www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 2099-2105

www.thepharmajournal.com
Received: 03-02-2022
Accepted: 09-03-2022

Mishmeet Kaur
Department Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India

Promila Godara
Department Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Mishmeet Kaur
Department of Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India

Various drying processes for fruit leathers preparation and its effects on quality of fruit leathers

Mishmeet Kaur and Promila Godara

Abstract
Fruit leathers also known as fruit slab is a product made by using fruit puree or fruit pulp which is made by removing moisture from the fruits which is also known as the process of dehydration. Fruit leathers are very nutritious in nature, not only nutritious but fruits get more attractive any colourful after getting dehydrated. The process of drying or dehydrations begins by taking out the puree or pulp from the fruit. Then the process continues by adding some additives like some nutrients like vitamins, carbohydrates, proteins, and colour, sugar etc. to maintain the level of nutrition which generally gets lost during the process of dehydration. Dehydration can be done through various processes like hot air drying, vacuum drying, microwave drying, cabinet drying, solar drying etc. this research paper will briefly explain some of the methods and their effect on different physical parameters like colour, texture, moisture content etc.

Keywords: Drying, fruit leathers, microwave drying, solar drying, vacuum drying, hot-air oven drying

1. Introduction

Fruit Leathers are fruit product made up of fresh fruit pulp or puree after a sophisticated operation that involves a dehydration step. Fruit leathers are called a fruit slab, a dehydrated fruit-based confectionery dietary product which is sometimes eaten as snack or dessert. It's chewy and flavourful, naturally low in fat and high in fibre and carbohydrates. Fruit leathers are often considered as "pure," "sun-dried," and "rich in vitamins" are accustomed describe them. There are large numbers of fruit leather products available on the market, like mango leather, apricot fruit leather, grape leather, berry leather, kiwifruit leather, and jackfruit leather. Also, mixed fruit leathers like guava and papaya fruit leather are available. It's also lightweight and easily stored and packed. Consuming fruit leather is an economic substitute for natural fruits as a source of various nutritional elements. Furthermore, fruit leather has only 100 kcals per serving, than many other snacks. They contain sufficient amounts of dietary fibres, carbohydrates, vitamins, antioxidants and other nutrients. The temperature used for dehydrating fruit leathers is 40-800C (Lemuel M. Diamante, Xue Bai, and Janette Busch, 2014) [16] for 24 hours. The dehydration process continues till the moisture content in fruit leathers reaches12-20%. The tactic for creating fruit leathers starts from washing, peeling and pulping. After pulping, the tactic of dehydration takes place. Before dehydration process fruit puree is mixed with some ingredients like sugar, pectin, acid, and colour so dried into sheet-shaped products. The sugar gave the merchandise a sweeter taste and increased the solids content; then pectin was accustomed thicken the pulp, modify the flexible texture, and make sure the retention of the shapes of the dried product Fruit pulp is dehydrated using various processes like, microwave drying, solar drying, hot air drying, sun drying etc. Transforming the natural fruit structure in dehydrated fruit leathers form makes the merchandise very attractive and vibrant. Moisture is much aloof from the wet purees, which are usually laid on an oversized flat tray until the fruit puree or fruit pulp with additives changes into cohesive "leathery" sheets. However, the quality is somewhat sick with the varied drying methods used and storage condition. Sun drying is that the only method of drying foods. Sun drying permits the last word product to possess a translucent appearance, a customary colour, and a gummy texture. However, there are disadvantages, sort of a protracted drying process, exposure of the products to environmental contamination, dependency on climate, and hand labour requirements that the tactic of sun drying is least preferred. Therefore, alternative drying methods were developed to beat the problems of hygiene and time, as these methods are rapid, safe, and controllable, as an example, conventional methods of drying like hot air oven drying cause heavy antioxidant loss. These losses of antioxidants are more obsessive about drying temperature rather than drying time. Another method are often microwave drying.

Microwave drying are faster than the new air oven drying (conventional methods). But this drying method can affect the colour of the fruit. as an example, if the drying is performed by microwave-vacuum drying then the colour of the fruit puree/pulp are visiting be slightly lighter than that of other methods like microwave-air drying that the physiochemical properties of fruit leathers are often preserved by using modern drying techniques carefully keeping all the parameters in mind like time of drying and method used within this growing market of fruit leathers, commercial packaging is extremely important. Packaging materials for fruit leather are required to prolong the shelf-life of the merchandise and, normally, relate to the soundness of water activity, microbiological stability, sensory properties, and physicochemical characteristics This paper will highlight the effect of varied drying methods over different forms of fruit leathers and might briefly explain how these drying techniques will effect different parameters like colour, moisture content, texture, etc.

2. Methods of preparation (fruit leathers)

The general method for preparation of fruit leathers begins with preparation of the fruit puree with or without mixing other ingredients before drying. The basic procedure may vary depending upon type of fruit used, the nature of the other ingredients and lastly, the drying method used. Then the other ingredients are mixed with the puree/pulp made using the fruit. That mixture is then poured into the trays and the trays are further proceeded for drying. After drying that puree or pulp is converted into leathery like structure known as fruit leathers. Given below is the flow chart which represents the processing of fruit leathers-

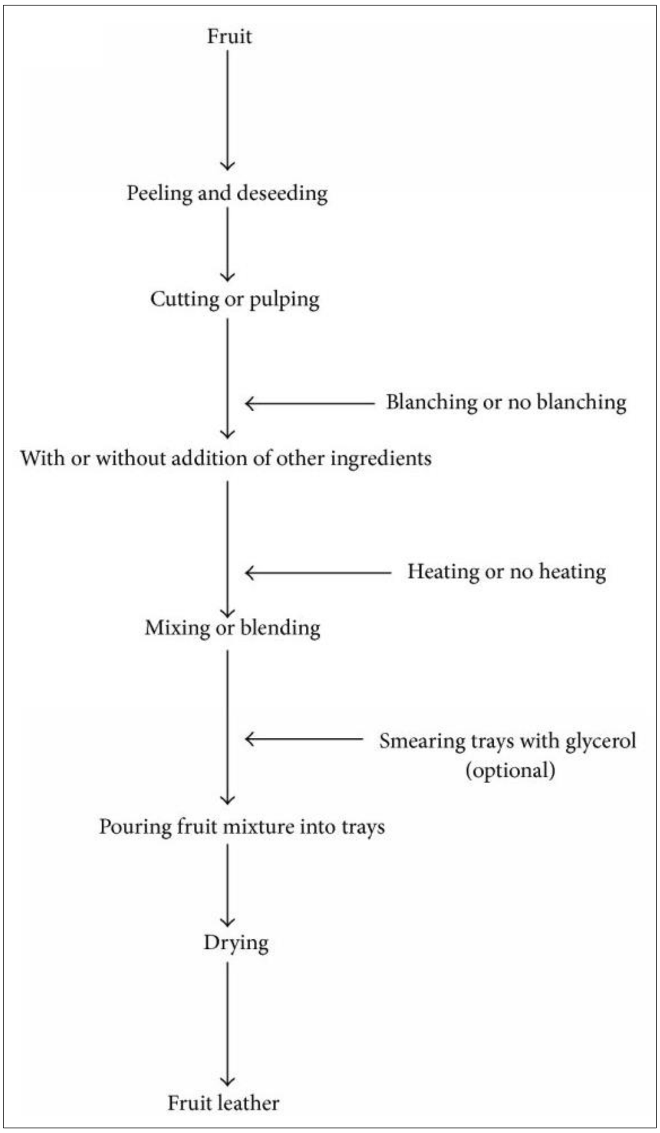

Fig 1: Processing of fruit leather

3. Drying methods used for preparation of fruit leathers

Drying or dehydration is a process of removal of moisture content from a product. Various methods can be used for drying or dehydration of a product like solar drying, sun drying, vacuum drying, microwave drying, and hot-oven drying etc. Various fruit leathers are prepared using these drying methods by drying out the fruit puree or pulp.

3.1 Solar drying

3.1.1 Preparation of jackfruit

Study showed the variation in the properties of which occurred due to the usage of different drying techniques while the major focus was on accessing the outcome of the particular solar drying method. The fruit used in this examination was Jackfruit (*Artocarpus heterophyllus* lam).

The choice of using jackfruit for this study was really on point as the usage of raw jackfruit comes with various challenges and thus the effective production of good quality fruit leather can aid in preventing losses and producing good quality products. After successful production of fruit leathers from the various drying methods, all bathes were judged on the basis physiochemical properties such as moisture content, colour and texture: furthermore, the batches were tested for overall acceptability by performing sensory evaluation. After comparison of the properties it was found that solar drying was able to achieve desired levels of reduced moisture level and had similar effects on the texture as well but there was lack in the colour and reduced overall acceptability. Solar dried fruit leather had its negatives such as long drying time, susceptibility to contamination from various organisms and is also liable for undergoing reactions such as browning reactions. Solar drying can be used for small scale home level production but it is not appropriate for industry level production.

3.1.2 Preparation of peach

Peach leather aids in providing a quality peach product throughout the year. Peach leather is formed with the help of dying the peach puree, solar drying was used to dry the product which were used to various parameters such as moisture, moisture distribution, texture, colour, flavour, aroma, microstructure and rehydration rate. After comparing the results of different drying methods attributes it was found that Infrared dried peach leather was having the best flavour, colour and physiochemical properties among solar drying, microwave drying, hot air drying, vacuum drying etc. However for faster processing Microwave drying is an option as it accomplished the drying of peach leather in shortest of time but the other attributes were compromised to a small extent.

Table 1: Effect of solar drying over various fruits

S. NO.	Fruit leathers	Effect on color			Texture	Reference
		L*	B*	A*		
1	jackfruit	_	_	4.20± 2.03	0.94± (0.121)a	[16]
2	Peach	0.89	1.42	0.456	_	[2]

3.2 Vacuum drying

3.2.1 Preparation of rose hip pestils

For the advancement of fruit leathers, a formulation containing rose hip pulp, plant product and citric acid were used as initial material for the drying process. Three dehydration techniques were tested: forced hot air, infrared and vacuum, all administered at 60 and 70 °C (Quintero Ruiz NA, Demarchi SM, Giner SA 2014) [3]. All techniques led to flexible, clear fruit leathers at each temperature. Color and Water activity were not changed with this dehydration method nor by the temperatures tested. Organic process parameters corresponding to inhibitor capability (TEAC) and content of synthetic resin substances were measured. The most effective retention was achieved with vacuum drying at 60 °C being of 57.5% and 25.1%, respectively. ESEM observations were conducted to assess the result of drying techniques and conditions on microstructure of leathers. Numerous extents of sucrose crystallization were inferred from surface images. Cross-sectional micrographs showed that amount of pores was decreased the drying however not by temperature in the range studied.

Triplicate drying experiments had been performed at 60 and 70 °C for every of the 3 techniques utilised, to provide a complete of 18 drying tests. The very last look of rose hip leather-based for dried through hot air at 70 C. For hot air (convective warmth transfer), vacuum (predominantly conductive heat transfer) and infrared drying (radiation warmth transfer), the drying time, that is, the time frame elapsed from drying begin to the attainment of a very last moisture content material of 0.25 kg water kg1 dry matter, numerous within side the variety of a hundred sixty five to 460 min, being the shortest drying time found for vacuum drying at 70 °C and the longest, for hot air at 60 °C. Hence, higher temperatures lead to shorter drying times in fruit leathers, and the method providing the largest driving force for mass transfer was vacuum drying, in agreement with authors that compared mass transfer mechanisms in similar foods.

For the nutrition-related characteristics studied in this work, AN interacting impact of technique and temperature allowed to pick vacuum drying at sixty °C because the combined condition resulting in the very best retention.

3.2.2 Preparation of blueberry

The effects of two-stage fruit processing on the standard of natural blueberry leather are reported (Chen Y, Martynenko A 2018) [4]. This study demonstrates a two-stage processing of a natural blueberry leather from blueberry fruits and investigated the effect of various pureeing and drying methods on the standard of the ultimate product. Although HTD processing resulted in slight reduction of anthocyanin and formation of polymeric colour, it completely inactivated enzymes, resulting in less degradation of bioactive compounds during vacuum drying. On the contrary, high enzymatic activity of pulp processed by CB resulted in rapid quality degradation during drying. Therefore, all drying methods significantly increased the antioxidant activity of blueberry pulp. Freeze and vacuum drying of HTD processed blueberry puree at vasoconstrictor (50 and 60C) preserved most of the bioactive compounds, including anthocyanins and other polyphenols, whereas higher temperature (80C) resulted in thermal degradation. Regarding colour, freeze drying resulted within the most favorable appearance of blueberry leather, followed by vacuum drying and EHD drying. The negative effect of EHD drying on bioactive compounds and colour of blueberry leather may be attributed to ozone, which is powerful oxidant. Although EHD drying revealed a negative effect on quality, significant reduction of enzyme activity was observed when blueberry puree was exposed to 20kV field. This beneficial effect may well be attributed to direct effect of EHD on proteins. Therefore, further studies are needed for industrial application of EHD drying to supply natural foods with premium quality. The study suggested two-stage production of natural blueberry leather: HTD pureeing and enzyme inactivation, followed with forced-air drying at temperature below 65C for better quality preservation.

Table 2: Effect of vacuum drying over various fruits

S. NO.	Fruit leathers	Effect on color			Texture	Reference
		L*	B*	A*		
1	Blueberry	37.85 ± 0.55	6.56 ± 0.19	3.84± 0.13	_	[4]
2	Rose hip	48.77 ± 0.63a	30.49 ± 0.22	18.80± 0.49	Chewiness – 8.16 ± 1.16ab	[11]

3.3 Hot-air drying
3.3.1 Preparation of medlar fruit
Hot-air drying treatments were performed with a cupboard type laboratory dryer with the technical features of 220 V, 50–60 Hz, 200 W. The temperature and ratio within the dryer was measured by temperature sensor (± 2 C) and ratio sensor (± 2%). Drying technique significantly affected total drying duration so as to get the ultimate moisture content. Vacuum drying at 60 degree C–300 m bar had the longest duration with 230 min while microwave of 180 W had the shortest one with 15 min (Abraham-Juarez MDR, Olalde-Portugal VÍCTOR,; 2019) [14]. Microwave drying spared the time by causing fast dissipation of water. In hot air drying, the time required to scale back the moisture was found higher at 70 degree C with 115 min than 60 degree C with 175 min at a relentless drying air with 20% ratio. Several authors reported that, increasing drying temperature accelerates the drying process, thus shortens the drying time like in pomegranate rose hip leathers. Hot air drying is taken into account better.

3.2.2 Preparation of plum
This study conducted by Abhinash Singh *et al*. regarding the production of plum (Prunus domestica) fruit leather by using varying concentration of the major ingredients such as sugar and the pulp. The technique used was thin-layer hot air drying also with variance in temperature. This study focuses on standardizing a ratio for the concentration of the pulp and sugar. Various time-temperature combinations were tested to identify the best suitable for production of plum fruit leather while attaining the best possible quality parameters and desirable traits. Six different batches were made with different Pulp: Sugar ration T1(50:50), T2(60:40), T3(70:30), T4(80:20), T5(90:10) and T6(100:0) and were dries at temperatures (60° C, 70° C, 80° C). Thereafter the sensory properties were evaluated on the basis of (9 point Hedonic scale by a group of panellists. Furthermore the physiochemical and microbiological tests such as TSS, Reducing sugar, Titratable acidity, pH, and moisture content and total plate count were also conducted to identify the best suitable combination. Study revealed that the sample of Plum leather prepared on the 70 ºC was exhibited better sensory score for the colour, taste and overall acceptability as it maintained the nutritional profile as well as was able to provide good quality output. The standardization of most palatable recipe was done by evaluating sensory properties and highest score was obtained by sugar: plum batch T3 (70:30). The plum leather contained comparatively higher amount of ascorbic acid (5.05mg/100g), TSS (78.38mg/100), moisture content (14.30%), pH (5.864) and titratable acidity (1.60). The leather was found most stable when packaged in Low Density Polyethylene (LDPE) pouches during storage as compared to High density Polyethylene (HDPE).

Table 3: Effect of hot-air drying over various fruits

S. NO.	Fruit leathers	Effect on color			Texture	Reference
		L*	B*	A*		
1	Medlar fruit	35.36 ± 0.25c	18.92 ± 0.27	19.34± 0.25	Chewiness-7.66 ± 0.51ab	[11]
2	Plum	28.6 ± 0.1	10.8 ± 0.1	11.3 ± 0.1	_	[15]

3.4 Microwave drying
3.4.1 Preparation of pestils
Evaluation of drying methods used in food industry, displays various methods for drying like hot air oven drying, vacuum drying, thin layer drying etc. Microwave drying is one of these drying methods used for the dehydration of fruit leathers, with various focal points like higher drying rate, homogeneous energy conveyance on the material and preferable process control. On contrary, there are some disadvantages of this method like unequal warming, textural harm and its high installation costs. Before the process of drying, preparation of fruits takes place by washing, peeling, pitting and then homogenizing with a blender. Then process of boiling is carried out for few minutes. This cooked mixture is then prepared for drying process by spreading it evenly on a sheet.
Microwave drying was conducted in a domestic microwave oven with the technical features of 230 V–50 Hz and maximum output of 800 W. Drying is performed at 90 and 180 W microwave power levels. In this sample (pestils) is placed on a greaseproof paper and is then placed on the rotating glass plate in a microwave drying was applied for 16-60 minutes depending upon microwave power level (Senem Suna, 2019) [16]. During drying, the rotating glass plate is removed from the microwave oven at 1-5 minutes interval and weighed using a digital balance.
Microwave drying spared the time by causing fast removal of water from the sample. If we observe the color, then the general colour of pestils (sample) is yellowish orange. But microwave drying has the negative effect on the color component as after drying process the color of the sample gets lighter. The antioxidants and the phenolic content also gets reduced.

3.4.2 Preparation of peaches
Peach is a delicious summer fruit cultivated in China. It is the third most important fruit worldwide and 55% of the world‟s peaches are produced in China. Microwave drying is one of the most fast and efficient moisture removal processes. It is a better process than infrared and hot air drying in terms of speed and energy efficiency. Microwave drying is known to be heat independent of temperature gradient between surface and internal part. (S. M. Roknul Azam, Min Zhang; Chung Lim Law and Arun S. Mujumdar, 2018) [8]. Even though Microwave drying is a faster mean of drying fruits and vegetable, overheating, scorching, puffing, arching etc.

problems have been reported to affect the final product quality.
The microwave-assisted hot-air dryer is a custom-built, which operates at maximum frequency of 2450 MHz and microwave power level of 1200 W.
In this experiment, airflow rate of 1 ± 0.1 m s−1 and temperature of 70 ± 0.5°C were maintained. The microwave cavity was 327 mm x 370 mm x 207 mm in size, and it consists of a rotating glass plate with 280 mm diameter at the base of the dryer. The glass plate rotates at 5 r min−1 (S. M. Roknul Azam, Chung Lim Law, and Arun S. Mujumdar and 2019) [8].
The color of dried peach leather was measured with a colorimeter (CR-400, Konica Minolta Co. Japan). The experiment was replicated five times. The value for the color is expressed in terms of *L** (whiteness/darkness), *a** (redness/greenness), and *b** (yellowness/blueness) (S. M. Roknul Azam, Min Zhang, Chung Lim Law and Arun S. Mujumdar, 2018) [8]. The aroma profiles of dried fruit leather were measured using an electronic nose (iNose102; Isenso, Ruifen Trading Co. Shanghai, China). Metal oxide semiconductor sensors combined with pattern recognition algorithms were used to construct the intelligent bionic olfactory system. Sample data were recorded for time 150 s. A total of 3.0 g dried peach leather was cut into smaller pieces (±0.5 cm) and inserted into glass tube fitted with plastic cap, then rested for 5 min before the analysis was carried out.
Generally, color parameters are considered as an indicator of the degradation of important compounds. The highest *L** (whiteness/darkness), value was obtained from Microwave drying that is 51.55. Peach leathers dried by microwave drying gave the highest darkness and redness. Comparing with the fresh PP color, microwave drying samples exhibited the most color change. In the beginning of the drying process the outer surface dried out much faster than the core and thus and resulted case hardening and exhibited finer surface (Nasri F 2020) [1]. Microwave drying sample has more pores per unit area than samples dried using other methods. Due to transformation of sugar and hence resulted in increase in bitterness in e-tongue methods to analyze the taste, microwave drying is not suitable method as it causes bitterness in fruit leather.
On the basis of drying kinetics, microwave drying was found to accomplish the drying of peach leather in shortest operating time.

3.4.3 Preparation of pomegranate
Pomegranate is one of the most widely produced fruits grown in Antalya, with more than 300,000 tons of fruits harvested in 2014, according to the Turkish Statistical Institute. This production is constantly increasing due to developments in agricultural practices. Although several products such as jam and sour or dried arils are produced from the pomegranate, it is mostly consumed in the form of fresh fruit or fruit juice.
Microwave-assisted hot air drying (90 or 180 W) were carried out in an oven (Siemens HB86K575, Germany) maintained at 50 ºC, 60 ºC and 70 ºC. The air velocity of the oven was 1.5 m/s, Microwave power levels were determined by IMPI 2-L test. The microwave frequency was 2450 MHz. The moisture content of the samples was determined by drying in an air oven at 70ºC for 24 hours according to the Turkish standards (TSE, 2000). Water activity measurements were performed at 25ºC using (4TE, Decagon Devices, Inc, Pullman, WA, USA) water activity meter, pH was determined using a pH meter (S20 Seven Easy, Mettler Toledo, Columbus, OH, USA). It was determined in terms of L*, a* and b* colour scale. The properties of texture were determined using a TA.XT 2Plus (Stable Micro Systems, Surrey, UK). Sample of 2.5 cm diameter and approximately 1.5 mm thickness were cut from the dried pestil and were subjected to texture profile analyses.
A moisture content of pestil below 15 g/100g not only prevents microbial growth but also retards other deterioration reactions (Suna *et al*., 2014). The pestil of pomegranate was therefore dried to a moisture level of 10–12 g/100g. Initially, the L, hue angle and chroma values of the pestil were in the ranges 29.08–32.51, 35.19–46.72 and 15.60–23.57 respectively. After microwave drying at different temperatures (50 ºC, 60 ºC and 70 ºC), reported values of L for pomegranate pestil leather is in the range 34.19–39.19.
The texture of the pestil was evaluated in terms of hardness, springiness and chewiness; these were determined to be 8.37–27.06 N, 0.87–0.93 N and 5.60–23.67 N.s respectively. Therefore, a marked decrease in hardness and chewiness was observed when determined with microwave drying. This decrease could be related to the gaps and channels formed during heterogeneous and fast moisture diffusion under these drying conditions.

3.4.4 Preparation of blackthorn
Blackthorn fruit is reported to be native to Turkey, Armenia and Southern Europe. The fruit has got a sour taste. Blackthorn fruits are rich in components with anti-oxidative properties such as β-carotene, ascorbic acid, polyphenols and anthocyanin. The paste mixture with the moisture content of 1.13 g water/g dry base was dried by microwave drying until the moisture content fell down to 0.06 g water/g dry base.
Microwave drying experiments were performed at two levels i.e. 90 and 180 W. Samples, placed on greaseproof paper were removed from the dryer at 5 and 2 min intervals during the drying processes for 90 and 180 W, respectively and their weights were saved using the digital scale. The colour of pestil of blackthorn sample was measured by using a Chroma Meter (Osaka, Japan) in accordance with L* a* b* system. The value for the color are expressed in terms of *L** (whiteness/darkness), *a** (redness/greenness), and *b** (yellowness/blueness) (Karabacak AÖ; 2019) [9]. On the bases of these parameters, Chroma and hue angle indicates color intensity, and color changes during drying respectively. Antioxidant capacity of the samples were measured by DPPH (2, 2-diphenyl-1-picrylhydrazyl), The Ferric Reducing
Ability of Plasma and Cupric Ion Reducing Antioxidant Capacity methods (Katalinic *et al*.; Benzie and Strain; Apak *et al*.). To reach the demanded moisture it took 14 minutes at 180 W by using microwave drying method. When the temperature in microwave drying is increased the drying time gets reduced. The values of effective moisture diffusivity (Deff) were found to vary in the range of 5.55 × 10−8 to 8.13 × 10−7 m2 /s for microwave drying at 180 W, respectively. The increase in drying temperature in microwave power caused the highest Deff values. This increment in Deff values can be related with the increasing vapour pressure inside the product that made the moisture diffusion towards the surface faster. Color is a crucial quality parameter for the determination of consumer preference. Color is a crucial quality parameter for the determination of consumer preference. In comparison with paste mixture, L* (lightness)

values significantly increased in the pestil samples. On the other hand, when compared with paste mixture, blackthorn pestils had lower redness due to the reduction in a* (redness) and Chroma values after drying. Samples dried with microwave drying has the lowest a* (redness) and C* (Chroma) values.

The shortest drying time was obtained from microwave drying at 180 W. All color parameters (L*, a*, b*, C* and h°) changed depending on the drying methods. However the color quality after drying gets degraded. Therefore, microwave drying is a fast drying process but not an optimum drying method as quality of fruit leather (blackthorn) decreases.

3.4.5 Preparation of mulberry

Mulberry, grape, apricot, and plum are the most popular fruits produced as pestil. In Turkey, mulberry pestil is the most common one with mulberry fruit (*Morus alba* L.) production number of 74,383 tons in the year of 2017. Mulberry is rich in bio-active components as well as the palatable and low-calorie features. It has also anti-cholesterol, anti-diabetic and anti-oxidative health beneficial effects. Drying of food is a combined thermal process including concurrent heat and mass transfer in the product. Advantages of food drying are in-corporate enzyme and microbial inactivation, shelf life prolongation, enhanced digestibility, and bioavailability of phenolic and anti-oxidants as well as the negative effects like the loss of desirable nutrients. Microwave drying experiments are conducted in a domestic microwave oven (Bosch, HMT72G420, Munich, Germany) with the technical properties of 230 V -50 Hz and maximum output of 800 W. The aspects of the microwave cavity are 520 × 479 × 341 cm in size. Drying procedures were completed at 90 and 180 W. 25g of mulberry pestil samples stated on greaseproof paper were put on the plate and drying was applied between 8 and 45 min according to the power level. During drying, plate was taken out at 5 and 2 min intervals, respectively, at 90 and 180 W and weighed using the same digital balance.

Color measurements of the mulberry pestils are determined over the outer surface of the samples using a Chroma meter (Konica Minolta CR-5, Bench-top, Japan). L*, a*, b* values were viewed as lightness/darkness, redness/greenness, and yellowness/blueness severally. L*, a* and b* values were utilized to determine Chroma and hue angle to character- size, color changes amid drying. The textural features of the pestil samples were analysed using a TA. XT 2Plus (Stable Micro Systems, Surrey, UK) (Tontul and Topuz 2017) [7]. The hardness, springiness, chewiness, gumminess, and adhesiveness of the mulberry pestils were determined from the analyses. Extractions were carried out. Antioxidant capacity of the samples was measured with 2- diphenyl-1-picrylhydrazyl (DPPH), method.

The drying time required to remove the moisture content of mulberry pestils from the primary value of 0.87 g water/g dm. to a final value of 0.06 g water/g dm. were 8, 45, 115, 125, 190, and 210 min, at the drying treatments of 90-180W of microwave (Suna S, Özkan-Karabacak A 2019) [10]. For microwave drying at 90 W constant rate period was observed after a short increased rate period. The increase in drying temperature for microwave drying caused to higher drying rates for mulberry pestils. The impacts of drying treatments on textural properties of mulberry pestils are like the highest hardness values were obtained from microwave drying sample. Mainly, drying temperature raised the springiness value, whereas microwave power did not cause any significant effects on it. Chewiness is defined as the amount to pretend the energy needed for chewing a semisolid sample to a stable status of swallowing. Higher drying temperature and microwave power caused a decrement in moisture content resulting with an increase in chewiness. In the conclusion, the findings are that the first and the second shortest drying times were obtained from microwave treatments of 180 and 90 W, respectively. Additionally, the highest effective moisture diffusivity was observed from microwave drying. It was concluded that microwave drying was found more feasible for mulberry pestil production.

Table 4: Effect of microwave drying over various fruits

S. NO	Fruit leathers	Effect on color			Texture	Reference
		L*	B*	A*		
1	Pomegranate	29.08–32.51	35.19–46.72	15.60–23.57	Hardness – 21.48 to 8.37 Chewiness – 17.97 to 5.60	[7]
2	Blackthorn	24.46-4.50	0.37-0.42	1.89-2.05	_	[10]
3	Peaches	51.55	37.17	12.75	Hardness force- 0.579 kg.	[8]
4	Mulberry	31.44- 35.42	14.10- 19.06	7.75- 8.15	A decrement in moisture content resulting with an increase in chewiness	[10]
5	Medlar pestil	35.5- 42.03	19.01-24.54	18.94-19.61	Pestils have poor sensory qualities after microwave drying.	[11]

4. Conclusions

Fresh fruits are known to be excellent source of macro and micro nutrients like vitamins, minerals, fibre, protein, carbohydrates, water etc. when these fresh fruits are converted into fruit leather it not only enhances the nutrition level of product but makes it more colourful and attractive. Fruit leathers are often considered as a food as this product contains only 100 kcals per serving, than many other snacks. Fruit leathers are nutritious and organoleptically acceptable to consumers. For the strategy of preparation, most fruit leathers were prepared by sorting, washing, peeling, and seed removing, then cutting into slices which might be pureed or pulped easily. Purees are heated, boiled, or blanched in a water bath so as to inactivate the enzymes. Additives like sugar, pectin, acid, glucose syrup, and colour are often added before or during blending. These ingredients are mixed with the fruit puree to create fruit leathers with a better quality, longer storage, or better organoleptic quality than the initial fruit. Most fruit leathers are dried at 30 to 80∘ C, especially at 500 to 600 C (Lemuel M. Diamante, Xue Bai, and Janette Busch, 2014) [16] for up to 24 hours or until they need reached the ultimate moisture content of 12–20%. During this paper four varieties of drying techniques are mentioned solar drying, vacuum drying, hot air drying, and microwave drying and their effect on various fruits leathers like strawberry, pear, plum, blackthorn, mulberry, peaches, kiwi and lots of more.

The effect of those drying methods on various parameters of fruit leather like colour, moisture content, texture, has also been mentioned. Hot air drying, including oven drying, is widely used and also the time taken relied on the drying temperatures and sample thicknesses. Microwave drying reduced the sample mass rapidly and includes a very short drying time. Solar drying includes cabinet drying, and sun drying. Solar cabinet dryers were similar temperament to drying small quantities of fruits; solar tunnel drying was a forced convection mixed-mode solar dryer which collected radiation from the atmosphere to input radiation into solar tunnel dryer. Sun drying is straightforward but lengthy and unhygienic. We will conclude that microwave drying shows the fastest results for drying but the standard of product gets bit degraded thanks to massive amount of warmth used as compared to hot air drying, vacuum drying and solar drying.

5. Reference

1. Nasri F. Solar thermal drying performance analysis of banana and peach in the region of Gafsa (Tunisia). Case Studies in Thermal Engineering. 2020;22:100771.
2. Mkhathini KM. Effect of maturity and postharvest handling of prunus persica 'landrace' produced in KwaZulu-Natal: case study of physicochemical properties, tunnel solar drying and quality of processed products (Doctoral dissertation), 2017.
3. Quintero Ruiz NA, Demarchi SM, Giner SA. Effect of hot air, vacuum and infrared drying methods on quality of rose hip (Rosa rubiginosa) leathers. International Journal of Food Science & Technology. 2014;49(8):1799-1804.
4. Chen Y, Martynenko A. Combination of hydro thermodynamic (HTD) processing and different drying methods for natural blueberry leather. LWT. 2018;87:470-477.
5. Concha-Meyer AA, D'Ignoti V, Saez B, Diaz RI, Torres CA. Effect of storage on the physico-chemical and antioxidant properties of strawberry and kiwi leathers. Journal of food science. 2016;81(3):C569-C577.
6. Sarkar T, Salauddin M, Hazra SK, Chakraborty R. Effect of cutting edge drying technology on the physicochemical and bioactive components of mango (Langra variety) leather. Journal of Agriculture and Food Research. 2020;2:100074.
7. Tontul I, Topuz A. Effects of different drying methods on the physicochemical properties of pomegranate leather (pestil). LWT. 2017;80:294-303.
8. Roknul Azam SM, Zhang M, Law CL, Mujumdar AS. Effects of drying methods on quality attributes of peach (*Prunus persica*) leather. Drying Technology. 2019;37(3):341-351.
9. Karabacak AÖ. Effects of different drying methods on drying characteristics, colour and *in-vitro* bioaccessibility of phenolics and antioxidant capacity of blackthorn pestil (leather). Heat and Mass Transfer. 2019;55(10):2739-2750.
10. Suna S, Özkan-Karabacak A. Investigation of drying kinetics and physicochemical properties of mulberry leather (pestil) dried with different methods. Journal of Food Processing and Preservation. 2019;43(8):e14051.
11. Suna S. Effects of hot air, microwave and vacuum drying on drying characteristics and *in vitro* bioaccessibility of medlar fruit leather (pestil). Food Science and Biotechnology. 2019;28(5):1465-1474.
12. Abraham-Juarez MDR, Olalde-Portugal VÍCTOR, Ceron-Garcia A, Sosa-Morales ME. Hot air drying kinetics of thin layers of prickly pear fruit paste. Sains Malaysiana. 2019;48(2):361-367.
13. Singh A, Sonkar C, Shingh S. Studies on development of process and product of plum fruit leather. Studies, 2019, 4(5).
14. Diamante LM, Bai X, Busch J. Fruit leathers: method of preparation and effect of different conditions on qualities. International journal of food science, 2014.