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PRODUCTION OPPORTUNITIES OF APPLE LEATHER (PESTİL) FROM "STARKING DELICIOUS" AND "GRANNY SMITH" APPLE VARIETIES

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ABSTRACT

Fruit leather (pestil) is a traditional fruit snack that can be produced from many fruits. Fruit leather is among the food products that are increasingly in demand with its durability, easy storage, and easy consumption features. It is also rich in energy and fiber. Apple leather is obtained by heating apples directly in paste form or after adding binders such as starch and flour and then drying them in a thin layer. In this study, apple leather was produced with three different formulations (pure, starchy, and floury) using Starking Delicious and Granny Smith apple varieties. pH, Titratable Acidity (0.26-0.38%), Water activity (0.99), Ash, Total Dry Matter (89.90-88.40 %), phenolic substance (321.32-245.43 mgGAE/100g), and sensory evaluation were made in the produced apple leather. The results of sensory evaluation showed that all samples were in an acceptable range and the effect of the apple variety on the sensory properties of apple leather is not very important. However, pure apple leather and floury apple leather were liked more by the panelists. Apple leather with high antioxidant content will be a healthy snack product that can be consumed with pleasure by people of all ages.

1. Introduction

Fruits are rich sources of vitamins, minerals, dietary fiber and antioxidants. They are considered a gift of nature, which helps to maintain health. Fruits are highly perishable products due to their high moisture content. In

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general, one of the methods used to preserve fresh fruits for a long time without losing their nutritional value is the production of fruit leather. (Özer & Yağmur,2004). Fruit leather is a fruit-based product that has been dehydrated and reconstituted. (Ruiz et al.). Sweet and/or sour fruits such as fresh grapes (Maskan et al., 2002), mulberry, apricot (Hepsağ et.al., 2012; Çagindi & Ötleş, 2005), apple and plum are used in leather production. In addition to these, fruit leather is produced from fruits such as banana, strawberry, orange, pear, pineapple, tangerine, kiwi, tomato, rosehip, mango, guava, durian, papaya and longan (Raab & Oehler, 2000; Irwandi & Che Man, 1996; Vijayanand et al. 2000; Chan & Cavaletto, 1978). The most commonly used fruit in making fruit leather in Turkey is grape (Nas & Nas, 1987). Despite its high functional properties, apple leather production is not yet at a sufficient level in Turkey. Apple (*Malus domestica*) belongs to the rosacea family. Apples are one of the most consumed fruits worldwide and are consumed fresh or in processed forms such as jam, juice, cider or dried. The homeland of apple is the South Caucasus, which also includes Anatolia. Apple can be grown in many regions of Turkey. Turkey has suitable climatic conditions for apples and is of great importance in world apple production. A large number of apple varieties are grown in the world. In Turkey, sweet and juicy 'Starking Delicious' and 'Golden Delicious' varieties are preferred more than other varieties of apple (Mordoğan & Ergun 2002). World apple production is around 75,749 thousand tons/year. While China ranks first with 40.500 thousand tons of apple production, the USA ranks second with 4.671 thousand tons and Turkey ranks third with 4.300 thousand tons (USDA, 2022). While apple production in Turkey constitutes 16,04% of the total fruit production, apples have the largest share of the fruits processed in the fruit juice industry with approximately 46% (Akdağ, 2011; MEYED, 2022). Apple is a fruit rich in vitamins, minerals, and organic acids. It contains a lot of vitamins A and C. Apple is one of the fruits with the highest free phenolic content compared to other fruits. (Sun et al., 2002; Hecke et al., 2006; Rana et al., 2021; Geana et al., 2021). It is also known that it is good for many diseases due to its rich nutritional value (Anonymous 2009; Wu et al., 2007). Apple is in higher demand than many temperate climate fruits and is a good source of vitamins and minerals (Bandaru & Bakshi, 2020). The best way to prevent post-harvest losses in popular and nutritious products such as apples is to preserve them by processing them into high-value-added products such as fruit leather, fruit juice, jam, canned food, puree, and candies. In general, fruit leather is produced by drying fruit purees; It is called 'Leather-Bastık' in Turkey, 'Bastegh' in Armenia, Qama and Aldeen in Syria and Arab countries, and 'Fruit roll or Fruit leather in the USA (Bandaru & Bakshi, 2020). As the free water is removed in the production of fruit leather, the nutritional elements such as sugar, vitamins, fiber, mineral substances, and antioxidants in the fruit become more concentrated, resulting in a functional product with high nutritional value (Ayotte, 1980, Doymaz, 2012). An attractive product with high nutritional value that is easy to pack and eat, fruit leather is a fruit snack that is consumed everywhere. Since the storage facilities of the fruit leather are easy, any cold chain etc. (Ayotte, 1980, Ruiz et al., 2012). The share of fruit leather, which is a healthy and functional product, in international trade has

started to increase in recent years (Che Man & Sin, 1997, Chowdhury et al., 2010). The fruit leathers naturally contain acids and sugar. Fruit purees can be dried directly, or various contributions can be added to the production of fruit leather. In its production, various contributions such as sugar, glucose syrup, various gums, pectin, carboxymethyl cellulose, and starch can be used to increase the dry matter ratio, increase sweetness, reduce water activity, provide softness, provide fullness and shine, prevent sticking and facilitate packaging. (Litaf et al., 2014; Valenzuela & Aguilera 2015 a,b; Shakoor et al., 2015; Bandaru & Bakshi, 2020). Apple leather is a healthy snack product that can replace confectionery and similar products, and studies on this subject are limited. In this study, the production of apple leather from "Starking Delicious" and "Granny Smith" apple cultivars and the effects of starch and flour use on some properties of apple leather were emphasized.

2. Materials and methods

2.1. Materials

"Starking Delicious" and "Granny Smith" apple varieties, wheat starch and wheat flour used in the study were obtained from local markets in the Şanlıurfa region. The chemicals used in the analyzes were provided by Sigma-Aldrich.

2.2. Methods

In accordance with local techniques, fruit pestil was produced with three different formulations: 2.5% wheat flour, 2.5% wheat starch and apple puree directly without using any contributions. The apples were washed in the laboratory to remove impurities. Core slots and unsuitable parts have been removed. Enzyme inactivation was achieved by heat treatment (100°C, 10 min) and the mechanical resistance of cells was broken. The apples were divided into three parts, 2.5% flour for the first part, 2.5% starch for the second part, the third part was passed through the pulper without any contributions and turned into a thin pulp. The pulp was produced by spreading a thin layer of 1 mm thick on oiled paper and drying at an average of 27 °C under room conditions. pH, titratable acidity (%), water activity, moisture (%), ash, total dry matter (%) and color (L*, a*, b* and C*, h^0 values) (AOAC, 2005; Cemeroğlu, 2007), total phenolic substance (Medina-Remon 2009) analyzes were made in the produced fruit pestils. In addition, sensory evaluations were made by panellists in terms of features such as appearance/brightness, color, odor, taste, chewiness, and delayed taste in order to measure consumer taste (Each character is evaluated out of 5 points) (Altuğ & Elmacı, 2011). Trials were made in two parallels and three replications, and the SPSS package program was used in the evaluation ($P<0.05$). The differences between the means in the groups were determined by Duncan's test. Sensory evaluation data were made using ANOVA 4x3 repeated measurement (Curran et al., 1996).

3. Results and Discussion

Some features of Starking Delicious and Granny Smith apples used in its production are given in Table 1.

Table 1. Average Values of Some Compositional Properties in Fresh Apples

Analysis	Starking Delicious			Granny Smith		
pH	4.02^{a}±0.03			3.26^{b}±0.02		
Total Acidity (%)	0.38^{b}±0.05			0.80^{a}±0.04		
Water Soluble Dry Matter (%)	14.24^{a}±0.72			13.56^{a}±0.85		
Total Dry Matter (%)	14.79^{a}±0.13			14.31^{a}±0.10		
Water activity (%)	0.991^{a}±0.02			0.992^{a}±0.01		
Total Phenolic Substance (mgGAE/100g)	374.3^{a}±1.20			324.6^{b}±1.18		
Peel Color	**L***	**a***	**b***	**L***	**a***	**b***
	44.05±1.13	35.72±1.80	19.03±2.04	68.50±1.26	-5.58±1.32	42.37±2.05
Fruit Flesh Color	**L***	**a***	**b***	**L***	**a***	**b***
	84.58±0.03	0.74±0.02	27.47±0.03	84.44±0.03	-1.31±0.02	28.10±0.02

The means with the same letter are not significantly different ($p < 0.05$).

As can be seen from Table 1, the pH (4.02) of Starking Delicious apples was higher and the acidity (0.38 %) was lower in apples, and Granny Smith apples were found to have a more acidic character and therefore a sourer taste.

The total acidity and pH values of the samples are in agreement with the results reported by Öztürk et al. (2010) and Wu et al. (2007). While there was not much difference between the samples in terms of water-soluble dry matter, total dry matter and water activity, the total amount of phenolic matter was found to be 374.3 mgGAE/100g in Starking Delicious and 324.6 mgGAE/100g in Granny apples. This difference is also statistically significant ($P<0.05$). In terms of color characteristics, since Starking Delicious apples have red color, a* value was found to be 35.72 in terms of skin color, while a* value was found to be-5.58 in Granny Smith apples due to green color.

The a* values of the fruit flesh were 0.74 in Starking Delicious and-1.31 in Granny Smith variety. This shows that the Granny Smith apple variety has a more greenish color in terms of fruit flesh. In terms of color values, it was determined that there were statistically significant ($P<0.05$) differences between apple varieties, especially in skin color.

As can be seen from Table 2, the highest pH value was 3.72 in pure Starking Delicious pestil, while the lowest pH was 3.48 in starchy Granny Smith pestil. Pure pestils in the same variety yielded lower pH values than those produced by adding starch and flour. Among the varieties, it was observed that the apple pestil produced from apples belonging to the Granny Smith variety gave lower pH values than the apple pestil produced from the apples of the Starking Delicious variety. This is due to the fact that apples belonging to the Granny Smith variety have a more acidic character and therefore lower pH values. A similar situation was evident in total acidity as well. In terms of titration acidity, the pulp produced from Granny Smith apples showed a more acidic character.

Table 2. Average Values of Some Composition Properties of Apple Leather

Analysis	Starking Delicious			Granny Smith		
	Pure Apple Leather	Floury Apple Leather	Starchy Apple Leather	Pure Apple Leather	Floury Apple Leather	Starchy Apple Leather
pH	3.72±0.02a	3.70±0.02a	3.68±0.03a	3.50±0.03b	3.51±0.03b	3.48±0.02b
Titratable Acidity (%)	0.26±0.04b	0.37±0.05a	0.36±0.04a	0.30±0.04b	0.38±0.04a	0.36±0.04a
Water activity (%)	0.47±0.01a	0.48±0.02a	0.46±0.03a	0.48±0.02a	0.48±0.03a	0.46±0.02a
Humidity (%)	11.60±0.06a	10.40±0.05b	10.10±0.06b	11.60±0.08a	10.30±0.06b	10.10±0.07b
Ash (%)	0.70±0.02	0.54±0.02	0.54±0.01	0.71±0.02	0.54±0.01	0.53±0.02
Total Dry Matter (%)	88.40±0.06b	89.60±0.05a	89.90±0.06a	88.40±0.08b	89.70±0.06a	89.90±0.07a
Total Phenolic Substance (mgGAE/100g)	321.32±1.23a	248.24±1.34d	255.63±1.23c	303.43±1.84b	245.43±1.36e	252.51±1.18d

The means with the same letter are not significantly different ($p < 0.05$).

The acidity and pH values of apple pestil were found to be higher than the pH (3.2) and titratable acidity (0.20 %) values stated by Litaf et al. (2014). This is due to the different techniques applied in production. Although there was no significant difference between the apple pestil samples in terms of water activity, the starch-added apple pestils produced in both cultivars showed lower water activity (0.46). It was determined that only apple pestil samples produced from fruit pulp in terms of moisture content had higher moisture content (11.60 %) and the difference was statistically significant (P<0.05). There was no statistically significant difference between the flour and starch-added apple pestil samples in terms of moisture content. This is thought to be due to the fact that flour and starch retain more moisture. In terms of total phenolic content, the highest value (321.32 mgGAE/100g) was seen in pure Starking Delicious apple pestil, while the lowest value (245.43 mgGAE/100g) was observed in Granny Smith apple pestil with flour added. The difference between the total amount of phenolic substances in all apple pestil samples was statistically significant (P<0.05). In terms of total phenolic substance content, samples belonging to Starking Delicious variety gave higher values in apple pestil samples than in apples. As seen in Table 3, the difference between the L* value of pure apple pestil and the apple pestil produced by adding starch and flour was found to be statistically significant (P<0.05). This decrease in L* value is due to the opaque appearance caused by the added flour and starch. In terms of a* value, flour and starch added to apple pestils gave close values, while pure apple pestils gave different values. The differences between the values were found to be statistically significant (P<0.05). The same was true for b* values. As can be seen from Table 3, pure apple pestils had higher values in terms of color saturation according to the calculated C* values, while flour and starch added apple pestils had lower

color saturation. Looking at the h^0 value, the fruit pulps obtained from Starking Delicious apples showed an angle close to yellow, while the pure apple pestil of Granny Smith apples gave the closest value. The apple pestil produced by adding flour and starch showed a lower h^0 value.

Table 3. Average Values of Color Characteristics of Apple Leathers

Variety	Example	L*	a*	b*	C*	h°
Starking Delicious	Pure Apple Leather	48,15±1.33a	7,26±1.26c	23,50±1.26a	24.68	80.88
	Floury Apple Leather	33,22± 1.21b	9,35±1.18b	9,80±1.16bc	13.54	51.24
	Starchy Apple Leather	34,38±1.19b	9,20±1.27b	11,48±1.23b	14.59	56.79
Granny Smith	Pure Apple Leather	48,05±1.23a	13,57±1.15a	24,50±1.16a	28.00	67.71
	Floury Apple Leather	32,78± 1.18b	10,50±1.20b	10,51±1.24b	15.9	54.04
	Starchy Apple Leather	34,66±1.14b	10,50±1.22b	11,93±1.20b	14.85	50.00

The means with the same letter are not significantly different ($p < 0.05$).

In the sensory evaluation, apple pestils were subjected to sensory evaluation in terms of appearance/brightness, color, odor, taste, chewiness, and residual taste.

As can be seen in Table 4, while the highest value in terms of appearance/brightness was 4.4, the flour-added samples had the lowest value of 3.1, while the starch-added apple pestils had the lowest value. Although there was no difference between floury and plain fruit pulps in terms of color evaluation, starch-added pulps had lower values (3.4/3.4). Similar cases were observed in terms of odor, taste, chewiness, and delayed taste characteristics. In general, starch-added samples had lower values. When the total scores were evaluated, fresh and flour-added samples got the highest scores, while starchy samples got lower scores. There was no statistically significant difference in sensory properties between pure and starchy samples. It was determined that there were significant differences in sensory properties between the starchy samples and the other samples. Depending on the apple cultivar, it was determined that there was no significant difference in sensory properties in the apple pestil obtained from Starking Delicious and Granny Smith apples. It has been determined that it has a positive effect on the sensory properties of the samples, especially on the appearance and taste of the flour, so it is more preferred.

Table 4. Elma Pestillerinde Yapılan Duyusal Değerlendirmelere Ait Ortalama Değerler

Analysis	Starking Delicious			Granny Smith		
	Pure Apple Leather	Floury Apple Leather	Starchy Apple Leather	Pure Apple Leather	Floury Apple Leather	Starchy Apple Leather
Appearance / Brightness	4.0	4.4	3.1	4.0	4.4	3.1
Color	4.0	4.0	3.5	4.0	4.0	3.4
Odor	4.0	4.0	3.5	4.0	4.1	3.4
Taste	4.5	4.4	3.7	4.3	4.3	3.4
Chewiness	4.0	4.1	2.6	4.0	4.1	2.6
Residual Taste	3.9	3.9	3.8	3.7	3.9	3.2
Total	24.4±1.12 [a]	24.8±1.20 [a]	20.2±1.22 [b]	24.0±1.14[a]	24.8±1.20 [a]	19.1±1.20 [b]

The means with the same letter are not significantly different ($p < 0.05$).

4. Conclusion

Apple pestil is high in antioxidants that can be consumed with pleasure, it will be a healthy snack product that can be preferred, the effect of the variety on the sensory properties of the apple pestil is not very important, while the pure and flour-added apple pestil is liked more by consumers, the starchy apple pestil is the least appreciated by consumers, and apple pestil has a high dry matter content since the water activity is low, it is concluded that a longer shelf can be stored under normal conditions without the need for a different storage method or any additives. It would be beneficial to carry out further research using apple pestil and different natural thickening and binding components other than flour and starch.

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