ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article DOI: 10.62425/pharmata.1605470

Vitamin C, Sugar Content, Color Intensity and Some Physicochemical Properties of Watermelon and Orange Peels

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ABSTRACT

Objective: The peels produced as waste during the consumption and processing of fruits and vegetables cause both nutrient losses and environmental pollution. Due to their high nutritional content, raw material potential, and the aim of reducing environmental pollution, the use of certain fruit and vegetable peels in various forms and applications in the food industry is becoming increasingly widespread. This study investigates the usability of watermelon and orange peels in terms of their functionality by analyzing their vitamin C and sugar contents, color intensities, and some physicochemical properties.

Methods: Glucose, fructose, and sucrose contents were determined by High-Performance Liquid Chromatography (HPLC), vitamin C content by titrimetric method, protein content by the Kjeldahl method, color intensities by a colorimeter, and other properties using standard methods.

Results: In watermelon peel, the dry matter content was found to be 3.57±0.27%, total acidity 0.59±0.01%, pH 5.74±0.02, total ash 0.65±0.02%, protein 1.76±0.01%, glucose 0.54±0.02%, fructose 1.26±0.06%, L* value 72.45±1.10, a* value -14.81±1.30, and b* value 35.91±3.46. Vitamin C and sucrose were not detected in watermelon peel. In orange peel, the total dry matter (TDM) was 23.31±0.08%, total acidity 1.22±0.02%, pH 5.09±0.02, total ash 1.12±0.05%, vitamin C 122.33±2.52 mg/100g, protein 2.41±0.08%, glucose 2.18±0.12%, fructose 1.89±0.03%, and sucrose 0.28%. The color values were L* 68.92±0.47, a* 19.23±4.09, and b* 63.85±1.8.

Conclusion: Based on the findings of this study, orange peel, which is produced in large quantities as waste in the industry, contains more nutrients, exhibits better color intensity, and has a significantly higher vitamin C content compared to watermelon peel. Therefore, orange peel can be used as a natural antioxidant and color source in the food, pharmaceutical, and cosmetic industries.

Keywords: Orange Peel, Physicochemical Properties, Sugar, Vitamin C, Watermelon Peel

Received 23.12.2024
Accepted 27.01.2025
Publication Date 16.03.2025

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Cite this article: Şengül M, Gökçe S, Karakütük İA. Vitamin C, sugar content, color intensity and some physicochemical properties of watermelon and orange peels. *Pharmata.* 2025;5(1):1-6.

INTRODUCTION

As the global population increases, food consumption rises proportionally, leading to a parallel increase in agricultural waste. This situation contributes to the depletion of limited natural resources and environmental pollution.[1] Food waste, while causing economic and environmental problems such as greenhouse gas emissions and inefficient use of water and soil, also represents valuable resources rich in food components and various bioactive compounds, including phenolic and antioxidant compounds.[2] Transforming these resources into value-added products through various technologies across different industries is crucial for preventing environmental pollution, ensuring sustainability in food resources, and reducing food loss and waste.[3]

Food losses occur during production, processing, retail sales, and as a result of improper storage conditions or overproduction/purchasing in restaurants or households. Parts such as peels, seeds, skins, stems, and leaves of agricultural products generate significant waste potential worldwide.

Similarly, losses occur during the preparation or processing of fruits and vegetables for consumption, contributing to environmental pollution through both household and industrial waste. However, fruits, vegetables, and their various parts (peels, stems, seeds) contain a wide range of nutrients, including vitamins, minerals, carbohydrates, dietary fiber, phenolic and antioxidant compounds, pectic substances, essential fatty acids, and beneficial pigments, making them important for human nutrition.

In Turkey and globally, significant amounts of watermelon (Citrullus lanatus) and citrus fruits are produced and consumed. However, a large portion of their peels is discarded without being utilized. Approximately 30% of a watermelon's total weight consists of its peel.[4] Watermelon rind is rich in bioactive components such as dietary fiber, various minerals, vitamins, phytochemicals, and phenolic compounds. Some studies have reported that compounds found in watermelon rind help protect the body against certain types of cancer. The phenolic compounds in watermelon rind are noted for lowering low-density lipoprotein (LDL) levels in the blood, while pectin cleanses intestinal walls and facilitates the synthesis of short-chain fatty acids in the intestines.[5]

Orange peel, another significant waste product, is rich in bioactive compounds and pectic substances, making it a promising material for the development of functional foods. The peel accounts for approximately 15% of an orange's weight.[6]. When only the juice is extracted, the pulp and peel result in a significant amount of waste. Orange peel contains essential minerals like iron, calcium, magnesium, potassium, and copper, as well as important vitamins such as vitamin C.[1] It has been reported to contain; 8.120±0.120 g/100g protein, 46.241±0.015 g/100g total carbohydrates in its dry matter. Research indicates that orange peel contains antioxidant such as flavonoids (2.685±0.062 g/100 g d.b) and vitamin C (0.105±0.003 g/100 g d.b).[7]

Rich in pectin, cellulose, hemicellulose, soluble sugars, carotenoids, flavonoids, and essential oils, orange peel is a valuable by-product with potential uses in the food, biotechnology, and energy industries.[8] Its antioxidant properties reduce the risk of cancers caused by oxidative stress, and its dietary fiber positively affects the digestive system. Additionally, the vitamin C and potassium content in orange peel contribute to skin health. In recent years, studies on utilizing orange peel in various forms and shapes within the food industry have become increasingly common.[9-11]

Vitamin C, also known as ascorbic acid, is a water-soluble essential vitamin that cannot be synthesized by the human body and is naturally found in various vegetables and fruits.[12,13] Due to its high vitamin C content and high per capita consumption, citrus fruits are undoubtedly the most important source of vitamin C in human nutrition. Therefore, citrus fruits are a significant source of vitamin C in the human diet. As a primary antioxidant compound, the vitamin C concentration is one of the indicators of the nutritional quality of citrus fruits and their derivative products.[14-16] Interestingly, vitamin C accounts for more than 65% of the antioxidant and free radical activity in many fruits and their beverages.[17,18] On the other hand, it is known that vitamin C directly scavenges free radicals such as hydroxyl radicals, superoxide, singlet oxygen, and hydrogen peroxide, thereby reducing the damage caused by these radicals.[19] One study noted that in most biological systems, vitamin C protects compounds both in intracellular and extracellular areas.[20] Additionally, vitamin C lowers plasma cholesterol levels and increases the absorption of inorganic iron.[21,22]

This study aims to determine the vitamin C content, glucose, fructose, and sucrose levels using HPLC as well as the color intensity and some physicochemical properties of watermelon and orange peels, which are considered food waste.

METHODS

Materials

In this study, watermelon and orange fruits were procured from the local markets in Erzurum province. Watermelons (Citrullus lanatus) were washed with tap water, dried with paper towels, and peeled to separate the rind from the flesh (entirely red part). The white rind and green rind were separated using a knife. The white rinds were blended into smaller pieces and used in analyses and extractions. Valencia oranges were used as the orange variety in the study. Both the flavedo and albedo layers of the orange peels were utilized. Oranges were washed with tap water, dried with paper towels, and peeled. The flavedo and albedo parts of the peels were blended together and used in analyses and extractions.

Physicochemical Analyses

The physicochemical properties of watermelon and orange peels, including total dry matter (TDM), total ash (total mineral content), titratable acidity (expressed as citric acid, g citric acid/100 mL), vitamin C content, and pH values, were determined according to Cemeroğlu (2013).[23]

The total nitrogen content of the peels was measured using the Kjeldahl method, and the protein content was calculated by multipliying the result by a factor of 6.25.[24]

The color intensities of the watermelon and orange peels were determined using a three-dimensional Konica Minolta Colorimeter (Konica Minolta CR400, Korea). In the color scale representing values L*, a*, b*, H^0 and C*:

- L* = 100 represents white, L* = 0 represents black
- +a* indicates red, -a* indicates green.
- +b* represents yellow, -b* represents blue
- Hue angle (H0) indicates color tone
- Chroma (C*) represents saturation. The blended peels were placed on a white surface for color measurements.

Fructose, Glucose, and Sucrose Determination

Two grams of blended peel were weighed and transferred into 50 mL volumetric flasks. A small amount of ultrapure water was added, and the mixture was stirred before the volume was brought up to 50 mL with ultrapure water. The mixture was shaken thoroughly and filtered through 0.45 µm filters into vials, which were then analyzed using an HPLC system (Shimadzu LC-2050C-3D model).[1]

HPLC Conditions:

- Column: C-18 (4.6 mm × 150 mm)
- Mobile Phase: Water/Acetonitrile (25/75 mixture)
- Detector: HPLC-RID
- Wavelength: 255 nm
- Injection Volume: 20 µL
- Flow Rate: 1 mL/min

Statistical Analyses

Statistical analyses were conducted using SPSS (IBM SPSS Statistics 25, 2020). The results were subjected to correlation and variance analyses. The significance of differences between groups was determined using Duncan's Multiple Comparison Test at a significance level of 0.05. Results are presented as mean values ± standard deviation.

RESULTS AND DISCUSSION

The total dry matter (TDM), total ash (mineral content), titratable acidity, protein, vitamin C content, and pH values of watermelon and orange peels are presented in Table 1. The TDM and total ash content of fruit peels were found to be statistically significantly different (P<.01), with orange peels having higher TDM and ash content than watermelon peels. Previous studies reported TDM content in watermelon rinds as 6.21–7.40% and 11.86% in orange peels.[25,26] The ash content of watermelon rinds has been reported as 7.9%, 10.2 g/100 g, and 13.2 g/100 g in various studies, whereas orange peels have shown ash content of 5.34% and 3.17 g/100 g dry weight.[7,26] Previous studies reported that from the spring season in plants total plant dry weight increased rapidly from they reported. Increasing temperature and light conditions in this increase has been effective. As a matter of fact, increasing temperature and light they stated that it affected plant dry weight.[27]

The pH values and titration acidity of watermelon rind and orange peel were found to be statistically significantly different (P<.01). The pH values of watermelon rind and orange peel were 5.74±0.02 and 5.09±0.02, respectively; and the titration acidity values were 0.59±0.01% and 1.22±0.02%, respectively. It was determined that the pH value of orange peel was lower than that of watermelon rind, while the titration acidity was higher (Table 1). Studies on orange peel reported a pH value of 5.67 and a titration acidity of 2.98 g/100g.[7,28] In another study, the titration acidity of watermelon rind was reported to be 0.360 g/100g.[29]

Fruits are generally not considered a source of protein.[30] It was determined that the protein content of fruit peels was statistically significantly different (P<.01), with orange peel containing a higher amount of protein (Table 1). In a study, the protein content of watermelon rind was found to be 0.15% in its fresh form, 2.067% in freeze-dried form, and 1.83% in hot air-dried form.[31] Different studies also reported the protein content of orange peel as 6.08%, 6.77 g/100g and 8.12 g/100g dry weight.[7,32] Factors such as the natural environment or greenhouse effect, pesticide use, fertilization, and whether the fruit is grown in season or not can cause variations in nutrient content.[33]

Ascorbic acid (vitamin C) is an important nutrient due to its vitamin activity and strong antioxidant properties. Antioxidants are substances that can prevent or partially delay oxidation. Thanks to these components, oxidation damage in the human body is minimized.[34]. Ascorbic acid is one of the components that prevent the formation of free radicals or inhibit the free radicals that are formed. For consumers, antioxidant capacity has become an element of quality.[35,36]

In the study, it was determined that orange peel contains 122.33±2.52 mg/100g of vitamin C, while no vitamin C was detected in watermelon rind (Table 1).

In a previous study, the ascorbic acid contents of orange, lemon, and grapefruit peels were examined, and the vitamin C content of orange peel was reported as 433.11±16.03 ppm.[37] The recommended daily intake (RDA) of ascorbic acid for healthy individuals to meet cellular requirements and reduce the risk of cardiovascular and neurodegenerative diseases, cancer, and stroke is 100–120 mg/day.[38] For example, it was found that one cup of orange juice (200 mL) provides 30% to 80% of the recommended daily amount of vitamin C.[39] Some previous research suggests that liver damage may be caused by free radical metabolites.[40] Vitamin C scavenges free radicals in a powerful way.[41] It is thought that vitamin C in orange peel may play an important role in scavenging free radicals. As seen in our study, 100g of orange peel can meet the daily vitamin C requirement of a healthy individual. Therefore, orange peels can be used as a good source of vitamin C by adding them to various formulations in the food, pharmaceutical, and cosmetic industries.

The sugars present in fruits and vegetables are almost entirely composed of glucose and fructose, along with small amounts of sucrose and the hexose mannose. The proportions of these sugars vary depending on the type and variety of the fruit or vegetable. Fruit peels generally have a lower sugar composition than the fleshy parts of the fruit.[23] The amounts of glucose, fructose, and sucrose in watermelon and orange peels are provided in Table 2. In the study, a statistically significant difference (*P*<.01) was found between the fructose, glucose, and sucrose content of watermelon and orange peels (Table 2). In one study, the amount of fructose in orange peel was reported as 1.72 g/L, and glucose was 6.26 g/L.[42] In another study, where watermelon rind juice was used, the fructose content ranged from 1.14-4.97 mg/mL, glucose content from 1.18-4.90 mg/mL, and sucrose content from 1.12-4.96 mg/mL.[43]

Color is an important quality parameter in food products. The color of fruits and vegetables can be influenced by chemical, biochemical, microbial, and physical changes that occur during growth, ripening, post-harvest storage, and processing.[44] In color analysis, L* represents lightness (0 = black/dark, 100 = white/light), +a* indicates red, -a* indicates green, +b* indicates yellow, and -b* indicates blue color intensities.[45] The C* value (chroma) indicates color intensity, and the Hº (Hue angle) specifies the color tone. Additionally, measured color values, including H0 (hue) and chroma represented by C*, were determined. Chroma is a dimensionless value that shows the saturation of color. In dull colors, the chroma value is lower, while in vivid colors, the chroma value is higher.[46]

The color intensities of watermelon and orange peels are shown in Table 3. A significant statistical difference (*P*<.01) was observed between the L*, a*, b*, C*, and H° values of the fruit peels. Orange peel was found to be darker (L* value) and more yellow (+b* value) compared to watermelon peel (Table 3). In one study, the L* value of orange peels was found to be 60.73±0.78, a* value -27.34±0.10, b* value 59.03±0.17, C* value 65.05a±0.19, and h value 65.04±0.12.51 The results of our study are similar to previously conducted studies. In another study, watermelon peels were subjected to quick freezing, and the resulting color values were reported as L* 77.22±0.2, a* -0.38±0.2, b* 19.8±0.2, C* 45.05±0.12, and H° 48.69±0.2.37 They reported that the quick freezing process led to an increase in the L* values, meaning a higher lightness of color.

Table 1. Physicochemical Properties and Vitamin C Content of Watermelon and Orange Peels

Fruit Peel	Total Dry Matter (%)	Total Ash (%)	pH	Titratable Acidity (%)	Protein (%)	Vitamin C (mg/100 g)
Watermelon Peel	$3.57±0.27^b$	$0.65±0.02^b$	$5.74±0.02^a$	$0.59±0.01^b$	$1.76±0.01^b$	ND
Orange Peel	$23.31±0.08^a$	$1.12±0.05^a$	$5.09±0.02^b$	$1.22±0.02^a$	$2.41±0.08^a$	122.33±2.52
Significance	**	**	**	**	**	**

**: Statistically highly significant (*P*<.01), ND: Not detected
a, b: Means in the same column with different letters are significantly different.

Table 2. Glucose, Fructose, and Sucrose Contents of Watermelon and Orange Peels

Fruit Peel	Glucose (%)	Fructose (%)	Sucrose (%)
Watermelon Peel	$0.54±0.02^b$	$1.26±0.06^b$	ND
Orange Peel	$2.18±0.12^a$	$1.89±0.03^a$	0.28
Significance	**	**	**

**: Statistically highly significant (*P*<.01), ND: Not detected
a, b: Means in the same column with different letters are significantly different.

Table 3. Color Intensity of Watermelon and Orange Peels

Fruit Peel	L* (Lightness)	a* (Red/Green)	b* (Yellow/Blue)	C* (Chroma)	H° (Hue)
Watermelon Peel	72.45±1.10[a]	-14.81±1.30[a]	+35.91±3.46[b]	38.84±3.70[b]	112.42±0.17[a]
Orange Peel	68.92±0.47[b]	-19.23±4.09[b]	+63.85±1.80[a]	66.75±2.40[a]	73.29±3.27[b]
Significance	**	**	**	**	**

**: Statistically highly significant (*P*<.01)

[a, b]: Means in the same column with different letters are significantly different

CONCLUSION

Natural and synthetic vitamin C and antioxidants are used in many products in the food, pharmaceutical, and cosmetic industries. In recent years, scientific research has focused on natural sources of antioxidants due to the potential harms of synthetic additives and antioxidants to human health. This study investigated the potential of watermelon and orange peels, which are significant industrial and processing by-products, as sources of natural vitamin C, antioxidants, and certain nutrients. The results of the study show that watermelon peel does not contain vitamin C and sucrose, while orange peel has a higher dry matter content than watermelon peel. Orange peel also contains more mineral substances, acidity, protein, glucose, and fructose, has better color intensity, and contains a high amount of vitamin C. Therefore, it can be concluded that orange peel can be used as a source of natural antioxidants and color in the food, pharmaceutical, and cosmetic industries.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.Ş, S.G; Design - M.Ş, S.G; Supervision - M.Ş; Resources – S.G; Materials - M.Ş, S.G; Data Collection and/or Processing - S.G, İ.A.K; Analysis and/or Interpretation - M.Ş, S.G, İ.A.K; Literature Search - M.Ş, S.G; Writing Manuscript -; Critical Review - M.Ş

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The author, İsa Arslan KARAKÜTÜK, is supported by the TUBITAK BIDEB 2211/A National Ph.D. Scholarship Program.

REFERENCES

1. Özkan G, Subaşı BG, Beştepe SK, Güven EÇ. Sürdürülebilir gıda ve tarımsal atık yönetimi. *Çevre İklim ve Sürdürülebilirlik*. 2022;23(2):145-160.
2. Castrica M, Rebucci R, Giromini C, Tretola M, Cattaneo D, Baldi A. Total phenolic content and antioxidant capacity of agri-food waste and by-products. *Ital J Anim Sci*. Jan 2 2019;18(1):336-341. [CrossRef]
3. Teixeira F, Dos Santos BA, Nunes G, et al. Addition of Orange Peel in Orange Jam: Evaluation of Sensory, Physicochemical, and Nutritional Characteristics. *Molecules*. Apr 2020;25(7). [CrossRef]
4. Erukainure O, Oke O, Daramola A, Adenekan S, Umanhonlen E. Improvement of the biochemical properties of watermelon rinds subjected to Saccharomyces cerevisae solid media fermentation. 2010:806-809.
5. Okwu D, Emenike I. Evaluation of the phytonutrients and vitamin contents of citrus fruits. *Int J Mol Med Adv Sci*. 2006;2(1):1-6.
6. Hashmi SH, Ghatge P, Machewad GM, Pawar S. Studies on extraction of essential oil and pectin from sweet orange. *Open Access Scientific Reports.* 1:291. [CrossRef]
7. M'hiri N, Loannou I, Ghoul M, et al. Proximate chemical composition of orange peel and variation of phenols and antioxidant activity during convective air drying. *J. New Sci*. 2015.
8. Mohsin A, Hussain MH, Zaman WQ, et al. Advances in sustainable approaches utilizing orange peel waste to produce highly value-added bioproducts. *Crit Rev Biotechnol*. Nov 17 2022;42(8):1284-1303. [CrossRef]
9. Ali J, Abid H, Hussain A. Study on Some Macronutrients Composition in Peels of Different Citrus Fruits Grown in NWFP. *J Chem Soc Pakistan*. Feb 2010;32(1):83-86.
10. Al-Bedrani DI, ALKaisy Q, Mohammed Z. Physicochemical, rheological and sensory properties of yogurt flavored with sweet orange (citrus sinensis) marmalade. IOP Publishing; 2019:012052. [CrossRef]
11. Huang D, Yuan Y, Tang ZZ, et al. Retrotransposon promoter of controls both light- and cold-induced accumulation of anthocyanins in blood orange. *Plant Cell Environ*. Nov 2019;42(11):3092-3104. [CrossRef]
12. Chebrolu SB, Ness LR. Impact of cloud aspects on IT effectiveness. *J. Inf. Technol. Manag*. 2012;23(1):1.
13. Valente A, Albuquerque TG, Sanches-Silva A, Costa HS. Ascorbic acid content in exotic fruits: A contribution to produce quality data for food composition databases. *Food Res Int*. Aug 2011;44(7):2237-2242. [CrossRef]
14. Gardner PT, White TAC, McPhail DB, Duthie GG. The relative contributions of vitamin C, carotenoids and phenolics to the antioxidant potential of fruit juices. *Food Chem*. Mar 2000;68(4):471-474. [CrossRef]
15. Zerdin K, Rooney ML, Vermuë J. The vitamin C content of orange juice packed in an oxygen scavenger material. *Food Chem*. Aug 2003;82(3):387-395. [CrossRef]
16. Magwaza LS, Mditshwa A, Tesfay SZ, Opara UL. An overview of preharvest factors affecting vitamin C content of citrus fruit. *Sci Hortic-Amsterdam*. Feb 14 2017;216:12-21. [CrossRef]
17. Lavelli V, Pompei C, Casadei MA. Quality of nectarine and peach nectars as affected by lye-peeling and storage. *Food Chem*. Aug 15 2009;115(4):1291-1298. [CrossRef]
18. Zulueta A, Esteve MJ, Frasquet I, Frígola A. Vitamin C, vitamin A, phenolic compounds and total antioxidant capacity of new fruit juice and skim milk mixture beverages marketed in Spain. *Food Chem*. 2007;103(4):1365-1374. [CrossRef]
19. Klimczak I, Malecka M, Szlachta M, Gliszczynska-Swiglo A. Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices. *J Food Compos Anal*. May 2007;20(3-4):313-322. [CrossRef]
20. Kaur C, Kapoor HC. Antioxidants in fruits and vegetables - the millennium's health. *Int J Food Sci Tech*. Oct 2001;36(7):703-725. [CrossRef]
21. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biol Tec*. Nov 2000;20(3):207-220. [CrossRef]

22. Mditshwa A, Magwaza LS, Tesfay SZ, Opara UL. Postharvest factors affecting vitamin C content of citrus fruits: A review. *Sci Hortic-Amsterdam*. Apr 14 2017;218:95-104. [CrossRef]
23. Cemeroğlu BS. *Meyve ve sebze işleme teknolojisi*. Nobel Akademik Yayıncılık; 2011.
24. Association of Official Analytical Chemists, & Association of Official Agricultural Chemists (US). Official methods of analysis of the Association of Official Analytical Chemists (Vol. 3). Association of Official Analytical Chemists. 1931.
25. Garcia-Amezquita LE, Tejada-Ortigoza V, Serna-Saldivar SO, Welti-Chanes J. Dietary Fiber Concentrates from Fruit and Vegetable By-products: Processing, Modification, and Application as Functional Ingredients. *Food Bioprocess Tech*. Aug 2018;11(8):1439-1463. [CrossRef]
26. Al-Saadi NHM, Ahmad NS, Saeed SE. Determination of some chemical compounds and the effect of oil extract from orange peel on some pathogens. *J Kerbala Uni*. 2009;7(2).
27. Öztürk A, Demirsoy L. Gölgelemenin camarosa çilek çeşidinde büyümeye etkisinin kantitatif analizlerle incelenmesi. *Anadolu Tarım Bilimleri Dergisi*. 2006;21(3):283-288.
28. Pélagie Y, Honorat W, Alexis T, et al. Physicochemical characterization of two varieties of oranges peels and evaluation of its potential in biodegradable plastic films formulation. *World J. Adv. Res. Rev*. 2022;16(2):926-934.
29. Zabala JA, Martínez-Paz JM, Alcon F. A comprehensive approach for agroecosystem services and disservices valuation. *Sci Total Environ*. May 10 2021;768:144859. [CrossRef]
30. Cemeroğlu B. Gıda Analizleri Genişletilmiş 2. *Baskı Gıda Teknolojisi Derneği Yayınları*. 2010;(34):1-86.
31. Mohan A, Shanmugam S. Comparison of the nutritional, physico-chemical and anti-nutrient properties of freeze and hot air dried watermelon (Citrullus Lanatus) rind. *Biosci. Biotechnol. Res. Asia*. 2016;13(2):1113-1119. [CrossRef]
32. Feizy J, Jahani M, Ahmadi S. Antioxidant activity and mineral content of watermelon peel. *J Food Bioprocess Engv*. 2020;3(1):35-40. [CrossRef]
33. Akalin AS, Kesenkas H, Dinkci N, Unal G, Ozer E, Kinik O. Enrichment of probiotic ice cream with different dietary fibers: Structural characteristics and culture viability. *J Dairy Sci*. Jan 2018;101(1):37-46. [CrossRef]
34. Dosedel M, Jirkovsky E, Macáková K, et al. Vitamin C-Sources, Physiological Role, Kinetics, Deficiency, Use, Toxicity, and Determination. *Nutrients*. Feb 2021;13(2). [CrossRef]
35. Sağlam S. *Effect of Jam Making Process on Phenolics and Antioxidant Capacity in Mulberry, Cherry, and Viburnum Berries Rich in Anthocyanins*. Master's Thesis. 2007.
36. Tokbaş H. *Processing of Black Mulberry Fruit (Morus Nigra L.) into Jam and Marmalade and Determination of the Antioxidant Properties of the Products*. Master's Thesis. 2009.
37. Güzel M, Akpınar Ö. Turunçgil kabuklarının biyoaktif bileşenleri ve antioksidan aktivitelerinin belirlenmesi. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*. 2017;7(2):153-167.
38. Naidu KA. Vitamin C in human health and disease is still a mystery? An overview. *Nutrition Journal*. 2003;2:1-10. [CrossRef]
39. Gliszczynska-Swiglo A, Wroblewska J, Lemanska K, Klimczak I, Tyrakowska B. The contribution of polyphenols and vitamin C to the antioxidant activity of commercial orange juices and drinks. 2004. [CrossRef]
40. Sadek KM, Saleh EA. Fasting ameliorates metabolism, immunity, and oxidative stress in carbon tetrachloride-intoxicated rats. *Hum Exp Toxicol*. Dec 2014;33(12):1277-1283. [CrossRef]
41. Kumar V, Rani A, Dixit AK, Pratap D, Bhatnagar D. A comparative assessment of total phenolic content, ferric reducing-anti-oxidative power, free radical-scavenging activity, vitamin C and isoflavones content in soybean with varying seed coat colour. *Food Res Int*. Jan 2010;43(1):323-328. [CrossRef]
42. Davaritouchaee M, Mosleh I, Dadmohammadi Y, Abbaspourrad A. One-step oxidation of orange peel waste to carbon feedstock for bacterial production of polyhydroxybutyrate. *Polymers*. 2023;15(3):697. [CrossRef]
43. Saad WMM, Salin NSM, Ramzi AS, Salim F. Identification and quantification of fructose, glucose and sucrose in watermelon peel juice. *Malays J Anal Sci*. 2020;24:382-389.
44. Pathare PB, Opara UL, Al-Said FA. Colour Measurement and Analysis in Fresh and Processed Foods: A Review. *Food Bioprocess Tech*. Jan 2013;6(1):36-60. [CrossRef]
45. Şengül M, Topdaş EF, Doğan H, Serencam H. Artvin ilinde geleneksel olarak üretilen farklı marmelat çeşitlerinin bazı fiziksel ve kimyasal özellikleri, antioksidan aktiviteleri ve fenolik profilleri. *Akademik Gıda*. 2018;16(1):51-59. [CrossRef]
46. Polatcı H, Tarhan S. Farklı kurutma yöntemlerinin reyhan (*Ocimum basilicum*) bitkisinin kuruma süresine ve kalitesine etkisi. *Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG)*. 2009;2009(1):61-70.