How to cite: Ersus, S. & A. Z. Hepçimen., 2021. Effects of different formulations on quality of pomegranate pestil, Ege Univ. Ziraat Fak. Derg., 58 (1):9-15, https://doi.org/10.20289/zfdergi.715125

Research Article
(Araştırma Makalesi)

Ege Üniv. Ziraat Fak. Derg., 2021, 58 (1):9-15
https://doi.org/10.20289/zfdergi.715125

Effects of different formulations on quality of pomegranate pestil

Farklı formülasyonların nar pestilinin kalitesi üzerine etkileri

Seda ERSUS[1]

Ahmet Zeki HEPÇİMEN[2]

[1] Ege University, Engineering Faculty, Food Engineering Department, Bornova-İzmir/Turkey

[2] Manisa Celal Bayar University, Saruhanlı Voc. School, Food Technology Department, Saruhanlı-Manisa/Turkey

* Corresponding author: hepcimen@gmail.com

Received (Alınış): **06.04.2020** Accepted (Kabul Tarihi): **06.05.2020**

ABSTRACT

Objective: The usage of pomegranate as a raw material in pestil production to develop new food products and the effects of different formulations on physical, chemical and sensory properties of pestil were investigated.

Material and Methods: Hicaz pomegranate juice (75% w/w) was concentrated up to 40 ° Brix and remaining (25% w/w) of the juice was used in three different pestil formulations. The thickening agents such as (a) 10% wheat starch, (b) 10% wheat flour and (c) 10% wheat flour + 5% sugar + 5% skimmed cow milk were used. The pH value, titration acidity, dry matter, water activity, color values, total and invert sugar content, total phenolic content, antioxidant capacity and sensory analysis were applied to dried pestil samples.

Results: It has been determined that antioxidant capacity of pestil samples were decreased compared to raw material. However, among the pestil samples produced with different formulations, the pestil sample containing wheat flour + sugar + milk additives was found the best thickening agent mixture which maintained the highest antioxidant capacity. Although the physicochemical properties of the samples were found different statistically, all samples were found structurally consumable by panelists. According to the sensory analysis results, the most preferred formulation of pestil was found which contained 10% wheat flour + 5% sugar + 5% added milk.

Conclusion: Overall, it was found that the pestil produced using pomegranate juice with wheat flour + sugar + milk as a thickening agent mixture can be an alternative healty food snack as an innovative food approach.

Keywords: Antioxidant capacity, fruit leather, healthy foods, snack foods

ÖZ

Amaç: Nar meyvesinin yeni ürünler geliştirmek amacıyla pestil üretiminde hammadde olarak kullanılması ve çeşitli formülasyonların fiziksel, kimyasal ve duyusal özelliklere etkileri araştırılmıştır.

Materyal ve Yöntem: Hicaz nar sularının %75'i 40° Brix'e kadar konsantre edilmiş ve kalan %25'i üç farklı formülasyon hazırlamak amacıyla kullanılmıştır. Jelleştirici olarak formülasyonlara (a) % 10 buğday nişastası; (b) %10 buğday unu ve (c) %10 buğday unu %5 şeker % 5 yağsız inek sütü karışımları eklenmiştir. Kurutma işleminden sonra elde edilen pestil örneklerine pH değeri, titrasyon asitliği, kuru madde, su aktivitesi, renk, toplam ve invert şeker miktarı, toplam fenolik madde, antioksidan kapasite ve duyusal analizler uygulanmıştır.

Araştırma Bulguları: Pestil örneklerinin antioksidan kapasitesinin hammaddeye göre azaldığı saptanmıştır. Ancak farklı formülasyonlar ile üretilen pestil örnekleri arasında hammaddeye en yakın değeri veren ve en yüksek antioksidan kapasiteli örnek buğday unu, şeker ve süt katkılı nar pestil örneği olarak bulgulanmıştır. Numuneler arasında fizikokimyasal özellikler açısından istatistiksel olarak farklılıklar olmasına rağmen, tüm numunelerin dokusal özellikler açısından tüketilebilir olduğu panelistler tarafından belirtilmiştir. Duyusal analiz sonuçlarına göre, genel özellikler açısından en çok tercih edilen formülasyonun buğday unu, şeker ve süt katkılı nar pestili olduğu belirlenmiştir.

Sonuç: Kıvam arttırıcı madde karışımı olarak buğday unu, şeker ve süt ilaveli nar suyu kullanılarak üretilen pestilin sağlıklı atıştırmalık yenilikçi gıda üretiminde önemli bir alternatif ürün olarak yer alabileceği düşünülmektedir.

Anahtar sözcükler: Antioksidan kapasitesi, pestil, sağlıklı gıda, çerez gıdalar

INTRODUCTION

Due to the increasing awareness of healthy nutrition in the world, studies on functional foods and functional components of these foods are also increasing. Among these foods, pomegranate is a functional food due to its antioxidants, polyphenolic substances and vitamin C. It is also known that these compounds have an important role in preventing cancer and cardiovascular diseases by preventing free radical formation in the body, and also preventing the disease by lowering blood pressure in patients with high blood pressure. Within these studies, pomegranate is an important raw material for the pharmaceutical industry as a medicinal plant (Şahin, 2013). The most grown pomegranate variety in Türkiye is Hicaz pomegranate (*Punica granutum L.*). As pomegranate can be consumed fresh, it can also be processed into secondary products such as pomegranate juice, syrup, canned, pomegranate seed dried, jam and wine (Poyrazoğlu et al., 2002). Pomegranate juice contains anthocyanins such as cyanidine, pelargonidine, some phenolic compounds and tannins such as punicalin, pedunculajin, punicalagin and ellagic acid (Türkmen, 2008).

Pestil is a traditional Turkish snack food generally made from fresh grapes (Maskan et al., 2002; Kaya and Maskan, 2003). Also, berry, apricot apples, plums, raisins and figs are used in Turkey (Çağındı and Ötles, 2005). Besides, in various countries, banana, strawberry, cherry, orange, pear, pineapple, tangerine, kiwi, tomato, rosehip, mango, guava, durian, papaya and longan fruits are used to produce pestil under the name of fruit skin (Diamante et al, 2014; Simão and others, 2000).

In conventional pestil production, the fruit juice is usually concentrated to a concentration of about 40-45 °Brix. Meanwhile, the starch used as a thickening agent is boiled in a part of fruit juice and dissolved. This mixture is mixed with the remaining fruit juice and the mixture is evaporated to 80 °Brix and above. Then this viscous fruit juice obtained is spread on a suitable cloth and dried under the sun or with convective dryers. The product, pestil, obtained is microbiologically resistant due to low water activity.

In this research, the effects of different formulations on the physical, chemical and sensory properties were examined in the production of pestil from Hicaz pomegranate.

MATERIAL and METHOD

Material

The Hicaz pomegranate used as a material in the research was obtained from a local market in İzmir, Türkiye and stored at + 4 °C in Ege University Pilot Plant as a whole until processing.

Method

The seeds of pomegranates were separated from the hull by manually, then pressed and filtered with laboratory hand press without breaking the kernels. Hicaz pomegranate juices (75% w/w) were concentrated up to 40 °Brix in vacuum evaporator at 60°C. The remaining 25% (w/w) was used to prepare the thickening agent mixture. These mixture contents were prepared by three different formulations. In the first formulation, wheat starch similar to traditional production was used where the 10% wheat starch was added to the juice. In the second formulation, 10% wheat flour was added to the juice. The 10% wheat flour + 5% sugar + 5% skim cow milk mixture was used in the third formulation. The prepared thickening mixtures are mixed with concentrated pomegranate juice and concentrated up to 80±2 °Brix in vacuum evaporator at 60°C. The concentrated product was spread on a cotton cloth about 3±0.5 mm thick and was left to dry in ambient conditions (temperature 28±4 °C, humidity 30±3%). At the end of the third day, the dried pestil samples were separated from the cloth. For sensory analysis samples were stored in vacuum bags at +4 °C and other samples were stored at -18 °C until physicochemical analysis.

Physicochemical analysis

Total dry matter content of fresh and dried pomegranate samples was determined at 65°C in a vacuum oven (EV core 018, Turkey), as indicated at AOAC, 2005 (Anon, 2005).

Color measurements were made as ten measurements for each condition and sample by using Konica-Minolta CR310 Chroma-meter (Konica Minolta Sensing, Inc., Osaka, Japan) in the C.I.E. L* a* b* system. The original white calibration plate was used as a reference (L^*=93.3, a^*=0.3162, b^*=0.3321) for calibration.

Water activity values of the samples were measured using the Testo 400 water activity meter. Water-soluble dry matter (°Brix) values of the samples were measured by using a refractometer (Hanna HI96801, Limena, Italy). pH values (WTW 330i, Germany) and titratable acidity as citric acid (Anon, 2000) were measured. Total and invert sugar amounts of raw materials and dry samples were determined using Lane-Eynon Method (Cemeroğlu, 2007).

Total phenolic content of raw materials and dried samples was determined by Folin Ciocalteu reagent as indicated in Spanos and Wrolstad (1990). The method is based on the principle of colorimetric measurement of the color blue at 760 nm by reducing the Folin Ciocalteu reagent in the basic medium by phenolic substances. In the analysis according to this method, 10 ml with 1.2 N HCl was added to 0.5 g samples, then homogenized in an ultra-turrax homogenizer and completed to 50 ml with 1.2 N HCl and then filtered through Whatman No. 1 filter paper. After filtration, 0.5 mL of clear filtrate was transferred to glass tubes, 2.5 mL of dilute Folin and Ciocalteu reagent (1:10) was added. 2 mL of Na_2CO_3 was added to the tubes which were kept in the dark for 4 minutes, vortexed and stirred at 50°C for a further 5 minutes in the dark. The absorbance of the blue color resulting from the redox reaction was measured colorimetrically. The measured absorbance values were calculated from the equation of the standard graph prepared in gallic acid and the amount of phenolic material was expressed in mg gallic acid/L.

For the determination of antioxidant capacity; as described in Blois (1958), 0.1 mL of sample extracts and standard solutions were allowed to stand in the dark for 30 minutes by mixing with 2.9 mL of DPPH solution dissolved in 0.1 mM ethanol. The absorbance of the mixture was then read at 517 nm against ethanol, calculated from the slope of the standard graph as mmol ascorbic acid equivalent per 100 g sample.

Sensory analysis

According to Altuğ and Elmaci (2011), sensory analysis was performed by trained panelists consisting of 8 females and 7 males between the ages of 26-55. Panelists were trained according to predetermined color, texture, taste, general preference criteria using traditionally produced pestils. Panelists ranked the samples from the most desirable (superior) to the least desirable (inferior) and the place of the samples in the ranking test was evaluated as points.

Statistical analysis

The mean values of the analysis results obtained in two parallel three replicates were evaluated statistically (IBM, SPSS Statistics 25 software, USA). To assess the significance of differences of values obtained for the analysis, the one-way analysis of variance (ANOVA) was applied. If significant differences were found, the post-hoc Duncan test was used. For all variables, the significance level of α=0.05 was adapted.

RESULTS and DISCUSSION

Physicochemical analysis

As a result, the pH value of the raw material was determined as 3.71 ± 0.03, while the pH value of the traditional fruit pestil sample with wheat starch was measured as 3.29 ± 0.04 (Table 1). While the highest pH value (3.42 ± 0.02) was found in the pomegranate pestil sample with wheat flour, it was determined that the wheat flour + sugar + milk mixture additive sample had the lowest pH value (2.52 ± 0.020).

According to the results of titratable acidity as citric acid, it was found that the acidity values of the samples ranged from 0.61 ± 0.02 to 0.79 ± 0.03 (Table 1). pH and acidity values are important both for the microbiological safety of the product and for directly affecting the taste.

In this context, as a result of interpretation of pH and acidity values with sensory analysis results, it has been found that the most preferred sample was wheat flour + sugar + milk added pestil sample with the lowest pH value and the least preferred sample was traditional pestil prepared with wheat starch. There was an important difference among the pH values, there was no statistically significant difference between acidity values ($p<0.05$). The results obtained are similar to previous studies (Simão et al, 2000).

According to the total dry matter analysis results (Table 1), the total dry matter content of the raw material was found to be 19.65 ± 0.09%. The total dry matter contents of the pulp samples obtained as a result of adding additives and evaporation applied varied between 78.27 ± 1.85% and 84.58 ± 0.73%. The total dry matter value of the wheat starch-added pulp sample was statistically significant from the total dry matter values of the other two fruit samples ($p<0.05$). The results were found similar with other researches in pestil production where the total dry matter values between 84% and 87% in grapefruit and 80% in apricot and mango pestils were specified (Kara and Küçüköner 2019).

Water activity values of wheat flour + sugar + milk added pomegranate pestil sample, wheat flour added pomegranate pestil sample and wheat starch added pomegranate pestil sample were 0.63, 0.52 and 0.61, respectively, as shown in Table 1. It was found that the highest water activity value was measured in the wheat flour, sugar and milk-added pestil sample and the lowest water activity value was measured in the wheat flour-added pestil sample. Products with water activity values below 0.6 can be stored for a long time without the need for chemical preservatives, and the results obtained are in line with similar products (Jay, 1992).

Table 1. pH, acidity, total dry matter and water activity values of pomegranate pestil samples

Çizelge 1. *Nar pestili örneklerinin pH, asitlik, toplam kuru madde ve su aktivitesi değerleri*

Pomegranate Pestil	pH	Acidity	Total Dry Matter (%)	Water Activity
Raw material	3.71^{a}±0.03	0.61^{b}±0.02	19.65^{c}±0.09	----
Wheat starch added	3.29^{c}±0.04	0.75^{a}±0.02	84.58^{a}±0.73	0.61^{b}±0.36
Wheat flour + sugar + milk added	2.52^{d}±0.02	0.79^{a}±0.03	78.49^{b}±0.20	0.63^{a}±0.10
Wheat flour added	3.42^{b}±0.02	0.77^{a}±0.03	78.27^{b}±1.85	0.52^{c}±0.17

**Different letters in the same column indicate a significant difference (p<0.05)*

Color analysis

When the color analysis results of the samples were examined, it was seen that the original bright red color of the raw material changes to the traditional pestil color as in similar studies (Yüksekkaya, 2013; Tontul and Topuz, 2017). When the samples of the pulp were examined in terms of L* values, color darkening is observed as a result of the non-enzymatic browning reaction that occurs during the concentration of the product. While the lightest colored sample was prepared with wheat flour, the color changes were statistically significant in the other two samples. When a * and b * values were analyzed, it was observed that the difference was statistically significant in all samples ($p<0.05$), with the decrease in L* values of the samples, it was observed that the color changed to matt dark red (Table 2). Considering the sensory evaluations, the closest sample to fresh pomegranate color was the wheat flour-added pestil sample. However, with the increasing b * value, the color changing towards yellow had a negative effect, and the wheat flour + sugar + milk additive sample, which is one of the new formulation trials, came to the fore as the most liked sample.

Table 2. Hunter L *, a *, b * color values of pomegranate pestil samples

Çizelge 2. *Nar pestili örneklerinin Hunter L *, a *, b * renk değerleri*

Pomegranate Pestil	L*	a*	b*
Raw material	21.88^{a}±0.22	23.57^{a}±0.22	11.38^{a}±0.15
Wheat starch added	20.14^{b}±0.16	4.42^{d}±0.14	0.26^{d}±0.12
Wheat flour + sugar + milk added	19.59^{c}±0.15	8.69^{c}±0.12	1.33^{c}±0.13
Wheat flour added	21.69^{a}±0.29	16.73^{b}±0.29	4.93^{b}±0.29

**Different letters in the same column indicate a significant difference (p<0.05)*

Sugar analysis

The total sugar amount of wheat flour + sugar + milk added pestil sample was 40.83 g/100 g dry matter. Total sugar content of wheat flour added pestil sample was found as 37.99 g/100 g dry matter. Total sugar content of wheat starch added pestil sample was found as 45.40 g/100 g dry matter (Table 3).

Table 3. Total and invert sugar values of pomegranate pestil samples
***Çizelge 3.** Nar pestili örneklerinin toplam ve invert şeker değerleri*

Pomegranate Pestil	Invert Sugar g/100 g	Total Sugar g/100 g
Wheat starch added	35.87^{a}±0.68	45.40^{b}±2.03
Wheat flour + sugar + milk added	28.96^{c}±0.55	40.83^{c}±0.48
Wheat flour added	30.24^{b,c}±0.44	37.99^{d}±0.58

**Different letters in the same column indicate a significant difference (p<0.05)*

While the highest amount of total sugar was found in the wheat starch added pestil sample, the lowest amount of total sugar was found in the wheat flour added pestil sample. It is thought that the high total sugar and invert sugar values measured in the samples with wheat starch, which is an example of traditional pestil production, are formed as a result of starch breaking into glucose. Hicaz pomegranate contains approximately 4% glucose and fructose on average (Anon, 2020). The unique sweet-sour taste of pestil is formed by the sugars released as a result of the breakdown of added starch and 10% carbohydrates in pomegranate composition and also increased dry matter during evaporation.

Total phenolic and antioxidant capacity

The total phenolic substance content of the fresh raw material was determined as 5176.84 mg GAE/100 g dry matter. In similar research, the total amount of phenolic substances in pomegranate juice was varied between 144-10086 mg GAE / L (Tezcan et al., 2009). According to total phenolic substance analysis results, total phenolic content of pomegranate pestil with wheat flour + sugar + milk pomegranate pestil, with wheat flour and pomegranate pestil with wheat starch, respectively; 2974.75, 3655.16 and 4807.92 mg GAE/ 100 g dry matter (Table 4).

The highest amount of phenolic substance was found in pomegranate pestil sample with starch and the lowest amount of phenolic substance was in pomegranate pestil sample prepared with wheat flour, sugar and milk. Especially, for starch added pestils; starch and derivatives are generally used to prevent oxidation of sensitive compounds in food technology because these ingredients prevent permeability of oxygen into the structure (Tontul and Topuz, 2018).

When the total phenolic substance contents of pomegranate pestil samples are compared to raw material, a decrease in total phenolic substance values has been determined, but high total phenolic substance values have been obtained according to the results given in pestil studies made from other fruits (Tontul and Topuz 2017; Kara and Küçüköner 2019; Tontul and Topuz, 2018; Yılmaz at al, 2017; Yıldız, 2013). In this context, it is thought that the pestil produced using pomegranate can take an important place in healthy snack food production.

The antioxidant capacity of the raw material was determined as 3.99 mmol ascorbic acid equivalent / 100 g dry matter. The antioxidant capacity of the wheat flour, sugar and milk-added pomegranate pestil sample is 0.81 mmol ascorbic acid equivalent / 100 g dry matter; pomegranate pestil with wheat flour additive 0.75 mmol ascorbic acid equivalent / 100 g dry matter and pomegranate pestil sample with wheat starch was determined as 0.53 mmol ascorbic acid equivalent / 100 g dry matter (Table 4). While the sugar-milk pomegranate pestil sample has the highest antioxidant capacity, the starch pomegranate pestil sample has the lowest antioxidant capacity. The antioxidant activity of pomegranates is due to phenolic compounds, ascorbic acid and anthocyanins. The evaporation process applied during the process causes degradation of these compounds and losses. (Tontul and Topuz, 2017; Aktaş and Malayoğlu, 2019.)

Table 4. Total phenolic content and antioxidant capacity values of pomegranate pestil samples
Çizelge 4. *Nar pestili örneklerinin toplam fenolik içeriği ve antioksidan kapasitesi değerleri*

Pomegranate Pestil	Total phenolic substance mg GAE/100 g DM	Antioxidant capacity mmol AAE/100 g DM
Raw material	$5176.84^{a}\pm1.77$	$3.99^{a}\pm0.09$
Wheat starch added	$4807.92^{b}\pm1.33$	$0.53^{c}\pm0.01$
Wheat flour + sugar + milk added	$2974.75^{d}\pm1.88$	$0.81^{b}\pm0.01$
Wheat flour added	$3655.16^{c}\pm1.62$	$0.75^{b}\pm0.01$

**Different letters in the same column indicate a significant difference (p<0.05)*

Sensory analysis

Pomegranate pestil samples prepared using different formulations were analysed according to their color, texture, taste and hedonic attributes. The most preferred pestil sample by the panelists in terms of all sensory attributes was wheat flour + sugar + milk added pomegranate pestil sample. While the starch added pomegranate pestil sample was the second preferred sample in terms of color, it was not preferred for other sensory attributes. According to results, it has been found that sugar and milk additives, together with starch as a thickener, was increased the preferability for pestil samples (Table 5).

Table 5. Sensory analysis results of pomegranate pestil samples
Çizelge 5. *Nar pestili örneklerinin duyusal analiz sonuçları*

Pomegranate Pestil	Color	Texture	Taste	Preference
Wheat starch added	2.3 ± 0.5^{a}	1.3 ± 0.7^{b}	1.3 ± 0.7^{c}	1.3 ± 0.7^{c}
Wheat flour + sugar + milk added	2.6 ± 0.6^{a}	2.5 ± 0.5^{a}	2.7 ± 0.5^{a}	2.7 ± 0.5^{a}
Wheat flour added	1.1 ± 0.5^{b}	2.1 ± 0.7^{a}	2.0 ± 0.7^{b}	2.0 ± 0.7^{b}

**Different letters in the same column indicate a significant difference (p<0.05)*

CONCLUSION

Pestil is a traditionally consumed snack food. The usage of pomegranate juice as an alternative raw material for pestil production instead of traditional grape juice was investigated. The importance of healthy snack food production is increasing due to the consumer demand. Our results showed that pomegranate pestils can be a new alternative healthy snack for children consumption. Instead of traditional thickening agents, new formulations can be improved to increase the acceptability of pestils. Wheat flour + sugar + milk combination usage is a new approach for thickening and improving the sensorial acceptance of the pomegranate pestils instead of traditionally used starch as a thickener. New researches needs to be done to improve the nutritional and sensorial characteristics of the traditional pestil products for increasing their economical value in our country.

REFERENCES

Aktaş, B., Basmacıoğlu Malayoğlu, H. 2019. Comparison of Phenolic Compounds and Antioxidant Activities of the Extracts of Grape Seed, Rosemary, Green Tea and Olive Leaf. Ege Univ. Ziraat Fak. Derg., 56 (1):77-82, DOI:10.20289/zfdergi.431192

Altug, T. and Elmaci, Y., 2011. Sensory evaluation in foods. 2nd edition. [in Turkish] Sidas Media, Izmir. ISBN 9789944566087, pp 50-55.

Anon, 2000. AOAC 17th edn, 2000, Official method 942.15 Acidity (Titrable) of fruit products read with A.O.A.C official method 920. 149.

Anon, 2005. AOAC 18th edition, 2005, Official method 920.151 Solids (Total) in Fruits and Fruit Products.

Anon, 2020. Ulusal Gıda Kompozisyon Veritabanı. www.turkomp.gov.tr/

Blois, M. 1958. Antioxidant Determinations by the Use of a Stable Free Radical. Nature, 181, 1199–1200 (1958). https://doi.org/10.1038/1811199a0

Cağındı, Ö. and Ötles, S. 2005, Comparison of some properties on the different types of pestil traditional product in Turkey. International Journal of Food Science and Technology, 40; 897-901.

Cemeroğlu, B. 2007. Gıda analizlerinde genel yöntemler, Gıda Analizleri. (1ed.) Bizim Büro Basımevi, Ankara.

Diamante, L. M., Bai, X., and Busch, J., 2014. Fruit Leathers: Method of Preparation and Effect of Different Conditions on Qualities. International Journal of Food Science, 12p http://dx.doi.org/10.1155/2014/139890

Jay, M.J., 1992. Modern Food Microbiology. Chapman &Hall Book, One Penn Plaza, New York NY 10119

Kara, O.O. and Küçüköner, E., 2019. Geleneksel bir meyve çerezi: Pestil. Akademik Gıda, 17(2) (2019) 260-268.

Kaya, S. and Maskan, A. 2003. Water vapor permeability of pestil (a fruit leather) made from boiled grape juice with starch. Journal of Food Engineering, 57. 295-299.

Maskan, A., Kaya, S. and Maskan, M. 2002. Effect of concentration and drying processes on color change of grape juice and leather (Pestil). Journal of Food Engineering, 54. 75-80.

Poyrazoğlu, E., Gökmen, V., Artık, N. 2002. Organic Acids and Phenolic Compounds in Pomegranates (Punica granutum L.) Grown in Turkey, Journal of Food Composition and Analysis, 15, 567-575.

Şahin, A., 2013, Nar Yetiştiriliciği, (Ed. K.,Yaz), TC. Tarım ve Köyişleri Bakanlığı Çiftçi Eğitim Serisi, Antalya, l-5.

Simão, R. S., Moraes, J. O., Carciofi, B. A. M. and Laurindo, J. B., 2020. Recent Advances in the Production of Fruit Leathers. Food Engineering Reviews, 12:68–82. https://doi.org/10.1007/s12393-019-09200-4

Spanos, G.A. and Wrolstad, R.W. 1990. Influence of Processing and Storage on the Phenolic Composition of Thompson Seedless Grape Juice. J. Agric. Food Chem., 38, 1565-1571

Tezcan, F., Gültekin-Özgüven, M. Diken, T., Özçelik, B. and Erim, F.B., 2009. Antioxidant activity and total phenolic, organic acid and sugar content in commercial pomegranate juices. Food Chemistry, 115 873–877.

Tontul, İ. and Topuz, A. 2017. Effects of different drying methods on the physicochemical properties of pomegranate leather (pestil). LWT – Food Science and Technology, 80 294-303

Tontul, İ. and Topuz, A., 2018. Production of pomegranate fruit leather (pestil) using different hydrocolloid mixtures: An optimization study by mixture design. J Food Process Eng., 41 1-12.

Türkmen, İ., 2008, Nar suyunda gerçeklik kontrol kriteri olarak sorbitol içeriği. Ankara Üniversitesi Fen Bilimleri Enstitüsü, Yüksek lisans tezi, 53 s.

Yıldız, O., 2013. Physicochemical and sensory properties of mulberry products: Gümüşhane pestil and köme. Turkish Journal of Agriculture and Forestry, 37.

Yılmaz, M.F., Yüksekkaya, S., Vardin, H., Karaarslan, M., 2017. The Effects of drying Conditions on moisture Transfer and Quality of Pomegranate Fruit Leather (pestil). Journal of the Saudi Society of Agricultural Sciences, 16, 33-40.

Yüksekkaya, S., 2013, Farklı Üretim Teknikleri İle Üretilmiş Nar Pestilinde Kurutma Kinetiği ile Fenolik ve Antisiyonin Bileşiminin Belirlemesi Yüksek Lisans Tezi. Harran Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği Anabilim Dalı, Şanlıurfa.