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ORIGNAL ARTICLE

Effect of Various Drying and Dehydration Techniques on The Organoleptic Quality of Mango Leathers

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ABSTRACT

Background: Mango is known as the king of fruits. It has several varieties however, some are more popular in the country including Sindhri. Each variety has its significance when used in different food products. The pulp of mango is used for developing jams, beverages, chutney (dips) etc., and sometimes preserved with some additives to be used for the production of mango leather. In general, the application of drying techniques to fruit puree yields a stable shelf-life product called fruit leather, which is of soft rubbery texture with a sweet taste and especially dehydrated.

Objectives: To analyze the effect of various drying techniques (i.e. sun drying, oven drying, and dehydration) on the organoleptic quality (i.e. quality that affects how a consumer experiences the food via their senses e.g. look, taste, smell, and touch) of mango leather.

Methodology: A drying experiment was performed like sun drying, hot air oven drying, and commercial dehydrator to determine the effect of drying times on the quality of mango leathers using these techniques. The effect of the storage period was also studied for the quality of mango leathers. The dried mango leathers were sensory analyzed by the trained panelists.

Results: A minimum drying time of 8-10hours was achieved in a commercial dehydrator for mango fruit leather at 70°C. It was also observed that despite the longer dehydration time, the mango leathers produced remained equally acceptable compared to other dehydration techniques. The mango leathers dried in dehydrater at 70°C ± 2°C gave the highest score of color (6.20), texture (6.13), flavour/taste (5.88), appearance (5.88), and overall acceptability (5.85), while mango leather dried in an oven at 70°C ± 2°C has recorded a score of color (5.93), texture (5.87), flavour/taste (5.77), appearance (5.53), and overall acceptability (5.70). The storage of mango leathers had also a significant effect ($p < 0.05$) in the storage period of mango leathers as compared to control. A non-significant difference was also observed in all the organoleptic parameters after 10-12 weeks of storage.

Conclusion: It is obtained from the current study that for the production of mango leather, the commercial dehydrator based drying techniques results in acceptable sensory characteristics as well as longer storage period by comparing other drying techniques, as it has a controlled environment.

Keywords	*Address of Correspondence	Article info.
Mango leathers, Commercial dehydrator, Hot oven drying, Sun drying, Sensory characteristics.	*kparkash707@gmail.com*	*Received: April 18, 2021* *Accepted: June 11, 2021*

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INTRODUCTION

Mango (*Mangifera indica* L.) is known as the king of all fruits. Pakistan is ranked as the 5th largest country in terms of world mango production. It is 2nd prime fruit of the country followed by citrus. In Pakistan, major mango growing provinces are Punjab and Sindh. It shows abundant market presence in the months of May, June, and July which is also the peak harvesting period. Greater than 200 types of mangoes are cultured in Pakistan. Chaunsa and Sindhri are the most well-known varieties in the country. However, its production is low due to insufficient and unstable fertilization, high water table, salinity, and deficiency of acceptable plant safety actions. The pulp of mango is used as a basic ingredient to develop jams, juices, sauces, chutneys (dips), and preserved with just intent of raw material for the development of delicacies like pastries fillings or cake toppings instead of its sole utilization as fruit leather. This is the reason that in Pakistan, more industries focus on the preservation of mango pulp as compared to its processing for other purposes[1]. Using chemicals either alone or in combination for preservation is mainstreamed in Pakistan, which helps to prevent microbiologically safe and rancidity or oxidation-free shelf-stable fruit preserves[2]. At times, chemical preservation is accompanied by storage at very low temperatures, which in case of prolonged duration calls for surface decay by discolouration and texture deterioration named as chilling injury[3].

The drying process involves the elimination of water from food either naturally or artificially with measured situations so that the attack of numerous spoilage microbes can be prohibited thus, preserving the food[4]. Drying is nothing but ensuring the minimization of free water in the fruit tissues which the microbes use for growth and survival. Application of drying techniques to fruit puree yields a stable shelf-life product fruit leather, which is of soft rubbery texture with a sweet taste and especially dehydrated[5]. The appetizing fruit slices (one or more varieties) are smashed, combined with other additives to enhance their nutritional and functional properties, molded, cooked, and processed for moisture evaporation on a smooth tray until consistent fruit leather is obtained[6]. Fruit leathers are appealing, nutritionally recommended and satiety providing fruit products that can be eaten for healthy snacking itself or in the processing of other fruit product development.

Several drying methods are being used for fruit leather preparations namely: commercial dehydrator drying, cabinet drying or hot-air oven drying, sun drying, and vacuum oven drying[5, 7]. The composition of the final fruit product may vary depending on the processing conditions. The finished fruit product's composition can differ based on the operating conditions. Conventionally, solar drying has been used to produce fruit leather from mature fruit. However, sun-dried items can discolour and the procedure can be unsanitary and time-consuming[8]. Sun drying is also a matter of nature's mercy and can be problematic due to rain or prevailing dust in the air. Hot air drying, on the other hand, is an efficient process that takes less time and increases the dried fruit's consistency[9, 10]. However, it has been shown that hot air drying can promote a decrease in the antioxidant capacity of fruit (such as oranges) at high-temperature drying or long-time drying at about 40°C[11]. Remarkably, the drying technique i.e. commercial dehydrator for the production of mango leather results in a product with better-quality flavour and colour associated with old-style sun-drying way; thus seems to be an ideal drying process for the production of mango fruit leathers[12].

Sun-drying allows the product to have a luminous presence, a typical colour, and a sticky texture. Though, there are drawbacks like drying process exposure of the products to ecological pollution, reliance on climate circumstances, and hand labour necessities. So, another drying method was settled to stun the difficulties of cleanliness and time, as these methods are safe, fast, and manageable[13].

Modern techniques-based dryers, such as forced air circulation, cabinet dryers and tunnel dryers, are being used for manufacturing organoleptically appealing fruit leathers especially focusing on flavour and colour. The product deviations during drying contain puffing and shrinkage due to the use of hot air occasionally, coupled with chemical reactions that cause changes in colour, texture, odor, and other properties in the final product. Drying occurs from the vaporization of liquid by the provision of heat to the wet material. In various methods, improper drying results in irrevocable harm to the quality of the product which makes the product non-saleable[14, 15]. With modern dehydrators and well-designed drying methods, fruit leather can be dried at any time of the year to reach the requirements of customers.

The appropriate selection of mango variety and post-harvest maturation phase is very important to maintain the product superiority and sensory properties after processing. Raw mangoes are acidic and ironic in vitamin C whereas, ripe mangoes comprise moderate levels of vitamin C. The content of β-carotene, carotenoids, and xanthophyll esters in fruit upsurges exponentially during ripening[16]. It has been stated that air-drying marks in substantial fluctuations in the color though freeze-drying results in goods with higher color[17]. The elevated temperature of drying amplified the blackening of mango fruits. Observed signs expressed that drying could either rise arytenoids content or decrease it. Extreme sufferers in the vitamin C contents of mango fruits after drying have also been informed. Despite wide study on mango slices of many varieties, there is limited data accessible on the effect of convectional air drying on mango leather[18]. Therefore, this research was conducted to develop the mango fruit leather under various drying methods and to evaluate the best suitable drying method for the development of mango Leathers from the Sindhri mango variety.

MATERIAL & METHODS

The study was carried out to examine the effect of several drying methods on the progress of the quality of mango leathers at the laboratories of the Institute of Food Sciences and Technology, Faculty of Crop Production, Sindh Agriculture University, Tandojam, during the year 2019. The development of mango fruit leather was conducted as the method applied by Maskan, *et al*. 2002 with slight modification[13]. The mature ripe mangoes (Sindhri variety) were procured from the mango orchard nearby Tandojam. The mangoes were peeled off and pulp was extracted using the lab scale pulper, mixed with the different additives as given in Table **1**.

Table 1. Preparation of Mango leather.

Ingredients	Quantity
Pulp	3 kg
Sugar	1 kg
Citric acid	2g
Ascorbic acid	0.8g

The pulp with additives was cooked to achieve the 50% total soluble solids and poured into the moulding trays[6]. The material was subjected to three different treatments (i.e., sun drying, hot air oven drying at 70°C ± 2°C and drying in a commercial dehydrator at 70°C ± 2°C).

Inclusion Criteria

With the development of technologies, several drying techniques have been introduced throughout the world and are still in progress to make the process more efficient and reliable.

Some common and widely used techniques for the quality assessment of Mango leathers are given here.

Sun Drying

The puree mixture was spread on a grease-free paper (butter paper) and was dried on a perforated tray at a temperature of 35ºC ± 2ºC for 4 days in sunlight, continuously as to maintain the content of moisture up to 15-20%. The dried leather was transferred to the cutting table, rolled, and desired shaped product was obtained after cutting. The final product was then packed in wrappers and stored in an airtight container at ambient temperature for further analysis[19, 20].

Commercial Dehydrator

The cooked pulp was transferred to parchment paper and dried in preheated tray dryer at 70ºC ± 2ºC for 8-10hours to maintain the moisture content of 15-20%. After obtaining dried leather it was moved to the tray and rolled to spread uniformly, and cut into the desired size. The final fruit leather product was then packed in packages impermeable to moisture and stored in an airtight container at shelf-stable temperature for further analysis[20, 21].

Oven Drying

The puree was spread on a grease butter paper and dried in preheated oven at 70°C ± 2°C for 24hours to maintain the moisture content of 15-20%. The dried leather was removed from the tray and cut into the desired size or rolled. The final product was then stored at ambient conditions after packing in wrappers to facilitate further analysis[20].

Sensory Analysis

The sensory characteristics (color, appearance, texture, flavor/taste, and overall acceptability) were assessed by a panel of trained judges following a 7-point hedonic scale (Larmound, 1977). The acceptability criteria was defined

as each characteristic will remain acceptable in the obtained mean score of 5 or above.

Statistical Analysis

Three different drying treatments were performed and samples were obtained from each treatment. The data were subjected to statistical analysis using SPSS 23 version, two and the one-way analysis of variance (ANOVA) was performed to know the significant results of different drying techniques to formulate the method of drying significantly ($p < 0.05$) influenced the sensory qualities followed by Steel *et al*. (1996) and storage period.

RESULTS

The mango fruit is used widely in the preparation of various food products including mango leather. The food industries preserve mango pulp with the addition of preservatives to enhance the storage period along with to retain the sensory quality. Later, they use the preserved pulp for the production of juices, jams, mango leather and so on. Our study focused on the drying methods and storage duration of mango leather with the observation of sensory characteristics as discussed here.

Colour Scores

The results for a colour score of mango leather are presented in Fig. **1**. It was observed that the score of colour was slightly decreased ($p < 0.05$) in the drying score of mango leather dried by the different drying methods during storage time. Mango leather dried by commercial dehydrator at 70ºC ± 2ºC gave the highest score of colour (6.20), hot air oven drying at 70ºC ± 2ºC was recorded (5.93) colour score, whereas the mango leather dried under sun-drying at 35ºC ± 5ºC gave the lowest score (5.88) of mango leather colour. In the results regarding the storage of the product prepared, there was a significant decrease ($p < 0.05$) in the storage period as compared to the initial stage (control). The mango leathers stored after 4 weeks gave the highest (6.33) score of colour, while those stored after 06, 08, and 10 weeks were observed as 6.23, 6.20, and 5.43 scores of mango leather colour, respectively. The mango leather stored after 12 weeks gave the lowest (5.33) colour score. There was no significant difference observed in colour after 10 and 12 weeks of storage.

Texture Scores

The results for the texture score of mango leather are presented in Fig. **2**. It was observed that the score of texture was slightly decreased ($p < 0.05$) in the drying score of mango leather texture dried by the different drying methods. Mango leather dried by commercial dehydrator at 70ºC ± 2ºC gave the highest score of texture (6.13), while those dried by hot air oven drying at 70ºC ± 2ºC was recorded (5.87) texture score and, those dried under sun-drying at 35ºC ± 5ºC gave the lowest score (5.65) of texture. In the results regarding the storage of mango leather, there was a significant decrease ($p < 0.05$) in the storage period as compared to control. The mango leather stored after 4 weeks gave the highest (6.13) score of texture, while those stored after 06, 08, and 10 weeks were observed 5.93, 5.87, and 5.53 score of texture, respectively and after 12 weeks of storage, gave the lowest (5.47) texture score. There was no significant difference observed in texture after 10 and 12-weeks storage.

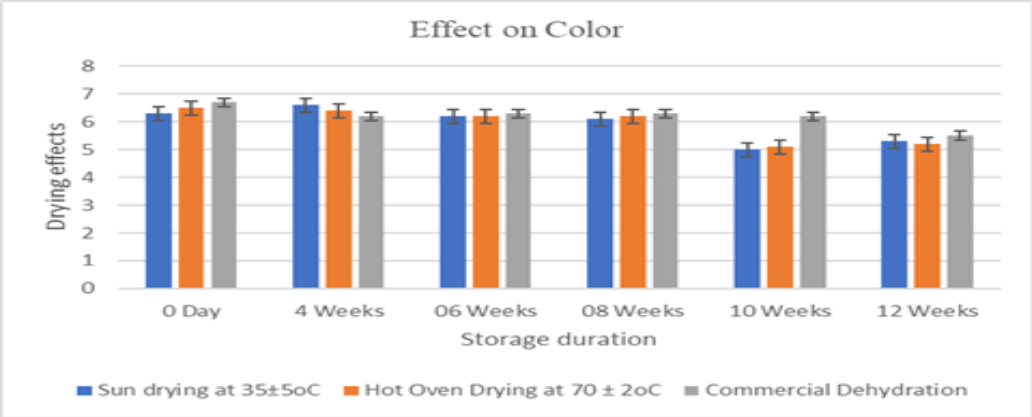

Figure 1. Effect of different drying methods on the color of Mango Leather.

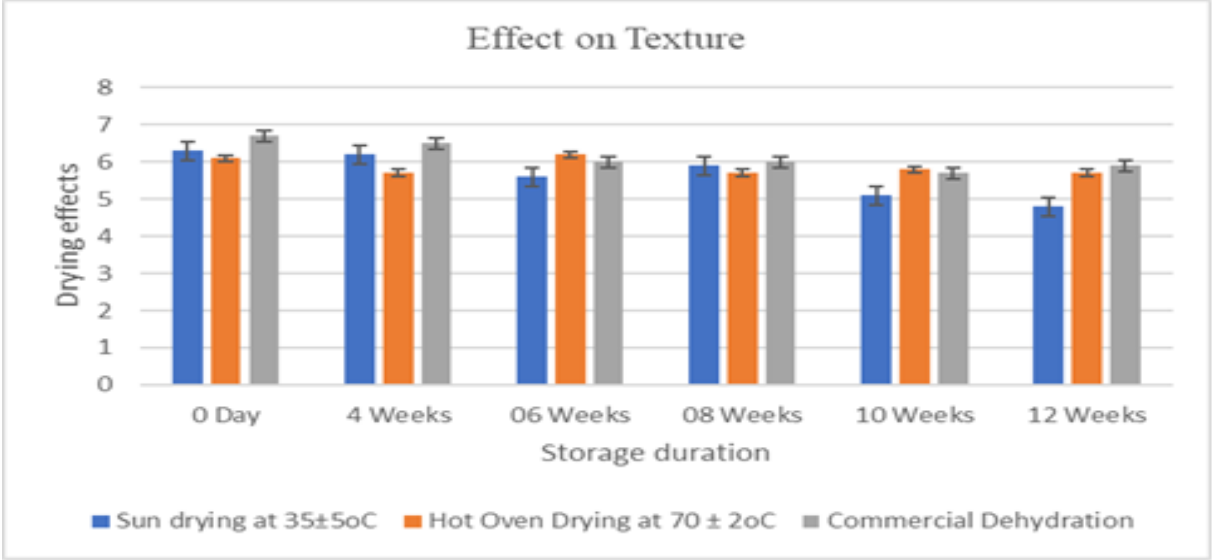

Figure 2. Effect of different drying methods on the texture of Mango Leather.

Flavor / Taste

The results for the flavour/taste score of mango leather are presented in Fig. **3**. It was observed that the score of flavour/taste was slightly decreased ($p < 0.05$) in the drying score of mango leather flavour/taste dried by the different dehydration methods used.The mango leather dried by the commercial dehydrator at 70ºC ± 2ºC gave the highest score of flavour/taste (5.88), while mango leather dried by hot air oven drying at 70ºC ± 2ºC was recorded (5.77) flavour/taste score, whereas under sun-drying at 35ºC ± 5ºC gave the lowest score (5.65) of mango leather flavour/taste. In the results regarding the storage of mango leather, there was a significant decrease ($p < 0.05$) in the storage period of mango leather as compared to control. Mango leather stored after 4 weeks gave the highest (6.13) score of flavour/taste, while those stored after 06, 08, and 10 weeks were observed 5.77, 5.73, and 5.33 scores of flavor/taste, respectively. The mango leather stored after 12 weeks gave the lowest (5.23) flavour/taste score. There was a non-significant difference observed in flavor/taste after 10- and 12-weeks storage.

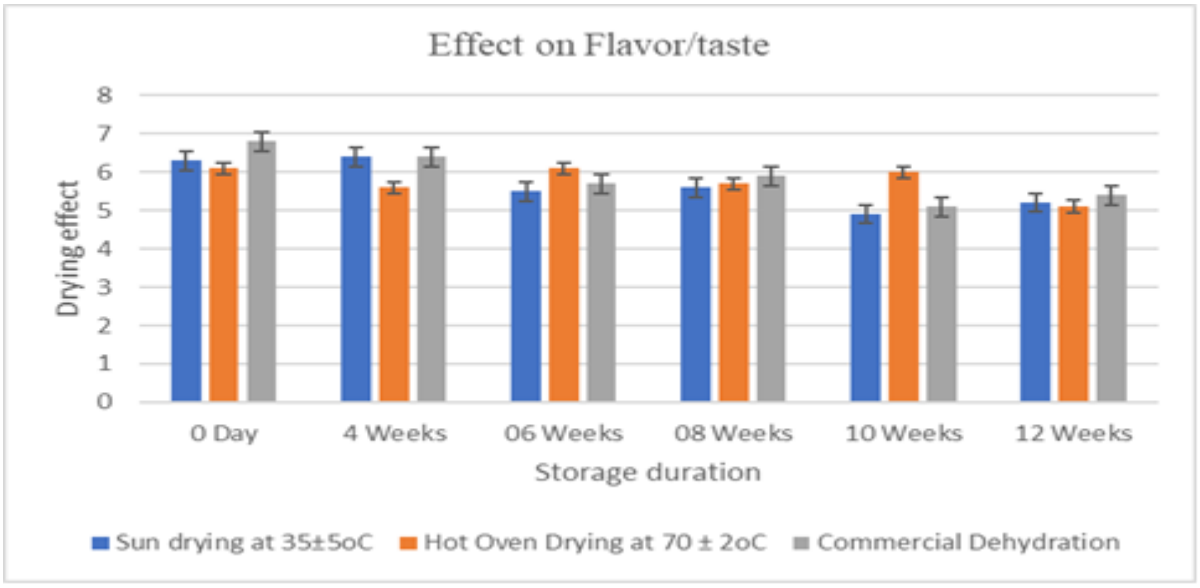

Figure 3. Effect of different drying methods on flavor/taste of Mango leather.

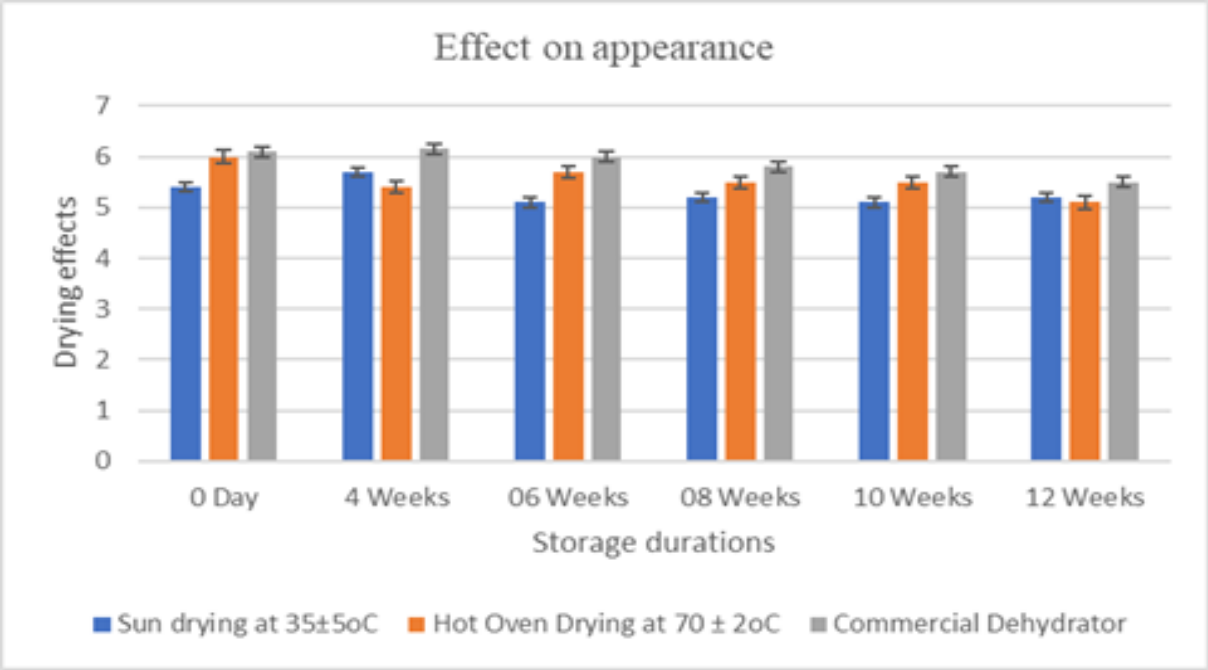

Figure 4. Effect of different drying methods on the appearance of Mango leather.

Appearance

The results for the appearance score of mango leather are presented in Fig. **4**. It was observed that the score of appearance was slightly decreased ($p < 0.05$) in the drying score of mango leather appearance dried by the different drying methods. mango leather dried by commercial dehydrator at 70ºC ± 2ºC gave the highest score of appearance (5.88), while mango leather dried by hot air oven drying at 70ºC ± 2ºC was recorded (5.53) appearance score, whereas mango leather dried under sun-drying at 35ºC ± 5ºC gave the lowest score of (5.28) appearance. In the results regarding the storage of mango leather, there was a significant decrease ($p < 0.05$) in the storage period of mango leather as compared to control. Mango leather stored after 4 weeks gave the highest (5.75) score of appearance, and those stored after 06, 08, and 10 weeks were observed at 5.60, 5.50, and 5.43 scores appearance, respectively. The mango leather stored after 12 weeks gave the lowest (5.27) appearance score. There was a non-significant difference observed in appearance after 10 and 12-weeks storage.

Overall Acceptability

The results for the overall acceptability score of mango leather are presented in Fig. **5**. It was observed that the score of overall acceptability was slightly decreased ($p < 0.05$) in the drying score of appearance dried by the different drying methods. Mango leather dried by a commercial dehydrator at 70ºC ± 2ºC gave the highest score of overall acceptability (5.85), while those dried by hot air oven drying at 70ºC ± 2ºC was recorded (5.70) overall acceptability score, whereas the mango leather dried under sun-drying at 35ºC ± 5ºC gave the lowest score (5.62) of overall acceptability. In the results regarding the storage of mango leather, there was a significant decrease ($p<0.05$) in the storage period of mango leather as compared to control. Mango leather stored after 4 weeks gave the highest (6.10) score of overall acceptability, while mango leather stored after 06, 08, and 10 weeks were observed 5.87, 5.83, and 5.20 scores of overall acceptability, respectively. The mango leather stored after 12 weeks gave the lowest (5.03) overall acceptability score. There was a non-significant difference observed in overall acceptability after 10 and 12-weeks storage.

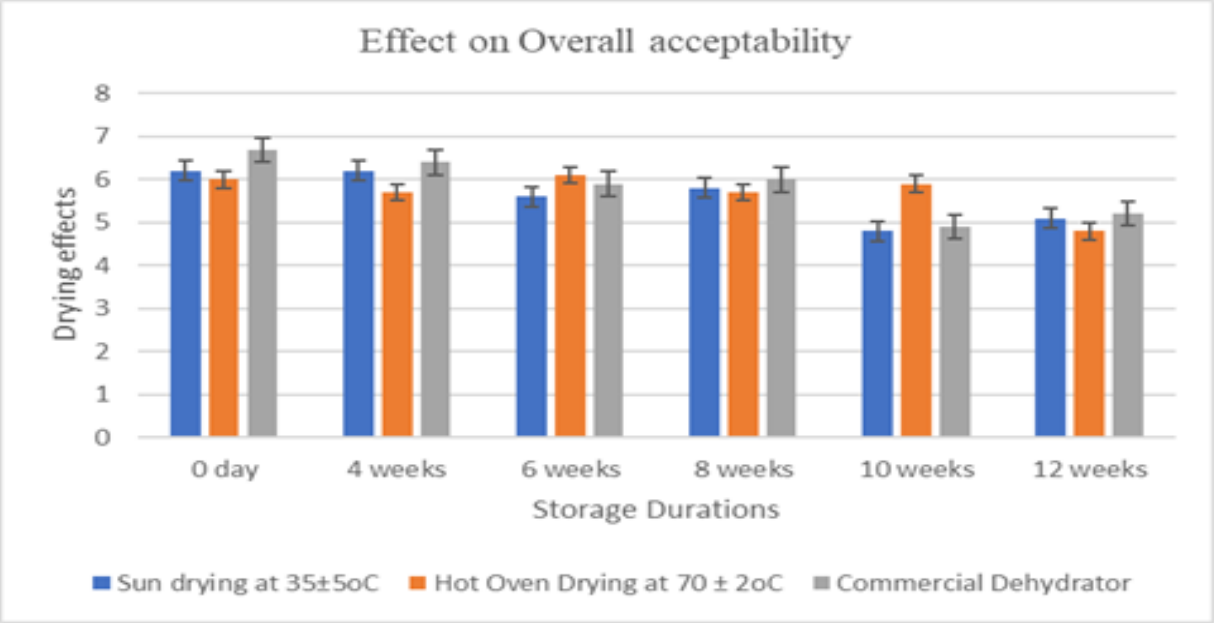

Figure 5. Effect of different drying methods on overall acceptability of Mango leather.

DISCUSSION

Fruit leather can be obtained using drying processes of fruit puree into a leathery sheet from dried sheets of fruit pulp that have a soft, rubbery texture along with a sweet taste (Raab and Oehler, 2011)[22]. It has been obtained from the results that the mango leather dried by commercial dehydrator at 70ºC ± 2ºC gave the highest score of colour (6.20), texture (6.13), flavour/taste and appearance (5.88), and overall acceptability (5.85), while mango leather dried by hot air oven drying at 70ºC ± 2ºC was recorded with the score of colour (5.93), texture (5.87), flavour/taste (5.77), appearance (5.53) and overall acceptability (5.70), whereas the mango leather dried under sun-drying at 35ºC ± 5ºC gave the lowest score of colour (5.88), texture (5.65), flavour/taste (5.65), appearance (5.28) with overall acceptability (5.62) and results are significant among all the drying methods. The multi-origin fruit pulps at times with edible peels are converted to puree, mixed with few compositional additives to enhance organoleptic and physicochemical properties, cooked, poured to moulding trays, cut into desired shapes, and then dried to form cohesive fruit leather catering especially the product appeal (Phimpharian *et al*., 2011)[6]. Fruit leathers can be eaten as snack foods or added to a variety of food preparations and textural properties can be modified by using different drying techniques and varied equipment (Raab and Oehler, 2011[22]; Irwandi *et al*., 2018[7]). The results further showed that the storage of mango leather had also a significant effect ($p < 0.05$) in the storage period as compared to control. Mango leather stored after 4 weeks gave the highest score of colour (6.33), texture (6.13), flavour/taste (6.13), appearance (5.75), and overall acceptability (6.10). The results further revealed that the mango leather stored after 12 weeks gave the lowest mango leather score of colour (5.33), texture (5.47), flavour/taste (5.23), appearance (5.27), and overall acceptability (5.03). There was a non-significant difference was observed in all the sensorial parameters after 10 and 12-weeks storage. Fruit product composition changes with modifications in processing conditions. The most conventional technique used for the development of fruit leather is sun drying, although the process of sun-drying is time-consuming and gives less hygienic product with a streak of discolouration, and susceptibility towards the microbial load (Teshome *et al*., 2012)[8]. High-temperature treatment at above 80ºC or even treatment at 40ºC for a longer duration decreases the antioxidant potential of fruit leathers (Heikal *et al*., 2016)[11]. Drying of fruit puree in hot air oven is comparatively a better solution for improved organoleptic and compositional quality of the end product developed from fruits as it utilizes less time (Maskan *et al*., 2013[9]; Garau *et al*., 2017[10]); however, it has been shown that hot air drying can promote a decrease in the

antioxidant capacity of fruit (such as oranges). There are limited studies found about the influence of conventional drying techniques for mango leather development from the Sindhri variety.

CONCLUSION

It is concluded from the above study that the sun-drying method is found time-consuming as compared to hot air oven drying and commercial dehydrator techniques. Additionally, the traditional drying technique results in poor sensory properties of mango leather. Furthermore, a commercial dehydrator is a more suitable and controlled method, showing the highest scores of sensory qualities than sun-drying and Hot air oven drying of mango leather. Moreover, storage condition results showed that the product remains shelf-stable for at least 6-month, without the need for chemical preservatives due to the reduction in moisture content of the products.

SUGGESTIONS / FUTURE PERSPECTIVE

It is suggested that further studies are required to study nutritional facts and the microbiological quality of mango leather in the storage period. Also, the texture of mango leather can be improved by adding hydrocolloid, guar gum/pectin etc. The mango properties during processing must be monitored and measured so that if there is any problem developed it can be quickly detected, and the process will be adjusted to compensate for it. This helps to improve the overall quality of the mango leather and reduce the amount of material and time wasted. The final mango fruit leather product has to be also analyzed and characterized to ensure that it retains its desirable properties up to the time when it is consumed, meets the appropriate high-quality requirements, and that it is safe for consumption.

CONFLICTS OF INTEREST

None.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
Kg	Kilogram

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