986). Beta-carotene andtotal carotenes were estimated by AOAC (1975) methods. Totalash, acidity, calcium, phosphorus and iron were determined by the procedure described by the Ranganna (1986). Sensory evaluation of the samples was carried out at nine point hedonic scale (Amerine *et al*., 1965) and the sensory data were subjected to analysis of variance (Rangannna, 1986).

Fig 3: Fortification of Mix Fruit leather with *Moringa oleifera*

Fruits have been used by humans as food and medicine since prehistoric times. Although, fruits are highly nutritious and widely available all over the world. Fruits are rich in a variety of nutrients, vitamins and minerals, consumption of which reduces nutritional deficiency disorders. Fruits have very short harvest season, so preparation of fruit leathers/bars from fruits is an effective method to preserve and future use without major nutritional changes. Fruit leathers also are confectionary dehydrated food snacks or desserts, generally prepared by mixing fruit puree with additives such as sugar, pectin, preservatives, color, and dehydrating them under suitable conditions. It is lightweight and easy to carry, convenient snack which can be easily stored and packed. Pulp was extracted from the peeled fruits with the help of blender. To the pulp Sugar, Skim Milk Powder (SMP) (3g), Citric acid (0.9g), Maltodextrin (1g) Pectin (1.5g) were added 6, Flavor profiling was done to find out the most optimum acceptance level. This was carried out to finalize the fruits to be used in the production of fruit leather. Fruits in the following combination were used: Ficus carica/Manilkara zapota (A), Ficus carica/Malus domestica (B), *Ficus carica*/ *Musa paradisiaca* (C) and *Ficus carica*/ *Malus domestica*/ *Manilkara zapota*/ *Musa paradisiaca* (D). Above chosen combination of fruits allowed to produce leather through Refrigeration (4 °C), Microwave oven (800 Watt) and Hot air oven (50 °C)(Fig.1) and analyzed to find the most optimum method in terms of time and temperature 7. After profiling, the fruit flavour combination of Ficus carica (25g) and Malus domestica (75g) are processed by Hot air oven at 50 °C for 2 hours were chosen for further fortification. Fortification of fruit leathers: Attempts were made to develop and fortify the fruit leather for which different proportions of fruit pulp, sugar, skim milk powder (Table 1) and *Moringa oleifera* leaf powder were considered to optimize the composition of fruit leather. The mixture was poured into trays smeared with butter in a highly thin layer and dried at 50 °C for 2 to 2 and a half hour in a hot air oven. Analysis fruit lather: The resulting fruit leathers (before addition of fortificant and after addition of fortificant) were analysed for the following parameters, namely Physical analysis, Chemical and Nutritional analysis by standard analytical procedures. Organoleptic analysis, Microbial analysis and stability testing.

Fig 4: Fortification of papaya leather with soy

The dehydration and storage stability of papaya leather was investigated by Chan Jr. and Cavaletto (1978). The papaya leather was prepared by steaming whole papaya for 1 minute, slicing, and then separating the flesh, skin, and seeds. Papaya pulp and soy slurry were mixed in different ratios as given below. Papaya pulp alone served as a control. The papaya pulp and soy slurry were mixed in a ratio A (100:0), B (90:10), C (80:20) and D (70:30). The TSS of mixture was raised to 30°Bx by addition of sugar amount - 86.25 g (A), 89.63 g (B), 93 (C) and 96.4 g (D) and then spread over almuniumtrays) and dried in a cabinet drier for 7 hours at 80 °C temperature until the thickness reached 5 mm. Now each papaya soy fruit leather were cut in an appropriate size and then packed in an air tight plastic bag separately and stored in cool and dry place until further analysis. They pulped the treated fruits and acidified them until the pH was 3.5. After inactivating the enzymes by heating the puree, the puree was stored frozen at -18 °C. Sugar (10% w/w) at 4.9 kg/m2 (11 b/ft2) was added in the papaya puree and then the puree was poured evenly onto Teflon-coated pans or pans sprayed with a lecithin release agent. Sodium bisulfite was added to give low (552 ppm) and high (1105 ppm) levels of SO2 treatment. The purees were dried in a forced draft oven until they reached about 12-13% moisture content or a water activity of 0.50–0.52. Babalola *et al*. (2002) also made pawpaw (papaya) leather by peeling the fresh fruits and adding 20% sugar, 0.2% citric acid, and 0.1% sodium benzoate to a concentration of 80% pulp. The pulp was then boiled, cooled, and spread on trays that had been previously oiled with glycerol and then dried at 60 °C for 8 hours.

Fortification of Mango and Banana Leather with Roasted Bengal Gram Flour

Among the various proportions of roasted Bengal gram flour (RBF) and skim milk powder (SMP), 0, 5 and 10%, the optimized level was selected for the preparation of mango and banana fruit leather, respectively. The effect of acidity (0.30, 0.45 and 0.60%, as citric acid) and TSS (20, 25 and 30O brix.) was studied on the sensory attributes (colour, texture, flavour and texture) of fortified mango and banana Fruit Leather. The results indicated that 5% level of RBF and SMP in mango and banana Fruit Leather, respectively gave better sensory attributes. The acidity and TSS, adjusted to 0.60%& 30 Obrix for fortified mango pulps and 0.45%& 25 Obrix for fortified banana pulps resulted into the products of superior quality in terms of sensory attributes. The fortified Leather were found to be richer in protein and minerals in comparison to plain Leather and also found to be superior in terms of OAA having score of 8.5 and 8.1 in comparison to plain mango and banana bar with the sensory OAA score of 7.8 and 7.5, respectively.

Fig 5: Fortification of peach leather with soy

The peach-soy leather was prepared from different blends of peach pulp and soy-slurry. The peach pulp and soybean slurry were blended in the ratios of 100:0, 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30. The prepared leather was stored for a period of four months to ascertain changes in physico-chemical and sensory characteristics. The analysis of leather revealed significant differences among different blends. Highest moisture content i.e. 21.99 percent was recorded in B1 (100:0:: P:S). The highest TSS and acidity of 12.05 degree Brix and 2.77 percent were recorded in B1 (100:0:: P:S), respectively, whereas the highest reducing sugar and total sugar contents of 30.16 and 60.41 percent were found in B1 (100:0:: P:S), respectively. The highest protein and fat contents were recorded in B7 (70:30::P:S), whereas ascorbic acid content was the highest (23.54 mg 100g-1) in B7 (70:30:: P:S). Sensory evaluation of leather revealed that the highest score of 8.14 was recorded in B4 (85:15::P:S) and lowest score of 5.63 was recorded in B7 (70:30::P:S). In general there was an increase in TSS, acidity and sugars and decrease in protein, fat and ascorbic acid contents and all sensory attributes during four months storage in different blends of leather.

Fortification of Mango Leather with Desiccated Coconut Powder

Mango (*Mangifera indica* L.) belongs to the family Anarcardiaceae. It is named as 'king of fruits and national fruit of India. Mango has good nutritional value and every 100 g of mango fruit pulp contains 81.7 g water, 16 g carbohydrate, 0.7 g protein, 0.4 g fat and 0.1 g fibres. It is also considered to be a good source of β-carotene and vitamin A, C, B-complex, minerals and anti- oxidants (Bose and Mitra, 2001; Ravani and Joshi, 2013). Due to its perishable nature, mango cannot be stored for longer time and consumed as fresh. In order to enhance the availability during off season, mango pulp can be converted as many processed products like soft drinks, juice, nectar, squash, RTS beverages, jam, jelly, powder, mango bar and canned mango slices (Hashmi *et al*., 2007; Hussain *et al*., 2003; Pruthi, 1992; Kalra and Tandon, 1985). Among different processed products, fruit bar is one of the processed products which are thick, pleasant and dried product made from fruit pulp having high calorie and rich source of the vitamins and minerals. Food can be fortified with nutrients either in powder or liquid form and the nutrients addition must impart desirable characteristics to the food i.e., change in colour, taste, smell, texture and increase shelf life. With this view, a study was conducted to observe the changes in chemical and organoleptic parameters and standardize fortified mango bar with DCP (Desiccated coconut powder) during storage.

Effect of Packaging and Storage

Kumar *et al*. (2007) prepared guava leather to study its storage stability in four packing materials: polypropylene (PP), butter paper (BP), metalized polyester polyethylene (MPP), and aluminum foil (AF) under ambient and low temperature conditions. During storage, the moisture content of the product decreased significantly under ambient conditions while it increased slightly under low temperature conditions. The products packed in MPP and AF showed the minimum loss of moisture. During storage period, it was also found that the acidity of guava leather increased more than under low temperature conditions.

A 40–50% reduction in vitamin C was observed under ambient conditions irrespective of the packaging material. The storage of guava leather in different packing materials invariably increased the reducing sugar content during storage under low and ambient temperatures. It was concluded that the samples stored in MPP retained a higher percentage of nutrients and minimum microbial counts at the end of storage under both conditions. The organoleptic rating was also higher for the samples stored in MPP. Polypropylene could not be compared with MPP or AF wrappers but, after considering economic conditions, it could be used for a shelf-life of one to two months. However, even though AF packaging was easy to use, the development of pin holes during handling rendered it unsuitable for packaging the guava leather product.

The quality of apple leathers with and without potassium metabisulphite (KMBS) during storage was evaluated by Quintero Ruiz *et al*. A KMBS-added formulation satisfactorily maintained the quality characteristics of apple leathers without microbial development over a 7-month storage period. The browning index (BI) was observed to increase during storage at C. This increase was especially moderate in the KMBS-added leather. A first-order kinetic model gave the best fit for the browning data. The antioxidant activity (AA), determined over storage and expressed as chlorogenic acid equivalents, decreased by 47% during the 7-month period at C in the control formulation, while losses in the KMBS-added formulation were considerably lower, 15.9% of theinitialvalue.AnacceleratedstorageexperimentoftheKMBS-addedformulationat Call owed the estimation of the effect of storage temperature using a coefficient of 2.55 for BI and16.3 for AA. According to these values, browning would be the storage-limiting parameter at or below C.

Water Activity

The thermodynamic properties and sorption equilibrium of a pestil were studied by Kaya and Kahyaoglu. They illustrated that water activity was one of the most important quality factors for long-term storage because the changing water activity directly affected all chemical and microbial deterioration reactions.

Kaya and Maskan determined the water vapor permeability (WVP) of pestil (a fruit leather) made from boiled grape juice with starch at three different temperatures (15, 25, and C) and different relative humidity (RH) values (31 to 76%). After exposure to the high RH environment, the thickness of the film was increased, showing the adsorption of water by the leather itself. It was found that the water vapor transmission rate (WVTR) and WVP of pestil were strongly affected by the changing RH and temperature. The effect of RH on WVP became more pronounced with increasing temperature.

Babalola *et al*. (2002) evaluated the effect of cold temperature storage on the quality attributes of pawpaw (papaya) and guava leathers. The calorific content, water activity, pH, and total mould count in pawpaw leather were significantly higher than those in guava leather throughout the duration of storage. However, the guava leather had a higher texture. Sensory scores in relation to the period of storage showed that guava leather gave better results in overall acceptability at zero, one, and two months of storage at C. The guava leather was accepted better based on better sensory qualities in fruitiness, smell, chewiness, toughness, color, and overall acceptability when various cold storage temperatures were considered during storage.

Effect of Packaging on Durian Fruit

The effects of types of packaging materials on the physicochemical, microbiological, and sensory characteristics of durian fruit leather during storage were studied by Irwandi *et al*. (1998). The study was carried out over 12 weeks at room temperature using four types of packaging materials: laminated aluminum foil (LAF), high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polypropylene (PP) film. They found that LAF had the lowest decrease in water activity and changes in moisture content so that it could maintain the desired textural characteristic of fruit leather. Low-density polyethylene resulted in the highest changes in moisture and water activity.

The type of packaging materials and storage time had significant effects on the nonenzymatic browning of durian leather with LAF having a lowest decrease in color quality while LDPE showed the highest degree of browning. Both the type of packaging materials and storage time affected the texture significantly by increasing its hardness during storage. The laminated aluminum foil maintained the desired texture well while samples packed in LDPE had the greatest increase in hardness up to eight weeks.

The acidity level fluctuated during storage. The packaging materials and storage time both significantly affected microbial growth during storage. Laminated aluminum foil seemed to be the best material to inhibit growth of the mesophilic bacteria, moulds, and yeasts.
However, the largest increase in microbial counts was in the LDPE. Panelists gave the lowest scores for texture, appearance, aroma, and overall acceptability to the LDPE-packed samples and the highest score to the LAF-packed samples. These results related to the water vapor characteristics of the packaging material. However, organoleptically, all four packaging materials were acceptable.
Vijayanand *et al*. (2002) assessed the storage stability and packaging requirements of a guava fruit bar prepared using a new process that gave better texture and sensory properties. A mango bar was also prepared as a comparison in this experiment. The bars were packed separately in two materials: PP (polypropylene) and BOPP (biaxially oriented polypropylene). The polypropylene had a water vapor transmission rate (WVTR)of6×10−3 kg/m2/dat90% RH, 38 °C and an oxygen transmission rate (OTR) of 35 × 10−3 L/m2/d atmosphere at 25 °C. The biaxially-oriented polypropylene had a water vapor transmission rate of 4 × 10−3 kg/m2/d at 90% RH, 38 °C and an OTR of 2.5 L/m2/d atmosphere at 25 °C. Guava and mango bars had similar textural characteristics initially that reduced after three months of storage at ambient conditions. The nonenzymatic browning of both guava and mango bars increased significantly after 60 days of storage. The overall quality of both the guava and mango bars packed in BOPP and PP decreased significantly at the end of 60-day storage because the bars absorbed moisture. However, the guava and mango bars packed in pearlized BOPP or PP were sensorily acceptable with respect to color, flavor, texture, and overall quality for up to 90 days at 27 °C and 65% RH and for up to 30 days at 38 °C and 92% RH.

Table 1: Attempts were made to develop and fortify the fruit leather for which different proportions of fruit pulp

S. No.	Name of the Fruit	Fortified With	References
1.	Papaya	Soy	Chan Jr. and Cavaletto (1978)
2.	Peach	Soy	B. Anju, K.R. Kumari (2004)
3.	Jamun	Iron	(Khanum *et al*., 2018)
4.	Mango	Bengal Gram	K. Prasad 2009 [1]
5.	Banana	Bengal Gram	K. Prasad 2009 [1]
6.	Mix Fruit Leather	Moringa Olifera	Thiruvengadam.*et al*. (2014)
7.	Mango	Desiccated coconut Powder	Jenish H. Parekha *et al*. (2000)

Conclusions

Fresh fruits are known to be excellent sources of vitamins, minerals, fibers, carbohydrates, and other bioactive compounds. Fruit leathers provide attractive, colored, and flavorsome products for people. A variety of researches have been carried out to study the effects on fruit leathers of different methods of preparation, different drying conditions, and packaging and storage conditions.
For the method of preparation, most fruit leathers were prepared by sorting, washing, peeling, and seed removing, and then cutting into slices which can be pureed or pulped easily. Purees are heated, boiled, or blanched in a water bath in order to inactivate the enzymes. Additives such as sugar, pectin, acid, glucose syrup, and color are often added before or during blending. The additives include potassium metabisulphite, sodium bisulfite, sodium metabisulphite, sucrose, soy protein and skim milk powder, corn syrup, and starch. These ingredients are mixed with the fruit puree to make fruit leathers with a higher quality, longer storage, or better organoleptic quality than the original fruit. Most fruit leathers are dried at 30 to 80 °C, especially at 50 to 60 °C for up to 24 hours or until they have reached the final moisture content of 12–20% (w.b.).
Various drying systems are used in making fruit leather depending on what fruits are being dried and how the products are designed. Combined convective and far-infrared drying provided a shorter drying time due to its higher heat and mass transfer coefficients. Hot air drying, including oven drying, forced-air cabinet drying, and thin-layer drying, is widely used and the time taken depended on the drying temperatures and sample thicknesses. Microwave drying reduced the sample mass rapidly and has a very short drying time. Solar drying included cabinet drying, solar tunnel drying, and sun drying. Solar cabinet dryers were well suited to drying small quantities of fruits; solar tunnel drying was a forced convection mixed-mode solar dryer which collected solar radiation from the atmosphere to input solar radiation into solar tunnel dryer. Sun drying is simple but lengthy and unhygienic.

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