Development of Nutrient Rich Fruit Leather of Kiwi, Guava, and Dragon Fruit and its Quality Assessment

Aditya Saskar, Aditya Gadekar, Aditya Panure, Aditya Gaikwad
School of Food Technology, MIT Art, Design and Technology University, Pune, India

Corresponding author- Prerana.shere@mituniversity.edu.in

Abstract

A fruit leather is a dehydrated snack made entirely of fruit pulp. The purpose of this study was to develop fruit leather from kiwi, guava, and dragon fruit. We assessed its physical, textural and sensory properties We modified the fruit pulps to 16-20°Brix by addition of sugar and pectin. We heated the mixture at the 80 degrees Celsius mark then dried it 60 degrees Celsius for seven hours. The final products possessed moisture content within the range of 11.8% and 13.2%. All the samples were found to be carbohydrate rich. Guava leather was higher in protein and dietary fibre than other alternatives. The fat content in each sample was low. There were clear differences in colour and texture. The leather of the dragon fruit was red, whereas that of kiwi was light-coloured with some greenness. Guava leather was tougher and chewier whereas the texture of dragon fruit was soft and smooth. The sensory analysis indicated that all the samples were liked. They had pleasant taste, mouth-feel, and overall quality. To sum up, kiwi, guava, and dragon fruit could successfully make fruit leathers with good nutritional value and quality as per the study. The potential products can be used commercially.

Keywords

Fruit leather, Kiwi, Guava, Dragon fruit, Drying, Nutritional composition, Texture, Sensory evaluation

1.Introduction

Of late, due to enhanced health awareness and changing food habits, the demand for healthier, convenient and minimal processed food products has steadily risen. Snacks made from fruit, in particular, have become quite popular as they pack in nutrients and are easy to eat. One common dehydrated product is fruit leather, which is produced commercially from fruit pulp into a thin flexible sheet. Its sweetness, texture and longevity, apricot is a value addition in processed foods made by removal of moisture. Production of fruit leather is an effective way of using surplus and highly perishable fruits and thus minimize post-harvest loss and add value. The type of fruit and the processing conditions has a large impact on the quality of fruit leather. The texture, stability, and acceptability of the final product are deter-mined by factors like the addition of hydrocolloids, pasteurization, and controlled drying. The fruit leather's physicochemical and sensory properties are greatly affected due to presence of many chemical components like different kinds of sugars, organic acids, dietary fibre and other bioactive compounds in various fruits. Thus, the choice of right fruits is important to get the desired qualities in taste, texture, colour and nutritional quality. Assessing each of the fruits can help understand how the individual fruit is contributing to the final product properties. A several studies are there on fruit leather preparation from different fruits. However, limited work has been carried on a comparative evaluation of kiwi, guava, and dragon fruit for fruit leather development. Although each of these fruits has its own nutritional and functional properties, little is known about their individual behaviour in fruit leather processing. For this reason, the study was carried out to formulate individual fruit leather from kiwi, guava, and dragon fruit under controlled processing conditions. The physicochemical attributes of moisture content, pH, total soluble solids, proximate composition, colour characteristics, texture profile, and sensory attributes were assessed for the developed products. The objective of the study is to evaluate the suitability of the specified fruits for the development of a snack that is more nutritionally rich and acceptable.

2. Nutritional and Functional Characteristics of Selected Fruits

2.1 Kiwi (*Actinidia deliciosa*)

Kiwi, scientifically known as Actinidia deliciosa, is a very nutritious fruit packed with vitamin c and antioxidants potential. Along with these properties, dietary fiber, and potassium, and some naturally occurring organic acids like citric acid and malic acid also give this fruit its slight sour taste. With the assistance of these acids, low pH has been effective in inhibiting micro-organism growth and enhancing the stability of processed products. Kiwi fruit is also known for its high levels of bioactive compounds such as polyphenols, flavonoids and carotenoids that give it a strong antioxidant capacity and help improve immunity and lower oxidative stress. According to Nishiyama, kiwi fruit provides vitamin C and phenolic compounds, which significantly enhances antioxidant activity. (Nishiyama, 2007) In the same vein, Stonehouse et al. (2013) noted that regular consumption of kiwi aids in digestion and helps the immune system due to its nutrient content. Kiwi contains the enzyme actinidin and soluble fiber that affects the consistency of the fruit pulp from a functional point of view. While processing, uniform dryer is achieved with the help of these components. To this end, kiwi is helpful in the formation of fruit leather with a smooth texture and uniform structure. Demonstrated by Richardson et al. (2018), the presence of actinidin helps digest proteins as well as improve the bioavailability of nutrients.

2.2 Guava (*Psidium guajava*)

Guava is a fruit that is highly nutritious with a high amount of dietary fibre and vitamin C. Calcium and iron are also in maize which enhances its nutritional value further. Also, guava is categorized as a functional fruit due to the bioactive substances it possesses (carotene, flavones and phenol compounds) with antioxidant, anti-inflammatory and anti-microbial properties. According to Jiménez-Escrig et al. (2001) guava is a good source of soluble and insoluble food fibre and antioxidants. According to Thaipong et al. 2006, guava is another antioxidant-rich fruit due to the presence of phenolics in its composition. Guava helps in keeping the body healthy and free of diseases. The natural pectin in guava fruit is one of the functional properties of guava. Pectin Used for Foods Applications. Pectin plays an important role in gel formation for thickening and stabilizing the processed food. Guava fruit leather will have a firm but a bit tender texture which helps in giving strength and slightly chewy texture to the fruit leather. Additionally, its mild sweetness and flavor enhance the taste and acceptability of the product. Thakur et al. (1997) reported that pectin enhances the texture and gel formation of a fruit-based product..

2.3 Dragon Fruit (*Hylocereus polyrhizus*)

Hylocereus polyrhizus fruit. The dragon fruit is a plant fruit species that is noted for its beautiful and colourful appearance. The fruit takes on red or pink color from its natural pigments known as betacyanins. These antioxidants are prone to wilting and instill the fruits with value. Dragon fruit is concentrated with antioxidants such as polyphenols, flavonoids and vitamin C other antioxidants provide antioxidant, anti-inflammatory, and also antimicrobial benefits with amazing health benefit. As noted by Esquivel (2008), dragon fruit contains betacyanins which may have antioxidant and oxidative stress-reducing outcomes. Besides, Wu et al. (2006) explained that dragon fruit is high in phenolic compounds and antioxidant activity. The dragon fruit has not only pigmentation but also dietary fibre, vitamins and many other bioactive components. When used to make fruit leather, it results in a softer texture and smoother mouthfeel than with other varieties. Due to its slight sweetness, it can help counteract the acidity of certain fruits, such as kiwi, for a smoother mix. As per Jamilah et al. (2011), the dragon fruit pulp had a lower structural fibre content due to its soft texture.

3. Materials and Methods

3.1 Materials

Ripened dragon fruit (Hylocereus polyrhizus) guinea (Actinidia deliciosa) and guava (Psidium guajava) were procured from one of the local markets at Loni Kalbhor, Pune, India. The fruits we used in the study were chosen carefully having uniform ripeness, freshness, colour and no visible physical damage or spoilage condition so that there is uniformity in the study. Fruit leather was prepared using food-grade ingredients like sugar (sucrose), pectin, citric acid and ascorbic acid. Pectin was added to achieve desired product texture, while citric acid and ascorbic acid were introduced in the process to preserve acidity, reduce browning, and overall integrity of the final product during and after storage. Chemicals and reagents used for analytical evaluation were of laboratory grade and suitable for food analysis experiments.

3.2 Methodology

3.2.1 Preparation of Fruit Pulp

At first, all fruit was washed in clean running water to remove the dirt and surface soils. Subsequently, the fruits were peeled as well as chopped into smaller sizes for blending Fruits were blended separately to further get a smooth uniform pulp of each fruit.

3.2.2 Formulation of Fruit Mixture

The pulp of every fruit has been prepared individually and mixed with selected ingredients in controlled quantity. The sweetness and overall acceptability had been improved by adding sugar while pectin was used for gelation and texture. In order to keep the juices tart and improve their consistency, citric acid has been added, while ascorbic acid has been impleded the helps reduce browning plus enhance the pulp's natural colour with its antioxidant effect.

3.2.3 Heating Treatment

The mixture of fruit pulp was slightly heated to around 80°C for a short period of time. This process has minimized microbial action in our ingredients, resulting in a product that is safer and more stable without a marked loss of nutrients.

3.2.4 Drying Process

The pulp was heated, and then uniformly spread on lighted greased trays to form a thin layer. The trays were subsequently placed in a hot air dryer at approximately 60 °C for a duration of 6–7 hours. Drying will continue until a flexible non-sticky sheet similar to fruit leather appears

3.2.5 Cutting and Storage

After sequencing the process of drying, the sheets of fruit leather were cooled down. Thus, the sheets were cut pieces, aluminum foil (which absorbs moisture) was wrapped on them and stored at room temperature for further processing.

Processing Flow

Fruit (Dragon fruit / Kiwi / Guava)
↓
Cleaning and Peeling
↓
Pulp Preparation
↓
Addition of Sugar, Pectin, Citric Acid, and Ascorbic Acid
↓
Heating (80°C for few minutes)
↓
Spreading on Trays
↓
Drying (60°C for 7 hours)
↓
Cutting
↓
Fruit Leather

Fig 1. Processing Flow Chart for Kiwi, Guava and Dragon Fruit Leathers

3.3 Proximate Analysis

The Proximate analysis was carried on individual fruit leather samples by using standard analytical procedures for moisture, protein, fat, crude fiber, ash and carbohydrate. The samples were dried in a hot air oven at 105°C, until constant weight to obtain the moisture content. The Kjeldahl method was used to measure nitrogen to estimate the crude protein content. A standard Soxhlet solvent extraction procedure was used to determine the crude fat content. Likewise, incineration of samples in a muffle furnace at a high temperature until the organic matter was completely removed estimates crude ash content. The standard acid and alkali digestion methods under laboratory conditions were used to estimate crude fiber content. The moisture, protein, fat, ash, and crude fiber values were determined, and total carbohydrate content was calculated by difference. In order to carry out the analyses using standard methods, AOAC (2019), Ranganna (2009) analysis were performed.

3.4 Mineral and Calcium Analysis

The fruit leather samples were subjected to mineral analysis using standard methods. The samples were heated in a muffle furnace at high temperature to remove organic matter and obtain inorganic mineral residue through dry ashing. The subsequent ash was dissolved in a suitable acid solution. Calcium estimation was carried out using standard titrimetric methods and the other mineral elements were estimated using suitable methods as per laboratory availability. The techniques are essentially used to evaluate the mineral composition of food samples (AOAC, 2019; Ranganna, 2009). All the analyses of the food samples were done in the laboratory as per standard procedure.

3.5 Sensory Evaluation

Sensory evaluation of the fruit leather samples was carried out using a panel of semi-trained assessors. The samples were evaluated for key sensory attributes including colour, taste, texture, aroma, and overall acceptability .A 9-point hedonic scale was used for assessment, where a score of 9 represented "like extremely" and a score of 1 represented "dislike extremely." Each panelist was provided with coded samples under controlled conditions to avoid bias during evaluation.The scores obtained from the panelists were recorded and used for further statistical analysis to determine consumer acceptability of the product. This method of sensory evaluation is widely used in food studies and has been described by Fellows (2017) and Meilgaard et al. (2007)

3.6 Statistical Analysis

All the experiments were done in triplicate analysis for accuracy, reliability, and reproducibility of results. The results obtained were expressed as mean ± SD. The data will be subjected to One Way ANOVA for the analysis of samples. The researchers highlighted the significance level at $p < 0.05$. As explained by Montgomery (2013) and Snedecor and Cochran (1989), this statistical technique is widely used in food research for analysis of experimental data and in determining variations of samples

4. RESULTS AND DISCUSSION

4.1 Influence of Temperature on Drying Rate

In the present study, drying temperature had a significant ($p < 0.05$) effect on moisture removal of all individual fruit leather samples. Drying at lower temperature 40 °C was relatively slow which resulted in higher residual moisture content (18.5–19.2%). The drying with slower speed may have been due to the lower heat transfer and moisture diffusion from the fruit surface to air. With drying temperatures of 50°C and 60°C, moisture content significantly reduced (17.2–18.0% and 11.8–13.2%, respectively). When the temperature is increased, the drying efficiency is improved due to the presence of a larger vapor pressure difference and greater moisture migration in the fruit. Out of the drying temperatures tested, it was found that 60°C was the most appropriate for drying because it effectively removed moisture with acceptable product quality. Maskan (2001) and Vega-Gálvez et al. (2009) reported similar findings, whose results showed an improvement performance of drying at moderate drying temperatures with only a minor impact on quality. Drying was faster at this temperature, resulting in less moisture content (10.5-11.2%). Nonetheless, the fruit leather samples showed darkening and chewiness traits which were noticeable quality changes. Due to increasing temperature effects, degradation of natural pigments and hardening of the structure can take place. Vega-Gálvez et al. (2009) and Ahmed et al. (2007) have reported similar effects on colour and texture deterioration of high drying temperature. The reduction of moisture content with temperature improved the drying heat and mass transfer. However, the excessive temperature deteriorated the overall quality of fruit leathers.

Fig 2. Drying Curve Of Kiwi Leather

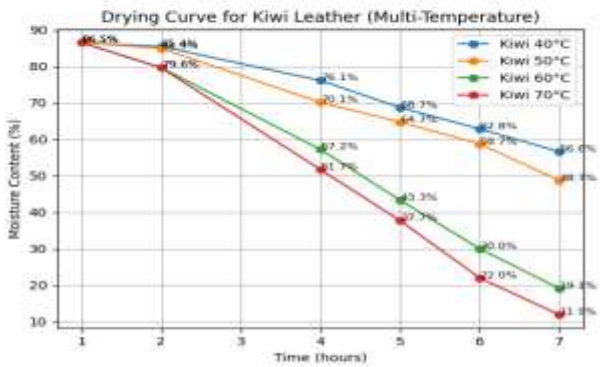
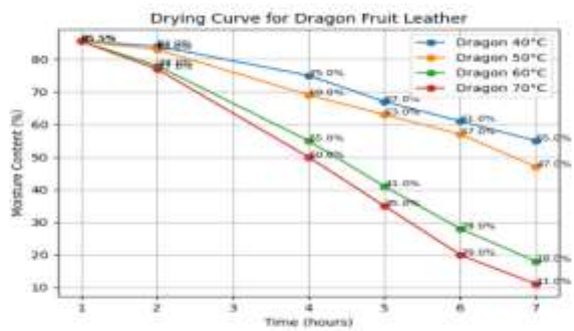


Fig 3. Drying Curve Of Guava Leather

Fig 4. Drying Curve Of Dragon Fruit Leather



4.2 Comparative Nutritional Profiling of Pulps and Leathers

4.2.1 Comparative Nutritional Profiling of Pulps and Leathers

The proximate composition of kiwi, guava and dragon fruit pulp showed noticeable differences in the present study due to their natural variation in nutritional composition. Guava pulp is more remarkable than kiwi and dragon fruit pulp for being comparatively richer in protein and dietary fibre. The higher levels of structural carbohydrates, including pectin and cellulose, may explain why they have a higher fibre concentration. The fiber content of the kiwi pulp was moderate and vitamin C was relatively high which can possess antioxidant potential. On the contrary, dragon fruit pulp has a relatively lower protein and fat content that could be due to its softer tissue structure and moisture content. Nonetheless, this contributed valuable bioactive compounds and antioxidants. USDA FoodData Central (2020) noted comparable variations in nutrient composition among these fruits, observing that guava has a higher fiber content and protein than many other fruits. Esquivel (2008) reported that dragon fruit has lower protein levels and instead is rich in bioactive compound betalains. According to Singh and Heldman (2014), the differences in proximate composition of fruits are largely due to differences in the cellular structure, moisture and biochemical composition.

Table 2. Proximate Composition of Raw Fruit Pulps(Per 100gm)

Parameter	Kiwi Pulp	Guava Pulp	Dragon Fruit Pulp
Moisture (%)	83.0 ± 0.3^{b}	80.5 ± 0.4^{c}	84.2 ± 0.3^{a}
Energy (kcal)	61.0 ± 0.5^{b}	68.0 ± 0.6^{a}	60.0 ± 0.5^{c}
Carbohydrates (g)	14.7 ± 0.2^{a}	14.3 ± 0.3^{a}	13.0 ± 0.2^{b}
Protein (g)	1.10 ± 0.05^{b}	2.60 ± 0.08^{a}	1.20 ± 0.06^{b}
Fat (g)	0.50 ± 0.02^{b}	1.00 ± 0.04^{a}	0.40 ± 0.02^{c}
Dietary Fiber (g)	3.00 ± 0.10^{b}	5.40 ± 0.15^{a}	3.00 ± 0.10^{b}
Ash (g)	0.60 ± 0.03^{b}	0.70 ± 0.04^{a}	0.50 ± 0.03^{c}

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at $p < 0.05$

4.2.2 Proximate Composition of Fruit Leathers

The study significantly altered the proximate composition of the individual fruit leather samples with respect to the pulp (control). The most significant change was a drop in moisture content with a corresponding rise in carbohydrates, dietary fibre, protein, and other solids after drying. The drying of hot air desiccated moisture has taken up free water. This will bring concentration of the nutrients on a dry weight basis in the fruit matrix. Thus, the rise in proximate values is largely a concentration effect rather than a real increase in quantity. Diamante et al. (2014) noted similar observation as moisture is reduced to a greater extent while the nutrients are concentrated during leather processing. According to Maskan (2001), drying reduces moisture content, thus stabilizing fruit-based products. Of the samples, guava leather had relatively higher fiber and protein content, which contributed to its firmer texture and structural stability. This can be due to its natural pectin and fibre content. Kadam et al. (2012) reported similar findings since fibre and protein retention was much higher in guava leather. According to Singh and Heldman (2014), dehydration works by reducing moisture level and increasing relative concentration of nutrients. Compared to the others the fat and protein content of dragon fruit leather was on the lower side and also it was softer which could be due to less structural fiber content and softer pulp matrix. The nutritional composition of kiwi leather is fairly balanced and contains moderate presence of carbohydrates, protein and dietary fiber. The fruit leather samples mainly showed variations because of the natural composition of each fruit..

Table 3. Proximate Composition of Fruit Leathers (Per 100gm)

Parameter	Kiwi Leather	Guava Leather	Dragon Fruit Leather
Moisture (%)	12.5 ± 0.2^{b}	12.8 ± 0.3^{b}	11.8 ± 0.2^{c}
Energy (kcal)	250.0 ± 1.5^{b}	265.0 ± 1.8^{a}	240.0 ± 1.4^{c}
Carbohydrates (g)	62.0 ± 0.5^{b}	65.5 ± 0.6^{a}	60.0 ± 0.5^{c}
Protein (g)	3.50 ± 0.10^{b}	5.20 ± 0.15^{a}	3.00 ± 0.10^{c}
Fat (g)	1.50 ± 0.05^{b}	2.00 ± 0.06^{a}	1.20 ± 0.05^{c}
Dietary Fiber (g)	8.50 ± 0.20^{b}	11.20 ± 0.25^{a}	7.80 ± 0.20^{c}
Ash (g)	2.00 ± 0.08^{b}	2.30 ± 0.10^{a}	1.80 ± 0.07^{c}

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at $p < 0.05$

4.3 Colour Analysis

The current study showed significant changes in the colour parameters (L*, a*, and b*) of the individual fruit leather samples in comparison to their original fruit pulp (control) and between the various fruit samples. The difference results from the drying as well as the exogenous pigment composition of the fruit. Dragon fruit leather has a smaller lightness value indicating it's darker than those of guava leather and kiwi leather which record the highest L* value as compared to the other sample. The lighter color of the dragon fruit leather could be attributed to the pigment's concentration and partial thermal degradation during drying. Ahmed et al. (2007) reported similar observations, who explained that the drying temperature could reduce lightness due to browning reaction and pigment decompositions. The chromaticity of dragon fruit leather was associated with the positive values of a*. This indicates that it strongly favours red as this pigment is betacyanin. On the other hand, a* value of kiwi leather was negative indicating that its green colour comes from chlorophyll pigments. According to Esquivel (2008), who reported similar findings, betacyanins are in charge of the intense red colour in dragon fruit and are sensitive to processing conditions. According to the b* values, kiwi leather presented the highest yellowness probably related to the presence of carotenoid pigments and chlorophyll changes during drying. The other samples exhibit lower b* values, signifying lower contributions of yellow pigments in them. Pathare et al. (2013) observed similar effects of natural pigments and thermal processing conditions on the values of L*, a* and b*. The increase in colour parameters changes observed in this study compared to the control may be attributed mainly to pigment concentration, thermal degradation, and structural changes as a result of drying, whereas the differences among the samples are due to the pigment composition of each fruit.

Table 4. Colour analysis of fruit Leather (L ,a ,b)

Sample	L* (Lightness)	a* (Red/Green)	b* (Yellow/Blue)
Kiwi Leather	48.3 ± 0.6[a]	-6.5 ± 0.3[c]	21.4 ± 0.5[a]
Guava Leather	42.5 ± 0.5[b]	4.2 ± 0.2[b]	12.8 ± 0.4[b]
Dragon Fruit Leather	35.7 ± 0.4[c]	15.8 ± 0.5[a]	5.2 ± 0.3[c]

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at $p < 0.05$

4.4 Texture Analysis

The texture profile of the individual fruit leather samples significantly differed from the fresh fruit pulp (control) and from each other after drying in the present investigation. The removal of moisture and the natural structure of each fruit caused these changes in texture. Guava leather has a higher hardness than kiwi and dragon fruit leathers, which means it is more firm-structure. The higher concentration of fiber and pectin during drying makes the set hard due to the presence of a compact matrix. Bourne (2002) made similar observations and explained that increased hardness was due to increased fiber and hydrocolloid content. Ahmed and others (2007) also state that drying results in structural tightening that leads to firmness. There was a similar trend in the case of cohesiveness values where guava leather displayed the highest cohesiveness owing to the tightly packed internal layer of the pectin gel network. On the other hand, dragon fruit leather was less cohesive and this could be due to having less fiber and lower structural matrix. Bourne (2002) similarly spoke about a composition–internal bonding relationship for fruit-based products. The springiness values for all samples were in a very narrow range showing their acceptable elasticity and ability of the fruit leathers to recover after deformation. This indicates that the samples' elastic properties were not negatively influenced by the drying process. Guava leather had the highest chewiness and gumminess values, while dragon fruit leather had the lowest. The differences are directly related to hardness and cohesiveness, since the first parameter affects hardness and the second cohesiveness. Bourne (2002) and Ahmed et al. (2007) described similar correlations among parameters of texture profiles. The hardness, chewiness, and cohesiveness of all fruit leather samples were significantly higher than the control. Moreover, similar differences were also observed in the elasticity of fruit leathers. This is because of loss of moisture and concentration of structural components such as fiber and pectin. The differences among the fruit leather samples are due to their natural composition.

Table 6. Texture Analysis of Fruit Leather

Sr. No.	Sample	Hardness (N) (Mean ± SD)	Cohesiveness (Mean ± SD)	Springiness (Mean ± SD)	Chewiness (N) (Mean ± SD)	Gumminess (N) (Mean ± SD)
1	Guava Leather	28.5 ± 0.8[a]	0.62 ± 0.02[a]	0.78 ± 0.02[a]	13.8 ± 0.5[a]	17.7 ± 0.6[a]
2	Kiwi Leather	24.2 ± 0.7[b]	0.58 ± 0.02[b]	0.81 ± 0.02[a]	11.4 ± 0.4[b]	14.0 ± 0.5[b]

3	Dragon Fruit Leather	20.6 ± 0.6^{c}	0.35 ± 0.01^{c}	0.76 ± 0.02^{a}	8.6 ± 0.3^{c}	11.3 ± 0.4^{c}

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at p <

4.5 Shelf Life Analysis of Fruit Leather During Storage

Fruit leather's shelf-life evaluation for storage. In the current investigation, a gradual increase in microbial load and water activity level of individual fruit leather samples during storage was observed as compared to initial (day 0) condition. By day 42, the total plate count (TPC) increased from 2.1 log CFU/g to 5.1 log CFU/g, and it was observed that yeast and mould counts were consistently increasing during storage. The increasing microbial load could be due to moisture uptake from the surrounding environment, in addition to the product's nutrient availability which facilitates microbial growth over a period of time. Increases in water activity (aw) on the rise from 0.58 to 0.72 supports this. Higher water activity creates more favourable conditions for microbial growth, especially yeast and mould. ICMSF (2005) made similar case that and that there is a strong relationship between water activity levels in food products and microbial growth. The FAO (2018) noted that the absorption of moisture during storage can affect the shelf stability of dehydrated food. The microbiological characteristics of the fruit leathers remained stable during a 30-day experimental period, after which fermentation by yeasts could be detected. Prolonged storage and increased aw might promote the growth of microbes when combined together. Demarchi et al. (2013) and Dhaliwal (2015) reported similar shelf life trend in fruit leather and other dried products, where the longer storage raised significant microbial load, due to expose to the environment. In general, compared to control (initial day), microbial load is greater because of increased water activity and longer storage period which gradually reduce product stability and favour microbial development.

Table 5. Shelf Life Analysis of Fruit Leather During Storage

Storage Period (Days)	Total Plate Count (log CFU/g)	Yeast & Mould Count (log CFU/g)	Water Activity (aw)
0	2.1 ± 0.1^{d}	1.2 ± 0.1^{d}	0.58 ± 0.01^{d}
7	2.6 ± 0.1^{c}	1.5 ± 0.1^{c}	0.61 ± 0.01^{c}
14	3.2 ± 0.2^{c}	1.9 ± 0.1^{c}	0.64 ± 0.02^{c}
21	3.9 ± 0.2^{b}	2.4 ± 0.1^{b}	0.67 ± 0.02^{b}
30	4.5 ± 0.2^{b}	2.8 ± 0.2^{b}	0.70 ± 0.02^{b}
42	5.1 ± 0.3^{a}	3.3 ± 0.2^{a}	0.72 ± 0.03^{a}

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at $p < 0.05$

Results of sensory evaluation of the individual fruit leather samples were evaluated for colour, taste, texture, aroma and overall acceptance. The natural composition of each fruit along with the effect of drying and formulation ingredients such as sugar and pectin significantly influenced these variations. Guava leather has relatively higher scores for texture and overall

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acceptability among samples. It may have a firmer texture and better mouthfeel due to naturally occurring high pectin and dietary fibre content of the carrot. Consumers expressed a preference for guava due to its balance of sweetness and flavour. The research shows that guava-based fruit leather is acceptable according to Kadam et al. (2012). The kiwi leather received higher scores for taste and colour due to its refreshing taste and attractive greenish-yellow colour. Organic acids and natural flavour compounds may have contributed to these sensory characteristics that make the fruit acceptable. Due to betacyanin pigments, dragon fruit leather was found to be good colour acceptable. Nevertheless, a softer texture than guava leather slightly lowered texture scores of dragon fruit leather. Esquivel (2008) and Ahmed et al. (2007) reported similar observations in terms of pigment contribution and sensory quality. All the samples of fruit leather had good sensory acceptability indicating the suitable utilization of kiwi, guava and dragon fruit for the preparation of acceptable consumer-friendly fruit leather products. Diamante et al. (2014) and Fellows (2017) also reported similar enhancement in flavour and sensory quality post-dehydration.

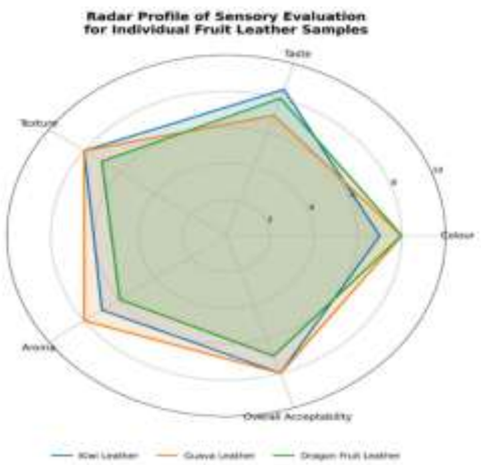
Table 8. Sensory Evaluation of Individual Fruit Leather Samples

Sample	Colour	Taste	Texture	Aroma	Overall Acceptability
Kiwi Leather	7.0 ± 0.2^{b}	8.5 ± 0.3^{a}	8.0 ± 0.2^{a}	7.0 ± 0.2^{b}	8.0 ± 0.2^{a}
Guava Leather	8.0 ± 0.3^{a}	7.0 ± 0.2^{b}	8.0 ± 0.3^{a}	8.0 ± 0.2^{a}	8.0 ± 0.3^{a}
Dragon Fruit Leather	8.0 ± 0.2^{a}	8.0 ± 0.2^{ab}	7.0 ± 0.3^{b}	6.0 ± 0.2^{c}	7.0 ± 0.2^{b}

Table Note

The mean and standard deviation were calculated with 3 data repetitions. According to one-way ANOVA, different superscript letters in each row indicated significant different at $p < 0.05$

Fig.5 Radar Profile of Sensory Evaluation Attributes of Individual Fruit Leather Samples



5. Conclusion

The present study successfully demonstrated the development and evaluation of individual fruit leathers prepared from kiwi (Actinidia deliciosa), guava (Psidium guajava), and dragon fruit

(Hylocereus polyrhizus). The findings revealed that both the type of fruit and the processing conditions significantly influenced the physicochemical, sensory, textural, and storage properties of the final products.Drying temperature played an important role in moisture removal and overall product quality. Although higher temperatures accelerated the drying process, excessive heat negatively affected colour and texture. Among the tested conditions, 60°C was found to be the most suitable drying temperature, as it provided effective moisture reduction while maintaining desirable product characteristics.

Nutritional analysis showed that dehydration resulted in concentration of nutrients, particularly carbohydrates and dietary fiber. Guava leather exhibited comparatively higher protein and fiber content, contributing to better nutritional and structural properties. Kiwi leather maintained a balanced nutritional profile, while dragon fruit leather contributed mainly to visual appeal and functional properties because of its natural pigments and bioactive compounds.

Colour analysis confirmed that natural pigments strongly influenced the appearance of the fruit leathers. Dragon fruit leather showed intense red coloration due to betacyanins, kiwi leather displayed greenish-yellow tones, and guava leather exhibited moderate colour values. Texture profile analysis further indicated that guava leather possessed higher hardness, chewiness, and cohesiveness, resulting in a firmer structure, whereas dragon fruit leather showed a comparatively softer texture.

Shelf life analysis demonstrated a gradual increase in microbial load and water activity during storage. However, the fruit leather samples remained microbiologically safe and acceptable for up to 30 days under ambient storage conditions.

Overall, the study confirms that kiwi, guava, and dragon fruit can each be effectively utilized for the preparation of nutritious and shelf-stable fruit leather products with desirable quality characteristics. Among the samples, guava leather showed superior nutritional and textural properties, while kiwi and dragon fruit leathers contributed distinct sensory and visual characteristics.

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