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Nutritional profile of traditional Tortum Bağbaşı (Haho) mulberry pekmez (molasses)

Geleneksel Tortum Bağbaşı (Haho) dut pekmezinin besin profili

Birol PETEK [1]

1 Uzman Öğretmen, Hilalkent 125.Yıl Ortaokulu, Yakutiye, Erzurum, Türkiye

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Corresponding Author(s):

Birol PETEK, birolpetek2016@hotmail.com

Abstract

Objective: This research was conducted to reveal the nutritional profile of traditional Bağbaşı (Haho) mulberry pekmez (molasses).

Material and Method: In this study, some physical and chemical properties of mulberry pekmez produced in the Bağbaşı (Haho) region were investigated. In this context, parameters such as mineral content, pH value, total ash content, hydroxymethylfurfural (HMF) level and the water-soluble dry matter (WSDM) ratio of the product were analyzed.

Results: In mulberry pekmez, the water-soluble dry matter (WSDM) content was determined to be 76.5%, the total ash content 2.02% and the pH value 4.71. The hydroxymethylfurfural (HMF) content was found to be 30.00 mg/kg, indicating that the product can be classified as Type 1 molasses according to the criteria specified in the TSE 12001 standard. As a result of the mineral profile analysis of the pekmez sample, the concentrations of Fe, Zn, Mg, K, Ca, P and Se were determined as 7.52 mg/kg, 5.42 mg/kg, 166.90 mg/kg, 2497.44 mg/kg, 52.13 mg/kg, 199.50 mg/kg and 0.01 mg/kg, respectively. This mineral profile demonstrates that Bağbaşı (Haho) mulberry pekmez is a highly nutritious food capable of contributing to the daily intake of essential minerals.

Conclusion: The low hydroxymethylfurfural (HMF) content determined in traditional Bağbaşı (Haho) mulberry pekmez indicates that the product was processed under appropriate production conditions and represents a favorable quality characteristic. On the other hand, the iron (Fe) content may contribute to dietary iron intake, particularly in populations where iron deficiency is prevalent. Furthermore, the findings obtained in this study may further enhance the potential for the traditional Bağbaşı (Haho) mulberry pekmez to be commercialized as a functional food, in conjunction with the future development of controlled production techniques and a more comprehensive evaluation of its biological effects.

Özet

Amaç: Bu araştırma, geleneksel Bağbaşı (Haho) dut pekmezinin besin profilini ortaya çıkarmak amacıyla yapılmıştır.

Gereç ve Yöntem: Araştırmada, Bağbaşı (Haho) yöresine ait dut pekmezinin bazı fiziksel ve kimyasal özellikleri incelenmiştir. Bu kapsamda, ürünün mineral madde içeriği, pH değeri, toplam kül miktarı, hidroksimetilfurfural (HMF) düzeyi ve suda çözünür kuru madde (SÇKM) oranı gibi parametreler analiz edilmiştir.

Bulgular: Dut pekmezinde suda çözünür kuru madde (SÇKM) %76,5, toplam kül %2,02 ve pH değeri 4,71 olarak belirlenmiştir. Hidroksimetilfurfural (HMF) içeriği ise 30,00 mg/kg olarak tespit edilmiş olup, bu değer TSE 12001 standardında belirtilen kriterler doğrultusunda ürünün Tip 1 pekmez sınıfında değerlendirilebileceğini göstermektedir. Pekmez örneğinin mineral profiline ilişkin analizler sonucunda Fe (7,52 mg/kg), Zn (5,42 mg/kg), Mg (166,90 mg/kg), K (2497,44 mg/kg), Ca (52,13 mg/kg), P (199,50 mg/kg) ve Se (0,01 mg/kg) düzeylerinde belirlenmiştir. Elde edilen bu mineral profili, Bağbaşı (Haho) dut pekmezinin günlük temel mineral gereksinimlerinin karşılanmasına katkı sağlayabilecek besleyici değeri yüksek bir gıda olduğunu ortaya koymaktadır.

Sonuç: Geleneksel Bağbaşı (Haho) dut pekmezinde hidroksimetilfurfural (HMF) içeriğinin düşük düzeyde belirlenmiş olması, ürünün uygun üretim koşulları altında işlendiğine ve kalite açısından olumlu bir özellik taşıdığına işaret etmektedir. Öte yandan demir (Fe) içeriği, özellikle demir eksikliğinin yaygın olduğu toplumlarda diyetle alınan demir alımına katkıda bulunabilir. Ayrıca, bu araştırmada elde edilen bulgular ileride kontrollü üretim tekniklerinin geliştirilmesi ve biyolojik etkilerinin daha kapsamlı çalışmalarla değerlendirilmesiyle birlikte, geleneksel Bağbaşı (Haho) dut pekmezinin fonksiyonel gıda olarak ticarileştirilme potansiyelini daha da artırabilir.

Introduction

Pekmez (molasses) is a traditional food widely consumed in Türkiye and is typically produced from sugar-rich fruits such as mulberries, grapes, apples and plums. With a long historical background, it is obtained by processing fresh, highly perishable fruits using traditional methods to extend their shelf life (1). Pekmez is commonly consumed at breakfast either alone or in combination with tahini and is also used in the preparation of various local dishes. Due to its high levels of simple sugars, essential minerals and naturally occurring organic acids, pekmez is considered a nutritionally valuable food product and an important source of readily available energy (2, 3). During the Ottoman period, it was also used as a medicinal remedy in the famous Spice Bazaar (Mısır Çarşısı) for the treatment of ailments such as sore throat, the common cold and chest congestion, often in combination with red hot pepper (4).

Pekmez is characterized by its high proportion of readily absorbable monosaccharides, mainly glucose and fructose, which provide a rapid source of energy. This feature makes it particularly important for infants, children, athletes and individuals requiring immediate energy (5). With increasing awareness of the role of nutrition in maintaining a healthy life, interest in antioxidant-rich foods has grown in recent years (6) and pekmez is recognized as one of these functional foods. Approximately 100% of the total sugar in grape molasses and about 80% in other molasses varieties are composed of monosaccharides, enabling rapid absorption without digestive breakdown (7). Glucose, the primary energy source in human metabolism, plays a critical role in both physical and cognitive functions; the brain alone derives approximately 20–25% of its energy from glucose (8). Insufficient glucose intake may result in serious health problems such as impaired cognitive performance, dizziness, seizures and coma (9). Therefore, pekmez has an important nutritional role, especially for infants, children and athletes with high energy demands.

In recent years, mulberry pekmez has gained increasing popularity due to its recognized health benefits. Mulberry cultivation is widespread in Türkiye, particularly in the Eastern and Central Anatolia regions (10). Pekmez is produced by both industrial and traditional methods and in rural areas it is generally manufactured as a family-based activity (1). Mulberry pekmez is obtained by concentrating the must of freshly harvested or dried mulberries, free from foreign materials, in open copper or aluminum boilers or under vacuum until a characteristic consistency is achieved (11). Among mulberry species (white, red and black), white mulberries are most preferred for pekmez production. In Türkiye, mulberries are consumed both fresh and dried and are also processed into various traditional products such as pekmez, pestil, köme, vinegar and alcoholic beverages (12).

Although traditional Bağbaşı (Haho) mulberry pekmez is an important functional food produced using local production techniques and consumed by the local population for many years, there is no scientific data in the literature regarding its nutritional profile. Existing studies have generally focused on various types of molasses produced from mulberry species belonging to different regions. However, it is thought that the traditional mulberry pekmez produced in the Bağbaşı (Haho) region may differ in terms of its unique production process, raw material characteristics and mineral content. In this context, the main objective of this study is to determine the mineral composition (Mg, P, K, Ca, Fe, Zn and Se) and selected physicochemical properties (pH, ash, hydroxymethylfurfural and water-soluble dry matter) of traditionally produced Bağbaşı (Haho) mulberry pekmez and to provide scientific evidence for its potential nutritional and functional value.

Material and Method

Pekmez (Molasses) Sample

In this study, a pekmez sample produced in July 2022 was used. The sample was obtained in September 2022 from Bağbaşı (Haho), a district of Tortum in Erzurum province. Bağbaşı (Haho) is located at an altitude of 1,378 meters (Figure 1)

Figure 1. Bağbaşı (Haho) mulberry pekmez

Source: Author's personal archive

This study aims to provide a preliminary evaluation of the physical and chemical properties of mulberry pekmez specific to the Bağbaşı (Haho) region. For this purpose, an in-depth characterization was conducted on a single sample in order to test the production process and analytical methods. Traditional pekmez production in the Bağbaşı (Haho) region is generally small-scale, and products are obtained in limited quantities. The sample used in this study was selected as a "representative example" because it reflects the typical production method commonly employed in the region. Additionally, since this research was carried out within the scope of a time- and budget-restricted project (TÜBİTAK 2204-B), the analyses were conducted on a single sample in alignment with the project's constraints. Nevertheless, it is acknowledged that analyses based on a single sample pose limitations in terms of statistical representativeness and generalizability. Therefore, future studies are recommended to include multiple samples obtained from different producers and production batches to enable more comprehensive evaluations.

Traditional Production Process of Bağbaşı (Haho) Mulberry Pekmez

In the Bağbaşı (Haho) region of the Tortum district, Erzurum province, only white mulberries are used in the production of pekmez. The harvested mulberries are first cleaned to remove leaves, wood pieces and insects. They are then placed into a boiling cauldron, and water is added at a ratio of 1/2 to 1/4. The mixture is thoroughly stirred to ensure that the fruit blends homogeneously with the water and is then boiled. Once the mulberries in the cauldron begin to boil, the process is continued for an additional one hour, during which the mixture is continuously stirred. After boiling, the mash is cooled to 40–50 °C and then transferred to a pressing system to obtain the juice (pekmez extract). In the pressing system, the mash is pressed, and the juice is separated from the pulp. The juice obtained is filtered through a fine cheesecloth or plastic strainer and then transferred back to the boiling cauldron. During the subsequent boiling process, the concentrate is stirred, and the foam formed on the surface is removed. Boiling continues until the concentrate reaches the desired consistency (Figure 2).

Figure 2. The concentrate, on which foam begins to form on the surface (a), the concentrate that begins to thicken (b)

Source: Author's personal archive

Once the mulberry juice reaches the desired consistency, the boiling cauldron (copper vessel) is removed from the stove, and the pekmez is stirred while cooling. It is then left to rest for approximately 10-15 minutes. The pulp remaining after the pressing process is dried and used as animal feed (1).

Microwave Digestion Process

The microwave digestion procedure was performed using the "Honey" method integrated into the Milestone Connect Ethos UP microwave digestion system. A 0.3867 g portion of the pekmez sample was weighed into a Teflon vessel, after which 9 mL of HNO_3 (65%) and 1 mL of H_2O_2 (30%) were added. The vessel was sealed to create a closed system and placed into the microwave unit. Digestion was carried out at 200 °C for 15 minutes at T1 and 200 °C for 15 minutes at T2 under a system power of 1800 W. Upon completion of the digestion, the sample was diluted to 15 mL with ultrapure water. A blank sample prepared with the same acid mixture was subjected to identical digestion and dilution steps. Both the sample and the blank were further diluted in 2% HNO_3 according to the specified dilution factors and subsequently analyzed using ICP-MS. Each analytical measurement represents the average of three parallel readings.

Sample Weight (g)	Stock Volume (mL)	Dilution Factor
0.3867	15	10-fold

Elemental Analysis

Element concentrations in the prepared solutions were quantified using an inductively coupled plasma mass spectrometer (ICP-MS, Agilent 7800 Series; Agilent Technologies, Japan). The ICP-MS instrument is equipped with a glass MicroMist nebulizer (U-series, Australia) and a quartz double-pass spray chamber (USA) for the introduction of samples into the system. The plasma interface consists of an inert sample introduction kit featuring a 2.5-mm quartz torch (Japan), along with a nickel sample cone and X-lens–compatible nickel skimmer cone (USA). Prior to the determination of elemental concentrations, all quartz and nickel components were cleaned in accordance with the standard procedure. Before initiating the analysis, the instrument was purged with helium gas for 45 minutes. After setting the instrument parameters, including the plasma gas flow rate (15 L/min), auxiliary gas (1 L/min), carrier gas (1 L/min), makeup/dilution gas (1 L/min), and the carrier gas pressure (1.45 kPa), the system was activated for operation. Following the activation of the instrument, the torch axis, resolution axis, EM, standard lenses tune, plasma correction, full spectrum and performance report tests were sequentially performed. Subsequently, the calibration of the instrument was carried out using a tuning solution containing 1 μg/L of Co, Ce, Mg, Li, Tl and Y. The values obtained from the tuning process were examined to determine whether any deviations were present in the instrument. The standard solutions prepared from the stock solutions were analyzed, and the accuracy and suitability of the calibration curves were verified. Following the verification of the calibration curves, the samples were introduced into the instrument via the autosampler, and the analytical measurements were performed. The autosampler and tubing system were cleaned using 2% HNO_3 and ultrapure water, while the probe section was rinsed with a 1% HCl solution, ensuring that the system was adequately prepared for the subsequent injection. The measurements were carried out under conditions of 1200 W RF power, a carrier gas flow rate of 1 L/min, and a nebulizer pump speed of 0.30 rps. Argon was used as the carrier gas throughout the analyses.

Calculation of Measurements

The "MassHunter 4.4 Workstation Software 7800 ICP-MS Top C.01.04" software was used for the calculation of the measurements.

Dilution factor = (final weight or volume / sample weight or volume) × dilution coefficient.

Elemental concentrations are automatically calculated by the system according to the formula given above and expressed in ppb. To obtain the values in ppm, all results are divided by 1000 (13).

pH Determination

The pH measurement was conducted using a WTW inoLab pH 7110 benchtop pH meter in accordance with the potentiometric method reported by Cemeroğlu (14). Prior to analysis, the instrument was calibrated at three points using pH 4.00, pH 7.00 and pH 10.00 buffer solutions. The electrode was rinsed with deionized water before each measurement, and the AutoRead function was employed to ensure that a stable reading was obtained. The pH value of the pekmez sample was measured directly after thorough homogenization and determined in quadruplicate.

Determination of Total Ash Content

Ash content is an important quality parameter that reflects the total salt and mineral content of food products. The determination is based on the principle of incinerating a known amount of sample and measuring the inorganic residue remaining after complete combustion. The ash determination in the pekmez sample was carried out using a Protherm Furnaces muffle furnace in accordance with the dry incineration method reported by Cemeroğlu (14). Approximately 2.0000±0.0001 g of pekmez was weighed into porcelain crucibles and pre-incinerated over a Bunsen burner flame to remove organic matter.

The samples were then ashed in a muffle furnace at 525 ± 10 °C until a gray-white ash, indicating complete incineration, was obtained. After cooling in a desiccator, the residue was weighed, and the ash content was determined in quadruplicate.

Determination of Hydroxymethylfurfural (HMF)

The determination of hydroxymethylfurfural (HMF) content in the pekmez sample was carried out in accordance with the TS 13356 standard (15) using an Agilent 1260 Infinity high-performance liquid chromatography (HPLC) system. A C18 reversed-phase column (250 × 4.6 mm, 5 µm particle size) was employed for the analysis. The mobile phase consisted of a mixture of ultrapure water and methanol (90:10, v/v) under isocratic conditions, with a flow rate set at 1.0 mL/min. Detection was performed using a UV detector at a wavelength of 284 nm. The injection volume was 20 µL, and the column temperature was maintained at 30 °C. For quantitative analysis, standard solutions at different concentrations were prepared from an HMF stock solution to construct a calibration curve with at least five calibration points, yielding a linear regression coefficient of $R^2 \geq 0.999$. The limit of detection (LOD) and limit of quantification (LOQ) of the method were calculated as 0.01 mg/L and 0.03 mg/L, respectively. Prior to analysis, the samples were filtered through a 0.45 µm PTFE membrane filter, and all measurements were performed in triplicate.

Determination of Water-Soluble Dry Matter (WSDM)

The water-soluble dry matter (WSDM) content of the pekmez sample was determined at 20 °C using an Abbe digital refractometer in accordance with the method described by Cemeroğlu (14). Water-soluble dry matter refers to the fraction of solid components in a food product that remains after the removal of water and is soluble in water, including mainly sugars, organic acids and certain minerals (16). WSDM is a critical quality parameter in pekmez production, as it directly influences product consistency, viscosity, shelf stability and consumer acceptability.

Results and Discussion

This section presents the physicochemical properties and mineral composition of traditionally produced Bağbaşı (Haho) mulberry pekmez and discusses the results in comparison with relevant quality standards and previously published studies. The findings are evaluated in terms of technological quality and potential nutritional significance, with particular emphasis on the effects of traditional processing conditions and regional characteristics on the final product profile.

Table 2. TSE 12001 mulberry pekmez standard values

Properties	Type 1	Type 2
pH	5.0-6.0	5.0-6.0
Water-soluble dry matter WSDM (brix) % (m/m) minimum	72	65
Invert sugar, % m/m,	51.0-65.0	35.0-50.0
Total sugar (inverted sugar), % m/m, maximum	66.0	60.0
Sucrose, %m/m, maximum	14	17
Ash insoluble in 10% HCl, %m/m, maximum	0.3	0.3
Total ash, %, maximum	4.0	3.0
Hydroxymethyl furfural (HMF), mg/kg, maximum **Heavy metals**	75	75
Arsenic (As), mg/kg, maximum	0.2	0.2
Copper (Cu), mg/kg, maximum	5.0	5.0
Zinc (Zn), mg/kg, maximum	5.0	5.0
Iron (Fe), mg/kg, maximum	15.0	15.0
Lead (Pb), mg/kg, maximum	0.3	0.3

pH Value of Mulberry Pekmez

According to the TSE 12001 Mulberry Pekmez Standards Draft, the pH values of both Type 1 and Type 2 pekmez should range between 5.0 and 6.0. The pH value of Bağbaşı (Haho) mulberry pekmez was determined to be 4.71, which is slightly below the standard range specified by TSE 12001. In a study conducted by Özdemir and Topuz (18) the pH value of pekmez was determined to be 3.74-5.65, while in a study conducted by Konal (2) it was determined to be in the range of 4.62-4.89. The data in the literature are close to the results of our study. However, the pH value of Bağbaşı (Haho) mulberry pekmez was found to be lower than those reported by Aksu and Nas (1), Karataş and Şengül (8) and Ergun et al. (19), which were in the ranges of 5.35-6.03, 4.84-5.30 and 4.77-5.18, respectively. The pH value of Bağbaşı (Haho) mulberry pekmez being determined below the TSE 12001 standard range (5.0-6.0), at 4.71, may be attributed to the production process being carried out entirely using natural methods without the addition of any alkalizing agents (such as molasses soil, lime, etc.). In some traditional production practices, alkaline substances like molasses soil are used to balance acidity and enhance clarification. The absence of such substances allows the naturally occurring organic acids in the product to remain dominant, resulting in a lower measured pH value. In addition, factors such as harvesting the mulberries at full ripeness, the mineral composition of the soil in which they were grown, the climatic characteristics of the region, and the absence of any additives during production may have contributed to the preservation of the natural acidity of the molasses. This situation also explains the consistency of the obtained pH value with those reported in the literature for certain natural and additive-free molasses samples.

Water-Soluble Dry Matter Values (WSDM) of Mulberry Pekmez

As shown in table 1, the soluble dry matter (WSDM) value of Bağbaşı (Haho) mulberry pekmez was 76.5%. According to the TSE 12001 Mulberry Pekmez Standards Draft, the soluble solid matter (Brix) value should be at least 72 for Type

1 pekmez and 65 for Type 2 pekmez. Based on these results, Bağbaşı (Haho) mulberry pekmez falls under Type 1 classification. In a study conducted by Aksu and Nas (1), the total dry matter content of mulberry pekmez samples obtained from different locations was found to be in the range of 63.1-76.0%. In a study conducted by Karataş and Şengül (8), the soluble dry matter (WSDM) content in mulberry pekmez samples was found to be between 71.25% and 82.17% and the total dry matter content was found to be between 72.50% and 84.01%. The results obtained in this study are consistent with the results of previous studies.

Total Ash Value of Mulberry Pekmez

As shown in table 1, the total ash content of Bağbaşı (Haho) mulberry pekmez was 2.02%. According to the TSE 12001 Mulberry Pekmez Standard, the maximum allowable ash content is 4.0% for Type 1 and 3.0% for Type 2 pekmez. Therefore, the ash content of Bağbaşı (Haho) mulberry pekmez complies with the limits specified for both Type 1 and Type 2 pekmez. Karataş and Şengül (8) determined the ash content in mulberry pekmez samples to be between 1.76% and 2.95%, Ergun et al. (19) between 1.84% and 2.40% and Salık et al. (10) between 1.44% and 3.47%. The amount of ash detected in this study was found to be consistent with the values obtained in previous studies. Ash content is closely associated with the mineral composition of pekmez and reflects both the raw material characteristics and processing conditions. Variations in ash values reported in the literature may be attributed to differences in mulberry variety, soil mineral composition and traditional production practices. In this context, the ash content obtained in the present study indicates an appropriate processing process and supports the mineral profile findings.

Hydroxymethylfurfural (HMF) Value of Mulberry Pekmez

Hydroxymethylfurfural (HMF) is formed as a result of heat treatment applied during the production of foods with high sugar content, such as jam and molasses, and is widely used as an indicator of thermal processing intensity and product quality (20). The amount of HMF in food products generally increases with storage time and temperature (21). According to the TSE 12001 Mulberry Pekmez Standards Draft, the maximum permissible HMF content is 75 mg/kg for both Type 1 and Type 2 mulberry pekmez. As shown in table 1, the HMF content of Bağbaşı (Haho) mulberry pekmez was determined to be 30 mg/kg. This value is well below the maximum limit specified in the standard and indicates appropriate processing conditions. Karataş and Şengül (8) reported HMF values ranging from 5.69 to 134.68 mg/kg in mulberry pekmez samples and concluded that storage significantly increases HMF formation. Similarly, Ergun et al. (19) determined HMF contents between 18.69 and 104.59 mg/kg in pekmez samples. Based on the TSE 12001 Standard, the HMF content determined in the present study complies with the regulatory limit.

Mineral Content of Mulberry Pekmez

To characterize the major and trace element profile of Bağbaşı (Haho) mulberry pekmez, its mineral composition was determined using ICP-MS; the analytical results are summarized in table 3.

Table 3. Mineral content of Bağbaşı (Haho) mulberry pekmez (molasses)

	Concentrations (mg/kg)
Major elements	
Mg	166.90
P	199.50
K	2497.44
Ca	52.13
Trace elements	
Fe	7.52
Zn	5.42
Se	0.01

Minerals, which are inorganic substances, are widely found in nature. They are essential for the growth, development, maintenance of life and preservation of health. Minerals are among the fundamental nutrients that constitute the structure of the human body and regulate numerous physiological functions. Although they make up only about 4% of our body, minerals contribute significantly to the formation of its structure. They are also present in muscles, bones, teeth, blood and other body tissues. Minerals that are required in amounts greater than 250 mg per day are referred to as "macrominerals." This group includes electrolytes such as sodium, potassium, calcium, magnesium, phosphorus and chloride. On the other hand, minerals with a daily requirement of less than 20 mg are classified as "trace elements," and this group includes chromium, copper, fluoride, iodine, iron, manganese, molybdenum, selenium and zinc (22). As shown in table 3, the molasses sample contained macro minerals Mg, P, K and Ca as well as trace elements Fe, Zn and Se. For a more comprehensive evaluation and to enable a direct comparison with previous studies, the mineral composition of mulberry pekmez and other traditional molasses types reported in the literature is summarized in table 4.

As shown in table 3, the magnesium (Mg) content of the mulberry pekmez sample was 166.90 mg/kg. This value is lower than the concentrations reported in previous studies (3, 23, 24), while it is higher than those reported by Karaca (25) and Dilek et al. (26). The phosphorus (P) content of the pekmez sample was determined to be 199.50 mg/kg. This value is lower than those reported in previous studies (3, 23, 24) and higher than the value reported by Dilek et al. (26). The potassium (K) content of the pekmez sample was determined to be 2497.44 mg/kg. This value is lower than those reported in previous studies (3, 23, 24) but higher than the values reported by Karaca (25) and Dilek et al. (26). Similarly, the calcium (Ca) content of the mulberry pekmez sample was determined to be 52.13 mg/kg. This value is lower than those reported by Akbulut et al. (3) and Şimşek et al. (23) but higher than the values reported by Yiğit (24) and Dilek et al. (26). These variations observed among different studies may be associated with differences in mulberry variety, harvest time, processing conditions and geographical origin.

Table 4. Mineral content of some traditional molasses types

Minerals	Mg	P	K	Ca	Fe	Zn	Se
mg/kg							
Mulberry molasses Şimşek and Artık (23)	670	540	4380	960	9.3	4.8	-
Mulberry molasses Yiğit (24)	559	327.2	8297	13.47	46.01	2.20	-
Mulberry molasses Akbulut et al. (3)	389.86	517.72	8146	575.81	5.48	3.31	-
Mulberry molasses Karaca (25)	11.3	-	178	28.7	3.26	4.73	3.88
Mulberry molasses Dilek et al. (26)	0.10	0.34	1.04	0.88	6.39	1.21	-
Carob molasses Şimşek and Artık (23)	500	550	4230	1350	3.4	120	-
Carob molasses Tetik et al. (27)	556	778	10573	3149	14	4	-
Carob molasses Yiğit (24)	503	577	11271	861	20.94	1.85	-
Carob molasses Karaca (25)	10.2	-	1936	30.4	3.32	2.86	3.58
Carob molasses Dilek et al. (26)	0.12	0.14	0.99	0.49	5.77	0.59	-
Juniperus drupacea fruit (Andız) Akıncı (28)	843	1445	18840	1499	6.9	12.8	-
Juniperus drupacea fruit (Andız) Akbulut et al. (29)	746	1248	17400	1881	1881	12.5	-
Juniperus drupacea fruit *(Andız)* Karaca (25)	11.4	-	385	33.8	2.92	3.68	3.96
Juniperus drupacea fruit (Andız) Dilek et al. (26)	0.08	0.33	1.24	1.17	7.49	1.52	-

"-": Not reported in the reference study. All values are expressed as mg/kg.

From a nutritional perspective, calcium is an essential mineral for bone health, muscle contraction and enzymatic activity. The recommended daily intake of calcium ranges from 200 to 1300 mg (30); therefore, although Bağbaşı (Haho) mulberry pekmez is not a major source of calcium on its own, it may contribute to the daily calcium intake as a complementary food. The iron (Fe) content of the pekmez sample was determined to be 7.52 mg/kg. According to the TSE 12001 Mulberry Pekmez Standard, the maximum allowable iron content in Type 1 and Type 2 mulberry pekmez is 15 mg/kg. It can be stated that the mulberry pekmez sample complies with the relevant standards in terms of its iron (Fe) content. The zinc (Zn) content of the mulberry pekmez sample was determined to be 5.42 mg/kg. This value is higher than those reported in previous studies (3, 23, 26). Zinc is an essential trace element involved in immune function, antioxidant defense and numerous enzymatic reactions; therefore, the relatively high Zn content enhances the nutritional value of the product. The selenium (Se) content of the pekmez sample was determined to be 0.01 mg/kg. This value is lower than the one reported by Karaca (25). Selenium is an essential trace element involved in antioxidant defense, immune function and thyroid hormone metabolism. The recommended daily intake of selenium (Se) ranges from 20 to 55 μg (31). Considering the relatively low selenium concentration determined in this study, Bağbaşı (Haho) mulberry pekmez alone cannot be considered a sufficient dietary source to meet the daily selenium requirement; however, it may contribute to overall selenium intake as part of a balanced diet.

The mineral composition of the Bağbaşı (Haho) mulberry pekmez reflects both nutritional characteristics of the raw material and the effects of traditional processing conditions. The predominance of macrominerals such as potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P) is consistent with previous reports on mulberry and grape molasses produced in different regions of Türkiye and other countries. Potassium plays a critical role in electrolyte balance and cardiovascular function, while calcium and magnesium are essential for bone metabolism, enzymatic activity and energy metabolism. The presence of trace elements such as iron (Fe), zinc (Zn) and selenium (Se), although at relatively low concentrations, is nutritionally important due to their roles in oxygen transport, antioxidant defense, immune response and endocrine regulation.

The observed differences in mineral concentrations among various studies may also be influenced by technological factors such as boiling duration, evaporation rate, clarification practices and contact with metallic surfaces during traditional processing. Prolonged boiling may lead to partial concentration of some minerals due to water loss, whereas clarification and filtering steps may reduce the levels of certain trace elements. Moreover, soil mineral composition and plant uptake capacity play a decisive role in determining the mineral profile of mulberries. Therefore, both agronomic and technological factors should be considered together when interpreting the mineral composition of traditional pekmez.

This study provides the first comprehensive evaluation of the physicochemical properties and mineral composition of traditionally produced Bağbaşı (Haho) mulberry pekmez. The findings demonstrate that the product meets the quality criteria for Type 1 mulberry pekmez according to the TSE 12001 standard and is characterized by a favorable mineral profile dominated by essential macro- and trace elements. These results confirm the nutritional value of Bağbaşı (Haho) mulberry pekmez as a high-quality traditional food and support its potential relevance in future regional characterization, standardization efforts and functional food research.

Due to their health benefits, the demand for natural foods has been steadily increasing both in our country and around the world. For this reason, interest in traditional foods has increased and studies focusing on these foods have intensified in recent years. In this study, it was aimed to determine some physical and chemical properties as well as the mineral content of the Tortum Bağbaşı (Haho) mulberry pekmez produced by traditional methods. The pH value of Bağbaşı (Haho) mulberry pekmez was determined as 4.71, which is slightly below the standard range (5.0-6.0) specified in the TSE 12001 Mulberry Pekmez Standard. However, the water-soluble dry matter (WSDM), total ash and hydroxymethylfurfural (HMF) values were found to be fully compliant with the relevant standard limits. The low HMF content indicates that the traditional production process was carried out under appropriate temperature conditions and that the product was exposed to minimal thermal degradation.

The WSDM content of 76.5% reflects the dense consistency and sugar-rich structure of the product and indicates a low water content, which enhances microbial stability and contributes to an extended shelf life. Moreover, the ash content of 2.02% demonstrates that Bağbaşı (Haho) mulberry pekmez is rich in mineral matter. Mineral analysis revealed the presence of essential macro and microelements, including Fe, Zn, Mg, K, Ca, P and Se. The relatively high levels of Fe and Zn support the traditional consumption of pekmez, particularly in populations where iron deficiency anemia is prevalent.

The originality of this study lies in the fact that the physical, chemical and mineral composition of Bağbaşı (Haho) mulberry pekmez has been comprehensively determined for the first time. Although several studies have investigated mulberry and grape pekmez produced in different regions, no detailed scientific data have previously been reported specifically for Bağbaşı (Haho) mulberry pekmez. Therefore, the present study fills an important gap in the literature by providing region-specific and product-specific reference data. In conclusion, Bağbaşı (Haho) mulberry pekmez stands out as a high-quality traditional product in terms of its physicochemical properties and mineral richness, indicating that it may be considered not only a conventional energy source but also a functional food with potential health-promoting properties. The findings of this study provide a scientific basis for future comparative regional, technological and nutritional studies, as well as for standardization efforts, functional food development and possible geographical indication applications. However, further comprehensive studies involving different harvest periods, production techniques and regional variations are recommended to more fully evaluate the nutritional and functional potential of this traditional product.

Author Contribution

The corresponding author is responsible for conducting the project and writing this manuscript.

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The author declare that the ethics committee approval is not required for this study.

References

1. Aksu, M. İ., & Nas, S. (1996). Dut pekmezi üretim tekniği ve çeşitli fiziksel-kimyasal özellikleri. *Gıda Teknolojisi Derneği Dergisi, 21*(2), 83-88.

2. Konal, K. F. (2024). *Giresun yöresinde geleneksel yöntemlerle üretilen pekmez çeşitlerinin bazı fizikokimyasal, antioksidan ve spektroskopik özelliklerinin (FTIR) belirlenmesi* (Publication No. 881187) [Master's thesis, Giresun Üniversitesi]. YOK Thesis Center.

3. Akbulut, M., Batu, A., & Çoklar, H. (2007). Dut pekmezinin bazı fizikokimyasal özellikleri ve üretim teknikleri. *Gıda Teknolojileri Elektronik Dergisi,* (2), 25-31.

4. Verit, A., Yeni, E., & Ünal, D. (2001). Tarihten günümüz ürolojisine kırmızı acı biber. *Türk Üroloji Dergisi 27*(4), 399-402.

5. Tosun, İ., & Ustun, N.Ş. (2003). Nonenzymic browning during storage of white hard grape pekmez (Zile pekmezi). *Food Chemistry, 80*(4), 441-443.

6. Karataş, N., & Şengül, M. (2018). Dut pekmezinin bazı kimyasal ve fiziksel özellikleri ile antioksidan aktivitesi üzerine depolamanın etkisi. *Türk Tarım ve Doğa Bilimleri Dergisi, 5*(1), 34-43.

7. Güngör, N. (2007). *Dut pekmezinin bazı kimyasal ve fiziksel özellikleri ile antioksidan aktivitesi üzerine depolamanın etkisi* (Publication No. 177802) [Master's thesis, Atatürk Üniversitesi]. YOK Thesis Center.

1. Mergenthaler, P., Lindauer, U., Dienel, G. A., & Meisel, A. (2013). Sugar for the brain: The role of glucose in physiological and pathological brain function. *Trends in Neurosciences, 36*(10), 587-597. https://doi.org/10.1016/j.tins.2013.07.001

2. Cryer, P. E. (2007). Hypoglycemia, functional brain failure, and brain death. *The Journal of Clinical Investigation, 117*(4), 868-870. https://doi.org/10.1172/JCI31669

3. Salık, M. A., Arslaner, A., & Çakmakçı, S. (2021). Erzincan geleneksel dut pekmezinin bazı fiziksel, kimyasal ve antioksidan özelliklerinin belirlenmesi. *Turkish Journal of Agriculture-Food Science and Technology, (9)*1, 181-190. https://doi.org/10.24925/turjaf.v9i1.181-190.3802

4. Tosun, M., & Keles, F. (2012). Testing methods for mulberry pekmez adulterated with different sugar syrups. *Akademik Gıda, 10*(1), 17-23.

5. Bakkaloğlu, Z. (2025). Kemaliye dut pekmezinin geleneksel üretim yöntemi ve gastronomi turizmi potansiyeli. *Journal of Tourism and Gastronomy Studies, 13*(1), 360-375. https://doi.org/10.21325/jotags.2025.1562

6. Milestone. (2019). *Milestone application note for acid digestion SK-food-069-honey*. Retrieved May 10, 2025, from https://subitam.sinop.edu.tr/wp-content/uploads/sites/93/2019/12/Mikrodalga.pdf

7. Cemeroğlu, B. (2010). *Gıda analizleri* (2nd ed.). Gıda Teknolojisi Derneği Yayınları.

8. Türk Standartları Enstitüsü (TSE). (2008). *TS 13356: Bal — Hidroksimetilfurfural (HMF) tayini — HPLC yöntemi*. TSE.

9. MEGEP. (2013). *Gıdalarda nem ve kuru madde tayini (541GI0082)*. Milli Eğitim Bakanlığı.

10. Türk Standartları Enstitüsü (TSE). (2022). *TSE 12001: Dut pekmezi (Made from mulberry)*.

11. Özdemir, F., & Topuz, A. (1998). Antalya yöresinde yetiştirilen farklı dutların bazı kimyasal özellikleri. *Derim, 15*(1), 30-35.

12. Ergun, M., Kalan, C., & Süslüoğlu, Z. (2019). Bingöl ilinin Servi yöresinde geleneksel yollarla üretilen ak dut pekmezlerinin bazı fiziksel ve kimyasal özelliklerinin belirlenmesi. *Turkish Journal of Agricultural and Natural Sciences, 6*(4), 917-924. https://doi.org/10.30910/turkjans.633637

13. Arslaner, A., & Salık, M. A. (2020). Yabani meyvelerden üretilen geleneksel reçellerin bazı kalite özellikleri, mineral ve ağır metal içerikleri. *Türkiye Tarım ve Gıda Bilimi ve Teknolojileri Dergisi, 8*(3), 678-687. https://doi.org/10.24925/turjaf.v8i3.678-687.3190

14. Yılmaz, H. (1994). *Doğu ve Güneydoğu Anadolu Bölgesi ballarının kimyasal bileşimlerinin araştırılması* (Publication No. 35160) [Doctoral dissertation, Atatürk Üniversitesi]. YOK Thesis Center.

15. Samur, E. G. (2012). *Vitaminler, mineraller ve sağlığımız*. Sağlık Bakanlığı Yayınları.

16. Şimşek, A., & Artık, N. (2002). Değişik meyvelerden üretilen pekmezlerin bileşim unsurları üzerine araştırma. *Gıda, 27*(6), 459-467.

17. Yiğit, M. (2016). *Üzüm, dut ve keçiboynuzu pekmezlerinin 5-hidroksimetilfurfural ve bazı mineral içeriklerinin belirlenmesi* (Publication No. 420138) [Master's thesis, Hacettepe Üniversitesi]. YOK Thesis Center.

18. Karaca, İ. (2009). *Pekmez örneklerinde vitamin ve mineral tayini* (Publication No. 236650) [Master's thesis, İnönü Üniversitesi]. YOK Thesis Center.

19. Dilek, N. M., Babaoğlu, A. S., Unal, K., Turan, M., Pırlak, L., & Karakaya, M. (2025). Nutritional profile and functional characteristics of various types of traditionally produced pekmez-Part I. *Food Science & Nutrition, 13*(7), e70662. https://doi.org/10.1002/fsn3.70662

20. Tetik, N., Turhan, İ., Karhan, M., & Öziyci, H. R. (2010). Keçiboynuzu pekmezinin karakteristiği ve 5-hidroksimetilfurfural içeriği. *Gıda, 35*(6), 417-422.

21. Akıncı, İ., Özdemir, F., Topuz, A., Kabas, Ö., & Çanakçı, M. (2004). Some physical and nutritional properties of *Juniperus drupacea* fruits. *Journal of Food Engineering, 65*, 325-331. https://doi.org/10.1016/j.jfoodeng.2004.01.029

22. Akbulut, M., Çoklar, H., & Özen, G. (2008). Rheological characteristics of *Juniperus drupacea* fruit juice (pekmez) concentrated by boiling. *Food Science and Technology International, 14*(4), 321-328. https://doi.org/10.1177/1082013208097193

23. National Institutes of Health. (2025, June 10). *Calcium-Fact sheet for health professionals.* https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/

24. Sur, Ü., Erkekoğlu, P., & Koçer-Gümüşel, B. (2020). Selenium, selenoproteinler ve Hashimoto troiditi. *FABAD Journal of Pharmaceutical Sciences, 45*(1), 45-64.