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Research Article/Araştırma Makalesi

Determination of some nutritional and quality properties of cape gooseberry leathers produced under different conditions

Farklı koşullarda üretilen altınçilek pestillerinin bazı besinsel ve kalite özelliklerinin belirlenmesi

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ABSTRACT

Fruit leather is a product obtained by pouring fruit puree as a thin layer on a flat surface and drying it. Fruit leathers can be produced from different fruits and are generally rich products in terms of minerals, fibers and energy value. They are also long lasting, easy to consume and package foods. Capegooseberry fruit is a tropical fruit that is rich in minerals such as phosphorus, magnesium, zinc and iron, and it is also a source of different functional compounds such as phenolic compounds, vitamin C and carotenoids. In this context, processing capegooseberries into fruit leather is a good alternative for producing a healthy product by using this fruit. In this study, the production of fruit leather from capegooseberry fruit in a drying cabinet at different temperatures and by using the sun drying method was carried out and the effects of different production processes on some nutritional and quality properties of the product were investigated. The protein, carbohydrate, fat and energy values, textural properties and thicknesses of the fruit leathers obtained under different conditions, and the microbial stability of the products after production and during storage were determined and the effects of different production conditions on these properties were investigated. It was determined that the products remained stable for six months in terms of microbiology and that cape gooseberries were a suitable fruit for processing into fruit leather. According to nutritional value analysis results it was found that the carbohydrate and energy values of products were high. Also it has been observed that the hardness values of fruit leathers produced in the drying cabinet increased as the temperature increased. No significant difference was observed between the final products thickness values after drying of the fruit leathers produced under different conditions.

Key Words: Fruit leather, fruit, cape gooseberry, dried food product, nutrition

ÖZ

Pestil meyve püresinin düz bir zemine ince bir tabaka halinde dökülerek kurutulmasıyla elde edilen bir üründür. Pestiller farklı meyvelerden üretilebilmekte olup genellikle mineral, lif ve enerji değeri bakımından zengin ürünlerdir. Ayrıca uzun ömürlü, tüketimi ve paketlenmesi kolay gıdalardır. Altınçilek meyvesi de fenolik bileşikler, C vitamini ve karotenoidler gibi farklı fonksiyonel bileşikler açısından kaynak teşkil eden yine fosfor, magnezyum, çinko ve demir gibi mineraller açısından zengin tropikal bir meyvedir. Bu bağlamda, altınçileği pestile işlemek, meyvenin kullanımı ile sağlıklı bir ürün üretilmesi için iyi bir alternatif oluşturmaktadır. Bu çalışmada, altınçilek meyvesinden kurutma kabininde farklı sıcaklıklarda ve güneşte kurutma metodu ile pestil üretimi gerçekleştirilerek farklı üretim proseslerinin ürünün bazı besinsel ve kalite özellikleri üzerine etkileri incelenmiştir. Farklı koşullarda elde edilen pestillerde protein, karbonhidrat, yağ ve enerji değerleri, tekstürel özellikleri ve kalınlıkları, ürünlerin üretim sonrası ve depolama boyunca mikrobiyal stabiliteleri belirlenerek farklı üretim koşullarının bu özellikler üzerine etkileri incelenmiştir. Ürünlerin mikrobiyolojik açıdan altı ay boyunca stabil kaldığı ve altınçilek meyvesinin pestile işlenmeye uygun bir meyve olduğu belirlenmiştir. Besin değeri analiz sonuçlarına göre ürünlerin karbonhidrat ve enerji değerleri açısından zengin ürünler olduğu bulunmuştur. Ayrıca kurutma kabininde üretilen pestillerin sertlik değerlerinin uygulanan sıcaklık arttıkça yükseldiği gözlenmiştir. Farklı koşullarda üretilen pestillerin son ürün kalınlık değerleri arasında ise belirgin bir farklılık gözlenmemiştir.

Anahtar Kelimeler: Pestil, meyve, altınçilek, kurutulmuş gıda ürünü, beslenme

Introduction

Regular fruit consumption in the diet is one of the important elements for healthy nutrition. This importance is due to the fact that fruits contain bioactive components such as phenolic compounds and carotenoids with antioxidant activity, as well as many vitamins and minerals that should be taken regularly (Bandaru and Bakshi, 2020; Kara et al., 2021). Especially in recent years, the increase in scientific data on nutrition-health relationships and the increase in awareness of consumers on these issues have led to an increasing interest in the consumption of fruits containing functional components and their processing into different products (Kara and Küçüköner 2024). In this context, as a fruit snack, fruit leather is a food product containing the beneficial components of fruits. Although it is produced in different ways, fruit leather is defined as a product obtained by pouring moist fruit puree on a flat surface in a thin layer and drying it until a cohesive leathery structure is obtained (Kara and Küçüköner, 2019). Drying process can be carried out by natural drying in the sun or by industrial methods such as drying with hot air in convective cabinet type dryers, microwave drying, freeze drying and solar drying with solar energy (Calin-Sanchez et al., 2020; Bandaru and Bakshi, 2020). Fruit leathers can be made from different fruits such as apple, pear, apricot, grape, strawberry, banana, pineapple, orange, peach, plum, melon or using mixtures of these fruits (Srinivas et al., 2020). In this study, the production of fruit leather was carried out using capegooseberry which is a tropical fruit. Cape gooseberry (*Physalis peruviana L.*), belonging to the *Physalis* genus of the nightshade family (*Solanaceae*), is a tropical fruit originating from South America. The fruit is a source of vitamins C and E, carotenoids and phenolic compounds which have bioactive properties. It also have a high content of phosphorus and dietary fiber (Kara et al., 2021; Kara and Küçüköner, 2024). Fruit leather is a highly suitable option for processing cape gooseberry fruit into a new product, as it is a fruit snack that is easily consumed and has a concentrated nutritional value. In this context, the production of fruit leather from cape gooseberry fruit offers a good alternative for both cape gooseberry fruit and fruit leather, in terms of increasing the consumption and market demand of these products.

In this study, fruit leather production was carried from cape gooseberry by drying at different temperatures in the drying cabinet and also by sun drying method. After production, the effects of different production conditions on some nutritional and quality properties of the product were investigated.

Material and Methods

Material

Cape gooseberry fruits were supplied by local producers in Antalya. Low density polyethylene (LDPE) packaging materials were purchased from local suppliers in Isparta and wheat starch, sugar and lemon were purchased from markets in Isparta. The fruits were kept in the refrigerator at 4°C until used in production. The fruit leathers were stored in closed vacuum packages in the closet at room temperature.

Methods

The production of cape gooseberry leathers

The production of fruit leathers were done according to (Kara and Küçüköner; 2025). The fruits were separated from the calyx parts by hand and washed under tap water. Then, the hard stem parts of the fruits were removed with a knife and the fruits were pureed with a blender. In another bowl, water (25% of the fruit used) and starch (8% of the fruit used) were mixed to make a slurry (Table 1). Sugar and lemon juice were also used in the production of fruit pulp. Sugar and starch slurry was added to the prepared fruit puree and heated by stirring, then lemon juice was added to this mixture and the heating was terminated at 63 ˚C. The hot mixture was then poured into trays with a thickness of 4 mm. The drying process was carried out in a cabin dryer (60 ˚C, 70 ˚C and 80 ˚C) at an air speed of 0.8 m s^{-1} and also by the sun drying method. Drying was continued until the product dry matter was 87%. The dried cape gooseberry fruit leathers were vacuum packed in low density polyethylene (LDPE) packages and stored at room temperature.

Table 1. Raw materials used in the production of fruit leather (Kara and Küçüköner, 2025)

Raw materials	Amounts
Cape gooseberry fruit	1000 g
Wheat starch	80 g
Water	250 mL
Sugar	150 g
Lemon juice	20 mL

Analysis

Determination of textural properties was carried out by Texture Profile Analysis (TPA) method using a needle tip probe with a texture analyzer (TA.XT Plus, Stable Micro Systems Ltd., Godalming, Surrey, England) (pre-test speed; 1 mm s^{-1}, test speed; 5 mm s^{-1}, post-test speed; 5 mm s^{-1}). Thickness values of fruit leathers were determined using standard equipment (caliper) according to TS 9776 (Anonymous, 1992). Dry matter contents of fruit leathers were determined according to TS 9776 (Anonymous, 1992). Results were calculated as g/100 g.

Protein content of cape gooseberry leathers were determined using the Kjeldahl Method according to method no. 920.152 in AOAC 2011 (AOAC, 2011). In protein determination, nitrogen amounts were determined by the Kjeldahl Method and protein values were determined by multiplying by a factor of 6.25. Carbohydrate values were determined by subtracting the sum of the percentage values of moisture, ash, protein and fat amounts in the samples from 100 (Ötleş, 1993). Fat content in cape gooseberry leathers were determined using a Sokselet apparatus (Uylaşer and Başoğlu, 2011). Hexane was used as oil solvent in extraction. The results were calculated as g/100 g.

The formula below was used to calculate the energy value. The fiber content of the fruit was taken as 4.9%, and the fiber ratios in the fruit leathers were determined according to the amount of fruit puree they contained (National Research Council, 1989; Ramadan, 2011).

Energy (kcal/100 g)= (Fat x 9)+(Protein x 4)+[(Carbohydrate-Dietary Fiber) x 4]

Total mesophilic bacteria and total yeast and mold counts in fruits and fruit leathers after production and during storage were determined according to Anonymous (1982). SPSS program (version 19, IBM, 2010) was used for statistical analysis. Analyses were repeated three times and averaged, and all analyses were performed three times (three parallels).

Results and Discussion

The results of protein, carbohydrate and fat analyses performed on the products are shown on a dry matter basis in Table 2. Statistically significant difference was not observed in terms of protein, fat and carbohydrate contents of the fruit leathers obtained with different methods ($p>0.05$). Products protein, fat and carbohydrate values vary depending on the protein, fat and carbohydrate contents of the fruit they contain and the type and amount of other additives used. In a study conducted on grape, mulberry and apricot fruit leathers produced and marketed in Turkey, it was determined that the fruit leathers protein values were between 3-4.6% on a dry matter basis and that grape leathers contained an average of 3.5% protein in dry matter, mulberry pestils an average of 4.5% and apricot pestils an average of 3.4% protein (Çağındı and Ötleş, 2005).

Table 2. Protein, carbohydrate, fat contents on a dry matter basis and energy values of fruit leathers produced in different ways[1]

Product	Protein contents (%) (w/w)	Fat contents (%) (w/w)	Carbohydrate contents (%) (w/w)	Energy values (kcal/100 g)
60°C	4.36^a±0.15	2.09^a±0.27	91.12^a±0.24	302.95^a±1.44
70°C	4.13^a±0.18	1.97^a±0.64	91.50^a±0.71	305.57^a±3.66
80°C	4.33^a±0.17	2.03^a±0.43	91.22^a±0.45	304.41^a±0.70
SD[2]	4.26^a±0.14	1.87^a±0.43	91.29^a±0.54	303.17^a±1.25

[1]Means ± s.d. of three times determination, means within a same column with different letters are significantly different ($p<0.05$).
[2]Sun drying

In the same study, it was determined that the fat content of different grape, mulberry and apricot pestils offered in the market was between 0.2-3.4%, grape pestils contained an average of 0.3% fat, mulberry pestils contained an average of 2.7% fat and apricot pestils contained an average of 2.6% fat. The carbohydrate values of the same study were found to be between 73.7-82.4%, the carbohydrate values of grape pestils were determined to be 80.8% on average, mulberry pestils 78% and apricot pestils 75.6% (Çağındı and Ötleş, 2005).

In another study, the carbohydrate values of fruit leathers which prepared by mixing mango and soursop fruits in different proportions and adding honey and citric acid were found to be in the range of 71.41-86.32% (Le and Ro, 2016). In the study conducted by Ayalew and Emire, (2020), they produced fruit leathers using soursop fruit and oat flour at different concentrations, the carbohydrate values were found to be in the range of 65.74-71.66%. Considering all these study results, it is seen that the general characteristic of fruit leather that it is a product containing high carbohydrates. In our study, no statistical difference was observed between the energy values of fruit leathers produced under different conditions. It was determined that the energy values of the products were also high (302.95-305.57 kcal/100 g) in parallel with the high sugar content of the products (Table 2). In the literature; Çağındı and Ötleş, (2005) determined the energy values of grape, mulberry and apricot pestil samples offered for sale in the market to be in the range of 321.5-356.4 kcal/100 g.

Texture Profile Analysis (TPA) was performed to determine the textural properties of the fruit leather samples obtained under different conditions. The results are shown in Table 3. The hardness values of fruit leathers produced in the drying cabinet increased statistically significantly ($p<0.05$) as the temperature increased. It was determined that the elasticity and breaking strength values of the samples dried at 80°C in the drying cabinet were statistically significantly ($p<0.05$) higher than those dried at 60°C and 70°C and those dried in the sun. In terms of adhesion values, it was determined that the values of the samples dried at 70°C were statistically significantly ($p<0.05$) higher than those dried at 60°C and 80°C and those dried in the sun.

Table 3. Texture values of fruit leathers produced in different ways [1]

Product	Hardness*	Springiness**	Adhesion	Breaking strength*
60°C	1.517^{a}±0.076	0.691^{a,b}±0.030	0.229^{a}±0.023	1.063^{a}±0.090
70°C	2.189^{b}±0.191	0.714^{a}±0.019	0.342^{b}±0.036	1.479^{a,c}±0.258
80°C	2.873^{c}±0.173	0.865^{c}±0.003	0.198^{a}±0.004	2.157^{b}±0.146
SD	2.549^{b,c}±0.070	0.652^{b}±0.018	0.260^{a}±0.034	1.794^{b,c}±0.166

*Newton **mm

[1]Means ± s.d. of three times determination, means within a same column with different letters are significantly different (p<0.05).

Thickness analysis was also performed on the fruit leather samples. Using the special apparatus we could poured all fruit leather were at a standard thickness of 4 mm. Raab and Oehler (1976) reported that fruit leathers should be poured in a thickness of approximately 3-6.5 mm. After the drying process, the product thicknesses were determined to be between 1.90-1.95 mm (Table 4). It was observed that there was no statistically significant difference (p>0.05) between the thickness values in the fruit leather samples. In the literature, Diaz et al. (2009) reported that the thickness of the apple fruit leather was 2 mm and Phimparian et al. (2011) reported that the thickness of the pineapple fruit leather they produced was between 2.0-2.1 mm. It is understood from these results that there may be differences in fruit leather thicknesses. However, regarding the thickness, an evaluation can be made and a value can be determined by taking into account the results of the analysis to be made regarding consumer preferences. Also, determining the thickness of the fruit leather, it should be taken into consideration that if the fruit pulp is poured too thinly, it will be difficult to peel it off when it will be dried and if it is too thick, it will affect the drying quality and if it is not dried sufficiently, the product may deteriorate during storage (Azeredo et al., 2006).

Table 4. Thicknesses values of fruit leathers produced in different ways [1](mm)

Product	Thickness (mm)
60°C	1.92^{a}±0.09
70°C	1.90^{a}±0.04
80°C	1.91^{a}±0.04
SD	1.95^{a}±0.05

[1]Means ± s.d. of three times determination, means within a same column with different letters are significantly different (p<0.05).

Total aerobic mesophilic bacteria and yeast-mold counts were also performed in the samples. Microbiological analyses were also performed on cape gooseberry fruits to be processed into fruit leather. In addition, analyses were repeated at two-month intervals during the six-month storage period. The results of the total aerobic mesophilic bacteria analyses are shown in Table 5. Some mesophilic bacteria were detected in the unprocessed fruits, but since heat treatment and drying processes were carried out in the production process, mesophilic bacteria were not detected in the samples after production. The low water content, high acidity, and storage in vacuum packaging of the samples ensured that they remained microbially stable throughout storage. However, very low levels of mesophilic bacteria were detected in some samples in the analyses performed in the 6th month of storage.

Low pH and low or medium water activity of the fruit leathers make them safer as microbiological (Ruiz et al., 2012). It has also been reported that factors such as pH and water activity exhibit synergistic effects in preventing microbial growth (Azeredo et al., 2006). In the literature, Azeredo et al. (2006) reported that Mango pestils produced without using preservatives remained microbially stable for six months. Irwandi et al., (1998) reported that the total mesophilic bacteria count was below 60 cfu/g in Durian pestils produced using sorbic acid as a preservative after three months of storage. Considering the results of the microbiological analysis in our study, it is seen that the fruit leathers are quite stable products in terms of storage. The long-term microbial stability of the fruit leathers produced in our study was probably due to the fact that they were produced from cape gooseberries, a fruit with characteristically high acidity, their water content was low because they were dried, and also because of they were stored in vacuum packaging.

Table 5. Total areobic mesophilic bacteria counts in fruit leathers produced in different ways (after production and during storage)[1] (kob g^{-1})

Product	After production	2-month	4-month	6-month
Fruit	$14x10^3$±1732	-	-	-
60̊ C	<10	<10	<10	$3x10^{1,a}$±10
70̊ C	<10	<10	<10	$1.33x10^{1,a}$±11.55
80̊ C	<10	<10	<10	$1.33x10^{1,a}$±5.77
SD	<10	<10	<10	<10[a]

[1]Means ± s.d. of three times determination, means within a same column with different letters are significantly different (p<0.05).

The results of yeast and mold analysis are shown in Table 6. Some yeast and mold were detected in fresh unprocessed fruits, but since heat treatment and drying processes were carried out in the production process, yeast and mold were not detected in the fruit leathers samples after production. In the literature, Irwandi and Che Man (1996), reported that the mold counts in durian leathers produced using sorbic acid as a preservative were below 40 cfu g^{-1} after three months of storage. Irwandi et al., (1998), reported that the total yeast and mold counts in durian leathers produced using sorbic acid as a preservative were below 140 cfu/g after three months of storage. Huang and Hsieh (2005), reported that the total yeast and mold counts in the pear leathers they produced were below 50 cfu g^{-1}. Yeast and molds can grow at lower water activity and pH values compared to bacteria (Azeredo et al., 2006). Despite this, it was determined that there was no detectable level of yeast and mold in the samples after production and during storage in our study. This situation is consistent with the yeast and mold results of different fruit leathers in the studies mentioned above.

Table 6. Total yeast and molds counts in fruit leathers produced in different ways (after production and during storage)[1] (kob/g)

Product	After production	2-month	4-month	6-month
Fruit	$2x10^2$±26.46	-	-	-
60̊ C	<10	<10	<10	<10
70̊ C	<10	<10	<10	<10
80̊ C	<10	<10	<10	<10
SD	<10	<10	<10	<10

[1]Means ± s.d. of three times determination, means within a same column with different letters are significantly different (p<0.05).

Conclusions

Fruit leathers are products that can be produced from different fruits and they are rich in terms of energy value, mineral content and fibers due to the nutritional compounds that are concentrated in their content with the drying process. They are also long-lasting, easy to consume and package foods. Therefore, they offer a healthy and practical alternative as confectionery. As for the cape gooseberry fruit, it is a tropical fruit that is rich in minerals such as phosphorus, magnesium, zinc and iron. Also it is a source of different functional compounds such as phenolic compounds, vitamin C and carotenoids. With these features, the fruit has an important potential to be processed into different products for healthy nutrition. In this context, processing cape gooseberries into fruit leathers is a good alternative for the production of a healthy product using the fruit. In this study, the production processes were carried out similarly to the production of traditionally produced fruit leathers (which names are pestil in Turkey) in Turkey. Fruit leather were produced from cape gooseberries in a drying cabinet at different temperatures and by using the sun drying method. After production the effects of different production processes on some nutritional and quality characteristics of the products were investigated. In this respect, it was determined that the products remained stable for six months in terms of microbiology and that cape gooseberries were a suitable fruit for processing into fruit leather. Also, similar to other studies on fruit leathers, it was found that the carbohydrate and energy values of products were high. Another analysis performed to determine the quality characteristics of products is texture profile analysis. This analysis was performed to determine the structural properties of the fruit leather samples obtained under different conditions. It was determined that the hardness values of fruit leathers produced in the drying cabinet increased as the temperature increased. However no significant difference was observed between the final products thickness values after drying of the fruit leathers produced under different conditions.

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Conflict of Interest
The authors declare that there is no conflict of interest between them.

Author Contribution
Authors contributed equally to the manuscript. O.O.K: Analysis, Writing, Review. E.K: Writing, Review.

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