Turkish Journal of Agriculture - Food Science and Technology, 12(s2): 2317-2327, 2024
DOI: https://doi.org/10.24925/turjaf.v12is2.2317-2327.7069

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Assessment of Traditional and Commercial Rosehip Marmalade Samples: Physicochemical, Antioxidant, and Antibacterial Properties in Gümüşhane Province

Fırat Yılmaz[1,a,*]

[1]*Gümüşhane University, Faculty of Engineering and Natural Sciences, Department of Food Engineering, 29100 Gümüşhane, Türkiye*
[*]*Corresponding author*

ARTICLE INFO

Research Article

Received : 14.08.2024
Accepted : 29.09.2024

Keywords:
Antibacterial
Antioxidant
Marmalade
Physicochemical
Rosehip

ABSTRACT

In this study, the specific physicochemical, antioxidant, and antibacterial properties of 20 different rosehip marmalade samples, produced using traditional and commercial methods in the Gümüşhane province and its districts, were comprehensively analyzed. To detect the chemical composition of the rosehip marmalade samples, analyses were conducted for total dry matter, pH, ash, titratable acidity (malic acid %), soluble solids, water activity, and color (*L**, *a**, *b**). Additionally, alongside the physicochemical analyses, the contents of hydroxymethylfurfural (HMF) and sugars (fructose, glucose, sucrose, and total sugar) were also determined. To assess the antioxidant properties, analyses for total flavonoid content, total phenolic content, DPPH (% inhibition), and ABTS (% inhibition) were performed. Furthermore, the antibacterial activities of the rosehip marmalade samples against pathogenic bacterial strains such as *Proteus vulgaris* ATCC 29212, *Enterococcus faecalis* ATCC 29212, *Klebsiella pneumoniae* ATCC 13883, *Staphylococcus aureus* ATCC 25923, *Pseudomonas aeruginosa* ATCC 27853, *Salmonella typhimurium* ATCC 23566, and *Escherichia coli* O157:H7 35150 were investigated.

Türk Tarım – Gıda Bilim ve Teknoloji Dergisi, 12(s2): 2317-2327, 2024

Gümüşhane İli'nde Geleneksel ve Ticari Kuşburnu Marmelat Örneklerinin Fizikokimyasal, Antioksidan ve Antibakteriyel Özelliklerinin Değerlendirilmesi

MAKALE BİLGİSİ

Araştırma Makalesi

Geliş : 14.08.2024
Kabul : 29.09.2024

Anahtar Kelimeler:
Antibakteriyal
Antioksidant
Fizikokimyasal
Kuşburnu
Marmelat

ÖZ

Bu çalışmada, Gümüşhane ili ve ilçelerinde geleneksel ve ticari yöntemlerle üretilen 20 farklı kuşburnu marmelatı örneklerinin, belirli fizikokimyasal, antioksidan ve antibakteriyel özellikleri kapsamlı bir şekilde incelenmiştir. Kuşburnu marmelatı örneklerinin fizikokimyasal niteliklerinin belirlenmesi amacıyla, toplam kuru madde, kül, pH, titre edilebilir asitlik (Malik asit cinsinden %), suda çözünebilen kuru madde, su aktivitesi ve renk (L*, a*, b*) analizleri gerçekleştirilmiştir. Ayrıca, fizikokimyasal analizlerin yanı sıra örneklerin hidroksimetilfurfural (HMF) ve şeker (fruktoz, glikoz, sakkaroz ve toplam şeker) içerikleri de belirlenmiştir. Antioksidan özelliklerin değerlendirilmesi için toplam flavonoid, toplam fenolik madde miktarları, DPPH (% inhibisyon) ve ABTS (% inhibisyon) analizleri uygulanmıştır. Ek olarak; *Proteus vulgaris* ATCC 29212, *Enterococcus faecalis* ATCC 29212, *Klebsiella pneumoniae* ATCC 13883, *Staphylococcus aureus* ATCC 25923, *Pseudomonas aeruginosa* ATCC 27853, *Salmonella typhimurium* ATCC 23566 ve *Escherichia coli* O157:H7 35150 gibi patojen bakteri suşlarına karşı kuşburnu marmeladı örneklerinin antibakteriyel aktiviteleri araştırılmıştır.

[a] *asst.prof.firatyilmaz@gmail.com* *https://orcid.org/0000-0003-3633-0012*

Introduction

Fruits are essential for a healthy diet, containing various nutrients that can reduce the risk of chronic diseases. The demand for healthy fruits and vegetables is increasing, yet their limited shelf life and transportation challenges present significant obstacles to commercialisation. However, they have a high water content and limited shelf life, so methods like jam making and drying are used to preserve them, often with added sugar (Yıldız Turgut et al., 2023). Rosehip fruit, also known as dog rose, is a highly nutritious shrub plant that contains minerals, vitamins, and antioxidants. It has various applications in the food, beverage, cosmetic, and pharmaceutical industries due to its therapeutic effects (Uğuzdoğan et al., 2024). In Türkiye, organic rosehip production in 2019 was 1.001 tonnes, with a potential harvest of 8,020 tonnes. Despite its beneficial properties, only a small percentage of rosehip fruit grown in Türkiye is harvested and utilised (Uğuzdoğan et al., 2024). Rosehip is rich in vitamin C, oil, phenolic substances, and carotenoids, making it effective in treating colds, gastrointestinal disorders, infections, and diabetes. It has a wide range of application areas, including traditional medicine, where it is used to treat kidney and bladder stone disorders, diarrhoea, bleeding gums, chest pains, and knee joint arthropathy (Demir et al., 2014). Furthermore, rosehip has diuretic, laxative, anti-inflammatory, antioxidant, and anti-cold properties, as well as the ability to inhibit melanin production and protect the liver. It may also offer potential health benefits and therapeutic applications by suppressing insulin-like growth factor and having an anticomplementary effect (Memiş Kocaman & Sormaz, 2023; Öz et al., 2018). Rosehip is commonly used in the production of various products, including jam, tea, and oil. It is known for its high content of vitamins and minerals (Aksu et al., 1997). The utilisation of processing techniques, such as the production of marmalade, serves to extend the shelf life of these fruits and vegetables. Furthermore, this technique is beneficial in maintaining the natural nutritional value of the foodstuff in question. Marmalades are a high-calorie foodstuff, providing a good source of energy and carbohydrates (Esin Yücel et al., 2024). Marmalade is a spread made from ripe fruit and is similar to jam, but with larger fruit pieces. The preparation of marmalade requires the use of a variety of fruits, which must be soaked and boiled prior to the application of the requisite techniques (Topdaş et al., 2018). The rosehip-based products that is rosehip marmalade widely consumed for breakfast in Türkiye. Marmalade is prepared by boiling the fruit pulp with sugar and acid until the desired brix value is reached. It is generally known that the shelf life of marmalade is approximately two years. In addition to the sensory properties of marmalade, rheological properties are among the most important factors determining consumer preference (Sagdic et al., 2015). Furthermore, the soluble dry matter content determined by refractometer in marmalade cannot be less than 55% according to Turkish Food Codex (Anonymous, 2006) . Due to its botanical characteristics, rosehips are not suitable for fresh consumption as they contain a large amount of seeds and hairs. It is therefore preferable to use the pulp for processing. The processing of rosehips into marmalade consists of two main stages: the extraction of pulp from the fresh fruit and the subsequent production of marmalade from the extracted pulp. In marmalade production, the pulp obtained is subjected to a pre-heating process. Sugar is then added and the mixture undergoes a second heat treatment to reach the desired brix level. At this point acid is added, the jars are filled and the pasteurisation stage begins. Adjusting the proportions of water, sugar and acid is of great importance in marmalade production (Özbey et al., 2017). A common practice in marmalade production is the boiling of traditionally produced marmalades at high temperatures for extended periods of time. This practice results in a reduction in the nutritional value and antioxidant activity of marmalade. Vacuum cooking and standardised quality production can be employed to address these issues. This study focuses on traditional and commercial rosehip marmalades produced in Gumushane province.

Material and Method

Material

In this study, rosehip marmalades produced traditionally and commercially in Gumushane province and its districts and sold in various markets and local markets were analysed. In this context, 10 rosehip marmalades produced by traditional method and 10 rosehip marmalades produced by commercial method were collected and the research material was formed. The rosehip marmalade samples were stored + 4°C until they were analysed in the laboratory. The analyses were designed as 2 replicates and 3 parallels.

Analyses of Physicochemical Properties

Water soluble dry matter (°Brix), pH, total dry matter, water activity (aw) (AquaLab, Series 3TE, USA), ash amount and the acidity (as % malic acid) were analysed according to the relevant method (Cemeroğlu, 2010). The *L**, *a**, and *b** colour values of the rosehip marmalade samples were measured using a Minolta CR 400 colour measuring device. Prior to the measurements, the device was calibrated with a white ceramic calibration plate, and all measurements were carried out on a white background using a liquid measuring cup. In accordance with the colour coordinate system, the *L** value serves as an indicator of whiteness and blackness, with a range of 0 (black) to 100 (white). The *a** value represents a greenness-redness indicator, with a range of -60 (green) to +60 (red). Finally, the *b** value functions as an indicator of blueness and yellowness, with a range of -60 (blue) to +60 (yellow).

Preparation of Marmalade Extracts

The extraction of the samples was conducted in accordance with the methodology outlined by (Topdaş et al., 2018), with certain modifications made to ascertain antioxidant property, antibacterial activity, total phenolic and flavanoid amount. For this purpose, 25 mL of ethanol was added to the samples, which were weighed individually at 5 g each in centrifuge tubes. The samples were subjected to an ultrasonic water (Bandelin RK 100 H, Germany) bath for 20 minutes and then stirred for 15 minutes with a mechanical shaker. Following

centrifugation (Beckman coulter Allegra XR30, Germany) at 8500 rpm for 20 minutes at 4°C in a refrigerated centrifuge, the clear supernatant was collected and stored in amber glass bottles at 20°C until further analysis.

Total Sugar and HMF (hydroxymethylfurfural) Amounts

The fructose, glucose and sucrose and hydroxymethylfurfural (HMF) contents of marmalade samples were quantified in accordance to Bogdanov et al. (2002). Fructose, glucose and sucrose contents were determined by dissolving molasses samples in deionised water and analysing them by high-performance liquid chromatography (HPLC) (Shimadzu, Japan). The results were calculated using the mobile phase, which was a mixture of acetonitrile and water. For the measurement of HMF, the molasses sample was dissolved in deionised water and analysed by HPLC. The amounts of HMF present in the samples were quantified using an HPLC device with a C-18 column. The chromatograms were obtained at a 284 nm wavelength using a Diode Array Detector (Shimadzu, Japan). The amount of HMF was determined using an external calibration curve.

Determination of Total Phenolic and Total Flavonoid Amount

Total phenolic and flavonoid contents of rosehip marmalade samples were measured according to Kalın et al. (2015). For this purpose, gallic acid was utilised as a reference standard substance to measure the total amount of phenolic substances in rosehip marmalade samples. A standard graph was prepared by combining the marmalade extract with gallic acid, adjusting the volume by distilled water and adding reagent (Folin-Ciocalteu) and 2% Na_2CO_3. After mixing, absorbance readings were taken at 760 nm and these values were used to determine the gallic acid equivalent (GAE) using a formula derived from the standard graph. Ethanol (99%) containing CH_3COOK and 10% $Al(NO_3)_3$ was also utilized to measure the total flavonoid amount in rosehip marmalade samples. 1000 µl of the extract was combined with the ethanol solution (aforemention) and the mixture was shaked by vortex. The absorbance of the mixture was then measured at 415 nm. Quercetin content (QE) was employed as a reference standard to calculate the total flavonoid concentration.

ABTS Radical Scavenging Capacity

The radical scavenging capacity of ABTS was determined according to the method that is occurred by Re et al. (1999) and Topal et al. (2024). Initially, ABTS radical solution were formed by adding a 2.45 nM persulfate solution. The extract of rosehip marmalade sample was subjected to addition of ABTS radical solution, followed by incubation, and the absorbances against the blank at 734 nm were evaluated at various concentration.

DPPH Free Radical Scavenging Capacity

1 mM DPPH solution was used as free radical. The Pre-prepared stock solution at a concentration of 1 mg/mL was used as a control sample. Then, the stock DPPH solution was added to each sample tube. After the incubation period, the absorbance was measured at 517 nm in comparison with the blank sample (Blois, 1958; Topal et al., 2024).

Antibacterial Activity

The selected bacterial strains were obtained from Gumushane University Central Research Laboratory and antibacterial assays were applied in the Food Engineering Laboratory. In the study, antibacterial activities of Rosehip marmalade were tested by disc diffusion method (Matuschek et al., 2014; Topal et al., 2024). The following bacterial strains were employed in this study: *Enterococcus feacalis* ATCC 29212, *Proteus vulgaris* ATCC 13315, *Klebsiella pneumoniae* ATCC 13883, *Pseudomonas aeroginosa* ATCC 27853, *Staphylococcus aureus* ATCC25923, *Salmonella typhimurium* ATCC 23566 and *Escherichia coli* O157:H7 35150. These were used to assess the antibacterial properties of traditional and commercial rosehip marmalades. Twenty microlitres of the extract was placed on sterile disc papers over Nutrient agar and the petri dishes were left to incubate at 36 °C for 24 hours. At the end of the incubation period, the zone areas formed around the disc papers were measured.

Statistical Analysis

The statistical data of this study were analysed using SPSS 22.0 (SPSS Inc., Chicago, USA). ANOVA (One-way ANOVA) analysis was applied to the raw values obtained and the averages of the data were calculated at $P<0.05$ significance level.

Results and Discussion

Rosehip Marmalades of Physicochemical Properties

The results of the analyses of total dry matter, water-soluble dry matter (Brix), ash, titration acidity, pH, and water activity of rosehip marmalades produced by traditional and commercial methods, collected from the Gumushane province and districts, are presented in Table 1. The total dry matter ratios of the rosehip marmalade samples exhibited considerable variation, with values ranging from 23.28% to 60.22%. It was observed that the highest and lowest total dry matter ratios were present in the rosehip marmalades produced through the traditional method. The mean total dry matter content of traditional rosehip marmalades (41.00%) was found to be significantly lower than that of commercial rosehip marmalades (49.61%), with the mean total dry matter content of the sample groups exhibiting a statistically significant difference ($P< 0.05$). Özbey et al. (2017), Özdemir et al. (1997), and Aksu et al. (1997) reported that the total dry matter ratios of rosehip marmalade samples varied between 36.45-67.72%, 52.00-66.40% and 33.00-50.00%, respectively. Topdaş et al. (2018) and Arslaner & Salık (2020) reported that the average total dry matter ratios of rosehip marmalade samples were 56.45% and 59.71% (respectively) and these ratios were higher than the average total dry matter ratio obtained in the present study. The ash ratios of rosehip marmalades were found to exhibit a range of values between 0.51 and 1.39%. It was observed that the mean ash ratio of commercial rosehip marmalades (0.85%) was higher than that of traditional rosehip marmalades (0.83%), although the mean ash ratios of the sample groups were not statistically different ($P>0.05$). It was stated that ash ratios of rosehip marmalade samples produced by applying different methods varied between 0.20% and 0.25% and there was no statistical difference between sample groups (Yıldız & Alpaslan, 2012).

Table 1. Physicochemical properties of rosehip marmalade samples

Sample	Total Solid Matter (%)		Ash (%)		Titratable Acidity (%Malic acid)	
	Traditional	Commercial	Traditional	Commercial	Traditional	Commercial
1	47.66±0.07	52.06±0.01	0.96±0.01	0.58±0.01	1.06±0.04	0.81±0.04
2	37.97±0.02	31.44±0.03	1.15±0.02	1.07±0.02	1.87±0.04	1.70±0.04
3	23.28±0.02	52.92±0.05	0.87±0.01	1.11±0.03	1.24±0.00	1.51±0.00
4	49.11±0.10	44.22±0.03	0.75±0.01	0.86±0.02	1.42±0.01	0.80±0.08
5	60.22±0.01	53.80±0.01	0.65±0.02	0.74±0.02	1.40±0.02	1.55±0.04
6	39.19±0.08	51.10±0.00	0.74±0.01	0.69±0.00	1.60±0.01	0.94±0.04
7	51.52±0.02	56.28±0.03	0.51±0.01	0.91±0.01	1.45±0.01	1.57±0.00
8	35.88±0.10	53.58±0.01	0.80±0.01	0.75±0.00	1.53±0.01	1.52±0.13
9	30.97±0.03	46.91±0.02	0.96±0.02	0.83±0.01	1.50±0.02	1.21±0.04
10	34.22±0.04	53.74±0.07	1.39±0.01	0.96±0.01	1.39±0.04	1.31±0.04
Mean	41.00±1.94[a]	49.61±1.29[b]	0.83±0.03[a]	0.85±0.03[a]	1.45±0.04[a]	1.29±0.06[b]
ANOVA (P)	0.000		0.688		0.038	
Min	23.28		0.51		0.80	
Max	60.22		1.39		1.87	
Sample	pH		Water-soluble dry matter (°Brix)		Water Activity (aw)	
	Traditional	Commercial	Traditional	Commercial	Traditional	Commercial
1	3.23±0.02	4.12±0.01	48.75±0.00	50.00±0.00	0.85±0.00	0.86±0.00
2	3.32±0.01	3.06±0.01	38.75±0.00	31.25±0.00	0.87±0.00	0.88±0.00
3	3.55±0.01	3.31±0.00	23.33±0.42	51.25±0.00	0.89±0.00	0.84±0.00
4	2.96±0.01	3.76±0.01	53.75±0.00	42.50±0.72	0.83±0.00	0.87±0.00
5	3.05±0.00	3.76±0.01	59.58±0.83	52.08±0.42	0.76±0.00	0.81±0.00
6	3.09±0.01	3.84±0.01	40.00±0.72	49.58±0.42	0.87±0.00	0.85±0.00
7	3.01±0.01	3.26±0.01	53.33±0.83	52.92±0.42	0.82±0.00	0.79±0.00
8	3.21±0.01	3.18±0.01	32.92±1.10	52.08±0.42	0.87±0.00	0.81±0.00
9	3.96±0.01	3.13±0.01	31.67±1.10	47.08±0.42	0.88±0.00	0.85±0.00
10	3.55±0.01	3.35±0.01	33.33±0.83	51.25±0.00	0.88±0.00	0.83±0.00
Mean	3.29±0.06[a]	3.48±0.06[b]	41.54±2.08[a]	48.00±1.17[b]	0.85±0.01[a]	0.84±0.00[a]
ANOVA (P)	0.031		0.009		0.110	
Min	2.96		23.33		0.76	
Max	4.12		59.58		0.89	

[a-b]: Averages shown with exponential letters in the same column differ from each other at P < 0.05 level.

Özbey et al. (2017) reported that the total ash values of rosehip marmalade samples varied between 0.659% and 1.430%, and the average ash rate was determined to be 0.935%. In titration acidity analyses, the highest titration acidity value (1.87%) was determined in traditional rosehip marmalades, while the lowest titration acidity value (0.80%) was determined in commercial rosehip marmalade samples. Upon analysis of the mean titration acidity values, it was observed that traditional rosehip marmalades exhibited higher titration acidity values (1.45%) than commercial rosehip marmalades. These results indicate a statistically significant difference among the mean titration acidity values of the rosehip marmalade samples (P<0.05). Vural (2023) observed that samples of rosehip marmalade produced using the traditional method exhibited higher acidity levels (0.91%) than those produced using the industrial method. Nevertheless, no statistically significant discrepancy was identified in acidity values between the sample groups. In a study investigating the quality characteristics of traditional wild fruit marmalades, the total acidity values of marmalade samples exhibited a range between 0.62% and 3.40%. The sample of rosehip marmalade demonstrated an acidity value of 1.05% (Arslaner & Salık, 2020). In addition, it was determined that the acidity values of rosehip marmalade samples produced by adding commercial sugar at different ratios to rosehip pulps varied between 0.40-1.31% at the beginning of storage and at the end of the five-month storage period, the acidity values were between 0.42% and 1.25% (Aksu et al., 1997). The significance of pH for optimal gel formation in products such as jam and marmalade is underscored. In this regard, the Turkish Food Codex states that the pH value should be within the range from 2.8 to 3.5 (Anonymous, 2006). In this context, it was determined that 70% of traditional rosehip marmalades and 60% of commercial rosehip marmalades were within the pH range specified in the Turkish Food Codex. Furthermore, the pH values of the sampled traditional and commercial rosehip marmalades exhibited a range from 2.96 to 4.12. The mean pH value of traditional rosehip marmalade samples (3.29) was found to be lower than that of commercial rosehip marmalades (3.48). A statistically significant difference (P<0.05) was observed between the mean pH values of the sample groups. Vural (2023) found that the pH value of traditional rosehip marmalade samples (4.01) was markedly higher than that of industrial rosehip marmalade samples, with a statistically significant discrepancy between the mean pH values of the two sample groups. These findings are largely in accordance with the pH values obtained in the present study. Furthermore, the pH

values of rosehip marmalade samples have been observed to vary considerably across different studies. For instance, the pH levels of rosehip marmalade samples ranged from 2.8 to 3.5 in a study conducted by Yıldız & Alpaslan (2012), and from 3.25 to 3.37 in another study by Özdemir et al. (1997). Additionally, the pH level of rosehip marmalade sample was reported as 3.64 in another research conducted by Arslaner & Salık (2020). The data demonstrate the considerable diversity in pH values observed among rosehip marmalade samples. It can be posited that this diversity may be significantly influenced by the production methods employed, the geographical origin of the fruit, and the specific fruit variety utilized. According to the Turkish Food Codex (Anonymous, 2006), the water-soluble dry matter (Brix) value determined by refractometry must be greater than 55%. In the present study, the °Brix values of the rosehip marmalade samples ranged from 23.33 to 59.88. It was found that 10% of the traditional rosehip marmalade complied the °Brix limit specified in the Turkish Food Codex, whereas none of the commercial rosehip marmalade complied this limit.

The mean Brix value of traditional rosehip marmalade (41.54) was found to be lower than that of commercial rosehip marmalade (48.00), with a statistically significant difference ($P<0.05$). The difference between the mean Brix values of the sample groups was considered statistically significant. Özbey et al. (2017) observed a range of °Brix values for rosehip marmalades from 41.00 to 82.00. This finding supports the view that the °Brix values found in this study are higher. Conversely, Vural (2023) reported that the °Brix values of rosehip marmalades produced by the traditional method varied between 33.7 and 35.6, with an average °Brix value of 34.8. Furthermore, Vural (2023) reported that the °Brix values of marmalade produced by the industrial method were significantly higher than those produced by the traditional method. These results are consistent with the differences in °Brix observed in the present study.

Water activity levels in rosehip marmalade samples ranged from 0.76 to 0.89. The mean water activity level of traditional rosehip marmalades (0.85) was found to be significantly higher than that of commercial rosehip marmalades (0.84). Nevertheless, the difference among the mean water activity values of the sample groups was minimal, and a general similarity among these values was observed ($P>0.05$). The water activity values of different types of marmalade were reported to range from 0.924 to 0.932 by Cingöz & Demirdöven (2022) and from 0.84 to 0.89 by Kaya et al. (2016). Also, Arslaner & Salık (2020) indicated that the water activity values in various marmalade samples ranged from 0.818 to 0.894, with rosehip marmalade having a water activity value of 0.885. Özbey et al. (2017) reported that the water activity (a_w) levels in rosehip marmalades exhibited a range from 0.804 to 0.904, and the mean water activity value was 0.881. Topdaş et al. (2018) reported that the a_w value in rosehip marmalade samples ranged from 0.79 to 0.90. The colour values in rosehip marmalade samples are presented in Table 2. The *L** colour value is considered a quality parameter as it reflects the degree of lightness or darkness of the product. The *L** values of the rosehip marmalades exhibited a range from 27.79 to 14.52. The mean *L** value was 20.03 for traditional rosehip marmalades and 22.31 for commercial rosehip marmalades. There are significant difference between the mean *L** values of traditional and commercial rosehip marmalade samples. The *a** values of the rosehip marmalades varied between 20.10 and 10.48. The mean *a** values were 13.62 for traditional rosehip marmalades and 14.49 for commercial rosehip marmalades. The *a** values exhibited no statistically significant differences amoung marmalade sample groups. The *b** values in rosehip marmalades exhibited from 23.90 to -1.49. The mean *b** value was found to be 6.03 in traditional rosehip marmalades and 9.24 in commercial rosehip marmalades. The statistical analyses revealed a significant difference between the mean *b** values of traditional and commercial rosehip marmalades. Arslaner & Salık (2020) and Topdaş et al. (2018) determined the *L**, *a**, *b** colour values of rosehip marmalades as 34.34-33.70, 20.86-23.59, 14.22-5.76, respectively. Özbey et al. (2017) reported the average *L**, *a**, *b** values of rosehip marmalades as 30.89, 10.90, 15.11, respectively. The findings that is our study revealed that *L** and *b** levels were lower to compared to previous studies. Kaya et al. (2016) reported that the *L**, *a**, *b** colour levels in rosehip marmalade samples were 34.44, 10.63, 18.00, respectively.

Table 2. Color values of rosehip marmalade samples

Sample	*L**		*a**		*b**	
	Traditional	Commercial	Traditional	Commercial	Traditional	Commercial
1	21.83±0.03	24.84±0.01	15.34±0.02	12.48±0.02	7.39±1.03	12.22±0.04
2	19.34±0.01	27.79±0.02	14.77±0.02	20.10±0.01	5.70±0.04	19.11±0.05
3	31.51±0.01	19.50±0.03	17.76±0.01	12.97±0.07	23.90±0.00	5.15±0.07
4	19.15±0.01	23.28±0.04	12.89±0.03	15.54±0.03	4.14±0.03	12.34±0.05
5	17.75±0.01	22.18±0.01	10.68±0.08	15.23±0.03	0.36±0.03	9.70±0.04
6	14.52±0.01	22.92±0.01	10.48±0.02	14.90±0.01	-1.46±0.02	10.51±0.03
7	16.91±0.01	17.82±0.01	11.21±0.04	11.46±0.02	0.67±0.04	1.05±0.01
8	19.84±0.01	22.23±0.00	14.62±0.08	15.10±0.01	6.37±0.03	9.20±0.04
9	19.89±0.01	22.25±0.01	14.31±0.02	13.37±0.05	6.98±0.04	6.58±0.19
10	19.55±0.00	20.27±0.02	14.18±0.03	13.76±0.08	6.21±0.02	6.50±0.07
Mean	20.03±0.79[a]	22.31±0.49[b]	13.62±0.41[a]	14.49±0.42[a]	6.03±1.24[a]	9.24±0.86[b]
ANOVA (P)	0.018		0.143		0.038	
Min	14.52		10.48		-1.46	
Max	27.79		20.10		23.90	

[a-b]: Averages shown with exponential letters in the same column differ from each other at $P < 0.05$ level.

Table 3. HMF amounts of rosehip marmalade samples

Rosehip Marmalade Samples	HMF (mg/kg)	
	Traditional	Commercial
1	N.D	N.D
2	7.56±1.47	N.D
3	5.39±0.31	N.D
4	4.19±0.00	N.D
5	9.25±1.14	N.D
6	3.92±0.03	N.D
7	9.33±0.25	N.D
8	4.37±0.16	N.D
9	N.D	N.D
10	N.D	N.D
Mean	4.40±0.65[b]	N.D
ANOVA (P)	0.000	
Min	N.D	
Max	9.33	

[a-b]: Averages shown with exponential letters in the same column differ from each other at P < 0.05 level. N.D: Not detected

Table 4. Sugar amounts of rosehip marmalade samples

RMS	Fructose (mg/kg)		Glucose (mg/kg)		Sucrose (mg/kg)		Total sugar (mg/kg)	
	Traditional	Commercial	Traditional	Commercial	Traditional	Commercial	Traditional	Commercial
1	19.02±0.02	11.78±0.15	18.70±0.04	13.58±0.07	46.38±0.02	72.18±0.16	84.11±0.01	92.55±0.12
2	11.40±0.00	11.67±0.17	5.44±0.00	13.18±0.19	33.17±0.00	21.89±0.20	50.02±0.00	46.76±0.41
3	7.18±0.00	13.23±0.09	7.70±0.00	16.25±0.02	15.13±0.00	40.05±0.21	30.01±0.00	69.55±0.49
4	33.83±0.13	19.31±0.01	35.96±0.13	24.51±0.34	19.68±0.01	41.65±0.34	89.48±0.01	85.48±1.21
5	48.81±0.11	18.94±3.39	54.32±0.20	28.63±5.71	12.10±0.03	19.86±3.80	115.23±0.09	67.43±2.37
6	21.11±0.15	0.58±0.25	21.29±0.37	0.58±0.30	25.67±0.12	1.65±0.77	68.06±0.59	2.82±0.29
7	38.46±0.23	31.00±2.07	41.62±0.03	38.13±1.18	8.93±0.22	2.47±0.31	89.01±0.84	71.60±1.19
8	22.90±0.02	14.66±0.26	24.41±0.08	18.29±0.40	9.87±0.24	11.53±0.07	57.17±0.51	44.48±1.29
9	13.20±0.01	17.60±0.18	14.65±0.17	22.35±0.27	17.87±0.03	44.85±0.17	45.72±0.33	84.80±0.45
10	9.40±0.47	14.41±0.29	9.97±0.85	17.56±0.72	12.90±0.80	36.89±1.23	32.26±0.67	68.87±3.90
Mean	22.53±2.42[b]	15.32±1.39[a]	23.40±2.81[a]	19.31±1.84[a]	20.17±2.09[a]	29.30±3.88[b]	66.11±0.92[a]	63.93±0.89[a]
A	0.012		0.228		0.043		0.755	
Min	0.58		0.58		1.65		2.82	
Max	48.81		54.32		72.18		115.23	

RMS: Rosehip Marmalade Samples; A: ANOVA (P); [a-b]: Averages shown with exponential letters in the same column differ from each other at P < 0.05 level.

HMF and Sugar Amount of Rosehip Marmalade

In products such as jams and marmalades, browning occurs as a result of the reaction of reducing sugars with amino acids. This process is accelerated by increasing the temperature and duration of the heat treatment applied. This non-enzymatic browning process, known as the Maillard reaction, results in the formation of intermediates, including HMF. HMF is formed both by the heat treatment of food and by the breakdown of sugars in an acidic environment, contributing to the formation of brown pigments (Başkaya Sezer et al., 2016; Duru et al., 2012; Yolcı Ömeroğlu & Acoğlu, 2020). The amounts of HMF detected in the rosehip marmalade samples are shown in Table 3. The amount of HMF was only detected in traditional rosehip marmalades; the average amount of HMF in traditional rosehip marmalades was determined to be 4.40 mg/kg (P<0.001). The results of our study are supported by the findings of Vural (2023), who reported that the amount of HMF was higher in rosehip marmalade produced by the traditional method than in those produced by the industrial method. Similarly, the HMF amount in marmalade samples determined by Başkaya Sezer et al. (2016) (0.389 mg/100g = 3.89 mg/kg) is in agreement with our results. Conversely, the study by Yolcı Ömeroğlu & Acoğlu (2020) did not identify the presence of HMF in marmalade samples. Yıldız & Alpaslan (2012) observed that the quantity of HMF present in rosehip marmalades produced via disparate methodologies exhibited a range of 3.86-32.64 mg/kg. Furthermore, the studies formed by Yıldız & Alpaslan (2012), Arslaner & Salık (2020), and Topdaş et al. (2018) have determined the HMF amounts in marmalade samples to be 0.22-11.80 mg/kg, 5.81-53.40 mg/kg, and 10.95-1094.11 mg/kg, respectively. The sugar contents of rosehip marmalade samples are presented in Table 4. The highest fructose amount (48.81 mg/kg) was determined in traditional rosehip marmalade, while the lowest fructose amount (0.58 mg/kg) was determined in commercial rosehip marmalade. The mean fructose amount in traditional rosehip marmalade (22.53 mg/kg) was significantly higher than commercial rosehip marmalade (15.32 mg/kg) (P<0.05). The glucose amount in rosehip marmalade samples was evaluated, and it was found that the highest glucose level (54.32 mg/kg) was present in traditional rosehip marmalade, while the lowest glucose level (0.58 mg/kg) was present in commercial rosehip marmalade. It was observed that the mean glucose

amount in traditional rosehip marmalades was significantly higher than commercial rosehip marmalades. Nevertheless, no statistically significant change was observed in terms of mean glucose content in rosehip marmalade sample groups (P>0.05). The sucrose amount in rosehip marmalade samples was analysed, and it was observed that the highest sucrose amount (72.18 mg/kg) and the lowest sucrose amount (1.65 mg/kg) were present in commercial rosehip marmalade samples. The results of the analysis demonstrated that the mean sucrose content of commercial rosehip marmalade samples was markedly higher than that of traditional rosehip marmalade samples (P<0.05). The total sugar content of the samples of rosehip marmalade was analysed, and it was determined that the highest total sugar content was present in the traditional rosehip marmalade, while the lowest total sugar content was present in the commercial rosehip marmalade. The results of the analyses demonstrate that the mean total sugar content of the traditional rosehip marmalade samples is greater than that of the commercial rosehip marmalade samples. However, no statistically significant discrepancy was identified amoung the mean total sugar contents of marmalade sample groups (P>0.05). Yıldız Turgut et al. (2023) determined the amounts of fructose, glucose, sucrose and total sugar to be 0.78-10.99, 0.56-7.43, 35.59-48.10, 36.82-66.59 mg/kg, respectively.

Total flavonoid and phenolic

The total flavonoid and phenolic substance contents in rosehip marmalade samples are presented in Table 5. The results of the analysis demonstrated that the total flavonoid content of the rosehip marmalade samples exhibited considerable variability, with values ranging between 259.44 and 669.64 µg QE/g. Nevertheless, the mean total flavonoid content of traditional rosehip marmalade samples was markedly higher than that of commercial rosehip marmalades (P<0.05). Vural (2023) reported that the average total flavonoid content of rosehip marmalade samples produced by traditional methods was significantly higher than that of rosehip marmalade samples prepared by industrial production methods. It was also emphasised that the difference between them was statistically significant. On the other hand, Uçan Türkmen et al. (2019) reported that there was no statistically significant difference between the total flavonoid contents of fruit pulp mixtures. The total phenolic content of rosehip marmalade samples varied between 567.78-2104.44 µg GAE/g. In this range, the highest and lowest phenolic matter levels were found in traditional rosehip marmalade samples. On the other hand, it was observed that commercial rosehip marmalade samples contained higher total phenolic substances on average. The mean total phenolic content of traditional and commercial rosehip marmalade samples was not found to be statistically significant (P>0.05). Kaya et al. (2016) found no statistically significant difference in the mean total phenolic content between traditional and commercial rosehip marmalade samples. The total phenolic content reported by Kaya et al. (2016) was 913.46 µg GAE/g. Bulut (2019) reported a range from 1047.60 to 1137.56 µg GAE/g for the total phenolic content in rosehip marmalade samples. Yıldız & Alpaslan (2012) found a statistically significant difference in the total phenolic content between rosehip marmalade samples produced by different methods. Esin Yücel et al. (2024) reported a range from 59.62 to 111.85 µg GAE/g for the total phenolic content in marmalade samples, with an average of 72.7585 µg GAE/g. Topuz et al. (2019) determined the total phenolic content in rosehip marmalade samples was 1054.6 µg GAE/g. Topdaş et al. (2018) emphasized that there were significant differences in total phenolic content between different marmalade samples, with rosehip marmalade having the highest total phenolic content. Additionally, Başkaya Sezer et al. (2016), Uçan Türkmen et al. (2019), and Kaplan & Okcu (2020) found statistically significant differences in the average total phenolic content of marmalade samples.

DPPH and ABTS Radical Scavenging Capacity

The antioxidant capacities of rosehip marmalade samples were calculated as DPPH and ABTS free radical removal percentage inhibition and the results of these samples are presented in Table 6. BHA, BHT, Tocopherol and Trolox were used as standard antioxidants in the determination of antioxidant capacity. In the analyses, the lowest DPPH inhibition rate was found in traditional rosehip marmalade samples and the highest DPPH inhibition rate was found in commercial rosehip marmalade samples.

Table 5. Total flavanoid and phenolic matter amounts of rosehip marmalade samples

Rosehip Marmalade Samples	Total Flavonoid (µg QE/g)		Total Phenolic (µg GAE/g)	
	Traditional	Commercial	Traditional	Commercial
1	525.82±2.60	259.44±3.57	1545.56±1.89	1267.78±1.11
2	610.05±1.33	669.64±0.00	1524.44±5.87	2018.89±1.11
3	518.75±2.95	504.17±2.75	2104.44±5.56	892.22±1.11
4	384.67±9.01	343.90±2.70	567.78±1.11	1506.67±3.33
5	581.69±6.40	519.86±2.19	945.56±1.11	1001.11±7.78
6	562.87±4.73	322.09±2.51	852.22±2.93	1151.11±2.94
7	435.57±3.04	428.50±2.65	656.67±1.92	820.00±1.93
8	665.63±4.01	494.49±3.01	1381.11±4.44	1545.56±2.93
9	667.63±2.01	511.91±2.90	1454.44±2.22	1247.78±2.94
10	649.70±1.99	522.47±3.43	1485.56±4.84	1208.89±2.94
Mean	560.23±1.87[b]	457.65±2.24[a]	1251.78±8.46[a]	1266.00±6.24[a]
ANOVA (P)	0.001		0.893	
Min	259.44		567.78	
Max	669.64		2104.44	

[a-b]: Averages shown with exponential letters in the same column differ from each other at P < 0.05 level.

Table 6. Antioxidant capacity of rosehip marmalade samples

Standard	DPPH (% scavening)		ABTS (% scavening)	
BHA	84.47±0.51		98.87±0.08	
BHT	43.11±1.70		98.84±0.03	
Tokoferol	75.89±0.38		98.93±0.06	
Trolox	95.98±0.04		98.96±0.03	
Sample	Traditional	Commercial	Traditional	Commercial
1	73.47±0.90	70.96±2.09	99.05±0.03	98.84±0.03
2	70.04±1.27	92.49±0.80	99.14±0.03	99.02±0.03
3	92.24±0.25	46.00±1.38	99.17±0.00	97.46±0.06
4	25.00±0.39	80.31±3.05	70.09±1.73	98.93±0.06
5	49.98±3.00	78.49±2.05	98.50±0.17	98.69±0.18
6	43.16±0.82	62.24±3.61	96.51±0.79	98.99±0.05
7	34.51±4.24	39.98±1.42	72.23±3.46	92.81±2.77
8	69.16±1.12	76.42±1.60	98.93±0.11	99.05±0.06
9	73.09±2.27	65.29±1.19	99.05±0.61	98.93±0.11
10	71.80±1.57	57.53±1.39	99.14±0.03	99.08±0.00
Mean	60.24±3.74[a]	66.97±2.89[a]	93.18±2.08[a]	98.18±0.41[b]
ANOVA (P)	0.051		0.000	
Min	25.00		70.09	
Max	92.49		99.17	

[a-b]: Averages shown with exponential letters in the same column differ from each other at P < 0.05 level.

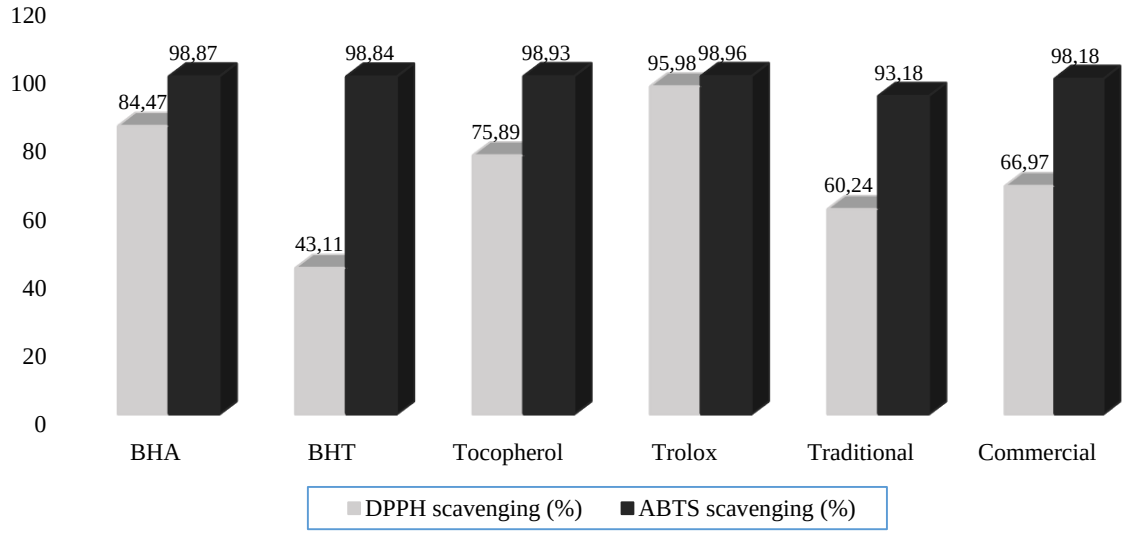

Figure 1. Comparison of the average antioxidant capacity of rosehip marmalade samples with standard antioxidant substances

However, it was observed that the average DPPH removal rate of commercial rosehip marmalade samples was higher than that of traditional rosehip marmalade samples. However, the DPPH removal rates among the two sample groups were not found to be statistically significant. Topdaş et al. (2018) obtained results at lower levels of DPPH free radical scavenging according to presented the study. Vural (2023) revealed that the DPPH free radical scavenging capacity of rosehip marmalade samples produced by traditional methods was significantly higher than the samples produced by commercial methods. Suna et al. (2023) stated that DPPH capacity in low-calorie marmalade samples varied between 34.07% and 65.18%. The analysis of ABTS removal rates in rosehip marmalade samples revealed that the lowest (70.09%) and highest (99.17%) removal rates were observed in traditional rosehip marmalade samples. Nevertheless, it was established that the ABTS removal rates of commercial rosehip marmalade samples were superior to those of traditional samples, with a statistically significant discrepancy between the two groups. This finding is consistent with the study conducted by Başkaya Sezer et al. (2016), which revealed differences in ABTS capacity in different marmalade varieties, thus supporting the results of our study. A comparison of the mean DPPH and ABTS scavenging rates of rosehip marmalade samples with standard antioxidants is presented in Figure 1. It was found that the DPPH scavenging rates in traditional and commercial rosehip marmalade samples to compare the standard antioxidants ($P<0.05$). On the other hand, the ABTS scavenging rates of rosehip marmalade samples were found to be almost equivalent to those of standard antioxidants and there was no statistically significant difference among them.

Table 7. Inhibition zone diameter of rosehip marmalade samples against selected pathogenic bacteria stain

RM	Bacteria Strain	Inhibition Zone Diameter (mm)					MS	Anova (p)
		1	2	3	4	5		
T	*Enterococcus feacalis*	12.33±0.20	13.13±0.73	13.57±0.05	13.60±0.50	13.77±1.01	13.47±0.15^{A}	0.151
C	ATCC 29212	14.20±0.98	13.30±0.80	14.47±0.96	13.47±1.82	10.97±0.61	12.88±0.37^{A}	
T	*Proteus vulgaris*	13.10±0.40	11.63±0.71	15.20±1.22	13.20±1.55	13.60±0.66	13.57±0.26^{B}	0.039
C	ATCC 13315	13.80±0.28	12.47±0.48	13.33±0.35	12.73±0.48	13.80±0.52	12.78±0.25^{A}	
T	*Klebsiella pneumoniae*	12.60±0.79	13.87±0.50	12.83±0.77	14.17±0.89	14.30±1.32	13.65±0.23^{B}	0.012
C	ATCC 13883	15.20±0.20	14.07±0.20	13.23±0.43	13.23±0.12	12.17±0.99	12.67±0.30^{A}	
T	*Pseudomonas aeroginosa*	12.50±0.85	13.27±0.54	13.13±0.53	13.53±0.52	15.20±0.63	13.47±0.21^{B}	0.008
C	ATCC 27853	13.57±0.77	12.80±0.10	14.33±0.28	13.30±0.60	10.70±0.00	12.53±0.26^{A}	
T	*Staphylococcus aureus*	13.17±0.17	12.67±0.17	12.67±0.34	14.90±1.27	15.30±0.75	13.61±0.23^{A}	0.398
C	ATCC 25923	14.90±0.89	13.23±0.43	14.07±0.20	14.70±1.41	13.13±0.88	13.31±0.26^{A}	
T	*Salmonella typhimurium*	13.93±0.57	12.10±0.58	15.33±0.54	14.63±0.86	13.70±0.40	13.77±0.26^{A}	0.059
C	ATCC 23566	13.07±0.08	13.37±0.55	14.60±0.45	13.70±0.40	10.90±0.57	12.99±0.30^{A}	
T	*Escherichia coli*	13.33±0.03	12.33±0.67	15.57±0.38	15.43±0.87	15.17±0.55	14.04±0.25^{B}	0.000
C	O157:H7 35150	14.43±0.66	14.57±0.26	13.60±0.49	13.43±0.78	10.40±0.80	12.56±0.30^{A}	
RM	Bacteria Strain	Inhibition Zone Diameter (mm)					MS	Anova (p)
		6	7	8	9	10		
T	*Enterococcus feacalis*	14.07±0.03	13.60±0.45	13.87±0.43	13.73±0.23	13.10±0.34	13.47±0.15^{A}	0.151
C	ATCC 29212	11.57±0.72	12.13±0.77	13.00±0.50	12.13±0.40	13.57±0.85	12.88±0.37^{A}	
T	*Proteus vulgaris*	13.10±0.15	14.00±0.63	14.57±0.68	13.27±0.43	14.07±0.43	13.57±0.26^{B}	0.039
C	ATCC 13315	11.63±0.33	14.23±1.31	12.63±0.41	10.90±0.40	12.60±0.75	12.78±0.25^{A}	
T	*Klebsiella pneumoniae*	12.57±0.43	13.67±0.38	15.50±0.41	13.70±0.12	13.27±0.43	13.65±0.23^{B}	0.012
C	ATCC 13883	12.70±0.70	12.83±0.46	11.93±0.27	9.57±0.24	11.73±0.33	12.67±0.30^{A}	
T	*Pseudomonas aeroginosa*	13.67±0.29	13.30±0.65	13.87±0.91	12.50±0.66	13.77±0.42	13.47±0.21^{B}	0.008
C	ATCC 27853	12.60±0.89	11.90±0.27	13.40±0.10	12.73±0.53	9.97±0.27	12.53±0.26^{A}	
T	*Staphylococcus aureus*	13.67±0.37	13.93±0.62	12.07±0.33	14.20±0.61	13.53±0.30	13.61±0.23^{A}	0.398
C	ATCC 25923	12.13±0.23	12.57±0.77	12.67±0.74	12.47±0.48	13.27±0.40	13.31±0.26^{A}	
T	*Salmonella typhimurium*	14.00±0.51	14.20±0.60	13.47±0.69	13.33±0.34	13.03±0.22	13.77±0.26^{A}	0.059
C	ATCC 23566	10.87±0.87	14.57±1.33	14.03±0.03	11.50±0.66	13.33±0.64	12.99±0.30^{A}	
T	*Escherichia coli*	13.83±0.94	14.50±0.20	13.10±0.60	14.43±0.24	12.73±0.23	14.04±0.25^{B}	0.000
C	O157:H7 35150	11.87±0.58	11.97±0.19	11.30±0.60	11.40±0.26	12.60±0.30	12.56±0.30^{A}	

RM: Rosehip Marmalade; T: Traditional; C: Commercial; MS: Means of Sample; $^{A-B}$: Averages shown with exponential letters in the same column differ from each other at $P < 0.05$ level.

Antibacterial Properties of Rosehip Marmalade Samples

Inhibition zone diameters of rosehip marmalade samples for antibacterial activity against selected pathogenic bacterial strains are shown in detail in Table 7. The data clearly show that rosehip marmalade samples produced by the traditional method formed wider zones of inhibition against selected pathogenic bacterial strains compared to commercial rosehip marmalade. It was found that the inhibitory effect of traditional rosehip jam against *Enterococcus faecalis* ATCC 29212, *Staphylococcus aureus* ATCC 25923 and *Salmonella typhimurium* ATCC 23566 strains was significantly stronger than that of commercial jam samples. However, it was concluded that the antibacterial activity of both groups of jams against these pathogenic bacteria was statistically similar. Çiftci & Tastekin (2023) investigated the antibacterial activity of rosehip fruit against *Enterococcus faecalis*, *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* bacterial strains and the results showed that rosehip fruit formed the highest inhibition zone especially against *Enterococcus faecalis* strain. This finding is consistent with the data obtained in our present study and shows parallel results. Other studies in the literature also support that rosehip powder has significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli* and *Klebsiella pneumoniae* Ghendov-Mosanu et al. (2020). Statistical analyses revealed statistically significant differences between the mean antibacterial effects of traditional and commercial rosehip jams. In particular, when the inhibition zone diameters against *Proteus vulgaris* ATCC 13315, *Klebsiella pneumoniae* ATCC 13883, *Pseudomonas aeruginosa* ATCC 27853 and *Escherichia coli* O157 35150 strains were examined, it was clear that the traditional rosehip jam samples were significantly more efficient against these pathogens ($P<0.05$). Overall, it has been determined that traditional rosehip marmalade samples exhibit higher antibacterial activity compared to commercially rosehip marmalade samples, with this activity showing a marked superiority particularly against various pathogenic bacteria.

Conclusion

In this study, it has been determined that rosehip marmalade samples produced in Gumushane province and its surroundings using traditional methods or industrial processes exhibit significant differences in the analyzed properties. These differences are attributed to a variety of factors, including the genetic characteristics of the rosehip fruit, geographical conditions, variety, harvest time, and ripening stage, as well as the production methods used in

marmalade and pulp processing, pulp/sugar ratios, thermal processing conditions / time, and storage duration of rosehip products.

Declarations

Author Contribution Statement

Fırat YILMAZ: Sample collection, design, laboratory work, and writing the orginal manuscript

Acknowledgements

The author thanks Dr. Fevzi TOPAL, for his contribution to the antioxidant measurements.

References

Aksu, M. İ., Özdemir, F., & Nas, S. (1997). The quality characteristics of marmalades produced at diffferent sugar/pulp ratios by using rose hips (rosa spp) pulp obtained by application of preheating during process. *Pamukkale University Journal of Engineering Sciences*, *3*(1), 243-248. https://dx.doi.org/

Anonymous. (2006). Türk Gıda Kodeksi Reçel, Jöle, Marmelat ve Tatlandırılmış Kestane Püresi Tebliği. *Resmi Gazete, Tarım ve Köyişleri Bakanlığı*, *2006/55*(26392). https://www.mevzuat.gov.tr/File/GeneratePdf?mevzuatNo=10942&mevzuatTur=Teblig&mevzuatTertip=5

Arslaner, A., & Salık, M. A. (2020). Some quality properties, mineral and heavy metal composition of wild fruit traditional marmalades. *Turkish Journal of Agriculture - Food Science and Technology*, *8*(3), 678-687. https://doi.org/10.24925/turjaf.v8i3.678-687.3190

Başkaya Sezer, D., Demirdöven, A., & Erdoğan Tokatlı, K. (2016). Çakal eriği ve yonuz eriği marmelatları. *Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG)*, *33*(1), 125-131. https://doi.org/10.13002/jafag899

Blois, M. S. (1958). Antioxidant determinations by the use of a stable free radical. *Nature*, *181*(4617), 1199-1200. https://doi.org/10.1038/1811199a0

Bogdanov, S., Martin, P., & Lullmann, C. (2002). Harmonised methods of the international honey commission. *Swiss Bee Research Centre, FAM, Liebefeld*, *5*(1).

Bulut, H. (2019). Farklı ısıtma sürelerinin kuşburnu pulpu ve konsantresinin özelliklerine etkisi. *Tokat Gaziosmanpaşa Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Tokat.*

Cemeroğlu, B. (2010). Gıda Analizleri Genişletilmiş 2. Baskı. *Gıda Teknolojisi Derneği Yayınları, No:34, Bizim Grup Basımevi, Ankara.*

Cingöz, A., & Demirdöven, A. (2022). Diyabetik bal kabağı (cucurbita moschata duch.) marmelatı üretimi [Production of Diabetic Pumpkin (Cucurbita moschata Duch.) Marmalade]. *Turkish Journal of Agricultural Engineering Research*, *3*(1), 146-156. https://doi.org/10.46592/turkager.1077320

Çiftci, G., & Tastekin, B. (2023). Antioxidant capacity and antibacterial potential of rosehip (rosa canina) fruits grown [Kuşburnu (Rosa Canina) Meyvesinin Antioksidan Kapasitesi ve Antimikrobiyel Potansiyelinin Araştırılması]. *Journal of Anatolian Environmental and Animal Sciences*, *8*(1), 103-109. https://doi.org/10.35229/jaes.1240877

Demir, N., Yildiz, O., Alpaslan, M., & Hayaloglu, A. A. (2014). Evaluation of volatiles, phenolic compounds and antioxidant activities of rose hip (Rosa L.) fruits in Türkiye. *LWT - Food Science and Technology*, *57*(1), 126-133. https://doi.org/https://doi.org/10.1016/j.lwt.2013.12.038

Duru, N., Karadeniz, F., & Erge, H. S. (2012). Changes in bioactive compounds, antioxidant activity and hmf formation in rosehip nectars during storage. *Food And Bioprocess Technology*, *5*(7), 2899-2907. https://doi.org/10.1007/s11947-011-0657-9

Esin Yücel, E., Kaya, C., Topuz, S., & Bayram, M. (2024). Farklı tatlandırıcılar kullanılarak üretilen hindistan cevizi marmelatlarının özelliklerinin belirlenmesi. *Journal of New Results in Engineering and Natural Sciences*, *2023*(19), 10-18. https://dergipark.org.tr/tr/pub/jrens/issue/79158/1317186

Ghendov-Mosanu, A., Cristea, E., Patras, A., Sturza, R., & Niculaua, M. (2020). Rose hips, a valuable source of antioxidants to improve gingerbread characteristics. *Molecules*, *25*(23).

Kalın, P., Gülçin, I., & Gören, A. (2015). Antioxidant activity and polyphenol content of cranberries (Vaccinium macrocarpon). *Records of Natural Products*, *9*, 496-502.

Kaplan B., & Okcu, Z. (2020). Hünnap meyvesinden üretilen marmelatların fiziksel ve kimyasal özelliklerinin belirlenmesi. *Journal of the Institute of Science and Technology*, *10*(4), 2649-2658.

Kaya, C., Esin Yücel, E., Bayram, M., Meşe, C., Aybakan, E., Gökgöz, G., & Sözer, T. T. (2016). Trabzon hurması (diospyros kaki l.) bazlı karışık meyveli geleneksel marmelat üretimi üzerine bir araştırma. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *47*(2), 107-112. https://dergipark.org.tr/en/pub/ataunizfd/issue/27846/294688

Matuschek, E., Brown, D. F., & Kahlmeter, G. (2014). Development of the EUCAST disk diffusion antimicrobial susceptibility testing method and its implementation in routine microbiology laboratories. *Clin Microbiol Infect*, *20*(4), O255-266. https://doi.org/10.1111/1469-0691.12373

Memiş Kocaman, E., & Sormaz, Ü. (2023). Fonksiyonel bir besin olan kuşburnu meyvesinin Türkiye'de tüketimi. *Safran Kültür ve Turizm Araştırmaları Dergisi*, *6*(3), 435-453. https://dergipark.org.tr/en/pub/saktad/issue/81481/1326143

Öz, M., Baltacı, C., & Deniz, İ. (2018). Gümüşhane yöresi kuşburnu (Rosa canina l.) ve siyah kuşburnu (Rosa pimpinellifolia l.) meyvelerinin C vitamini ve şeker analizleri. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*, *8*(2), 284-292. https://doi.org/10.17714/gumusfenbil.327635

Özbey, A., Öncül, N., Tokatlı, K., Yıldırım, M., & Yıldırım, Z. (2017). Determination of some physicochemical and microbiological properties of rosehip marmalades. *Turkish Journal of Agriculture - Food Science and Technology*, *5*(4), 358-365. https://doi.org/10.24925/turjaf.v5i4.358-365.1171

Özdemir, F., Aksu, M. İ., & Nas, S. (1997). Isil işlemsiz elde edilen kuşburnu pulplarindan farkli pulp/şeker oranlarinda üretilen marmelatlarin kalite özellikleri. *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi*, *3*(2), 353-358. https://dergipark.org.tr/tr/pub/pajes/issue/20548/218995

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M., & Rice-Evans, C. (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, *26*(9), 1231-1237. https://doi.org/https://doi.org/10.1016/S0891-5849(98)00315-3

Sagdic, O., Toker, O. S., Polat, B., Arici, M., & Yilmaz, M. T. (2015). Bioactive and rheological properties of rose hip marmalade. *Journal Of Food Science And Technology-Mysore*, *52*(10), 6465-6474. https://doi.org/10.1007/s13197-015-1753-z

Suna, S., Kalkan, S., Dinç, M., & Çopur, Ö. U. (2023). Production of low calorie persimmon marmalades with stevia and maltitol: physicochemical properties and in vitro bioaccessibility of polyphenols. *Journal Of Food Measurement And Characterization*, *17*(1), 1082-1095. https://doi.org/10.1007/s11694-022-01676-9

Topal, M., Topal, F., & Yılmaz, F. (2024). Exploring the impacts of Angelica purpurascens extracts on anticholinergic, antidiabetic, antibacterial potential, and antioxidant capacity. *Journal of the Institute of Science and Technology*, *14*(2), 790-804.

Topdaş, E. F., Şengül, M., Doğan, H., & Serencam, H. (2018). Artvin İlinde geleneksel olarak üretilen farklı marmelat çeşitlerinin bazı fiziksel ve kimyasal özellikleri, antioksidan aktiviteleri ve fenolik profilleri. *Akademik Gıda*, *16*(1), 51-59. https://doi.org/10.24323/akademik-gida.415888

Topuz, S., Kaya, C., Bayram, M., & Kola, O. (2019). Alıç marmelatı üretiminde farklı tatlandırıcı kullanımının ürün özelliklerine etkisi. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, *8*(3), 180-192. https://dergipark.org.tr/en/pub/gbad/issue/50458/649756

Uçan Türkmen, F., Bingöl, B. N., Şahin, E., Özkaraman, F., & Tekin, Z. (2019). Erik (Prunus domestica) bazli karışık meyveli geleneksel marmelat üretimi. *Gıda*, *44*(4), 707-718. https://doi.org/10.15237/gida.GD19065

Uğuzdoğan, E., Kamberoğlu, N., Olçeşer, C. B., Düzyol, F., Cücen, Z., & Hajıyev, V. (2024). Kuşburnu (Rosa canina L. L.) meyvesi ve atıklarından pektin ekstraksiyonu. *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi*, *30*(1), 109-118. https://dergipark.org.tr/tr/pub/pajes/issue/83370/1445354

Vural, S. (2023). Çorum yöresinde geleneksel yöntemlerle üretilen kuşburnu marmelatlarinin bazi fizikokimyasal ve mikrobiyolojik özelliklerinin belirlenmesi. *Hitit Üniversitesi, Lisansüstü Eğitim Enstitüsü, Gıda Mühendisliği Anabilim Dalı, Yüksek Lisans Tezi, Çorum*.

Yıldız, O., & Alpaslan, M. (2012). Properties of rose hip marmalades. *Food Technology And Biotechnology*, *50*(1), 98–106.

Yıldız Turgut, D., Tanriseven, M., Bayır Yeğin, A., Gölüklü, M., Tokgöz, H., & Kola, O. (2023). Düşük şekerli turunç marmelati üretiminde Rebaudioside A kullanımının araştırılması. *Gıda*, *48*(4), 872-887. https://doi.org/10.15237/gida.GD23052

Yolcı Ömeroğlu, P., & Acoğlu, B. (2020). Nar suyu ve yeşil çay ilaveli kalorisi azaltılmış fonksiyonel geleneksel karışık meyve marmelatı üretimi. *Akademik Gıda*, *18*(2), 143-155. https://doi.org/10.24323/akademik-gida.758817