Citation: Durmishi B, Knights V, Mehmeti I, Stamatovska V, Nuha D, Rizani, Bytyçi P, Hazırı V, Sadiku V. Determining the quality of honey in the region of Kosovo with physio-chemical analysis. U. Arı D. / U. Bee J. 2023, 23(2): 202-214 DOI: 10.31467/uluaricilik.1349616

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

DETERMINING THE QUALITY OF HONEY IN THE REGION OF KOSOVA WITH PHYSIOCHEMICAL ANALYSIS

Kosova Bölgesindeki Balın Kalitesinin Fizyokimyasal Analizle Belirlenmesi

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Received / Geliş Tarihi: 25.08.2023 Accepted / Kabul Tarihi: 24.10.2023 DOI: 10.31467/uluaricilik.1349616

ABSTRACT

This article examines the physicochemical and nutritional characteristics of honey produced in different regions of Kosovo. The aim of this study is to investigate the physicochemical properties and nutritional characteristics of honey from various regions in Kosovo, shedding light on the factors influencing its composition and quality. It also underscores the importance of local beekeepers in sustaining honey production and environmental preservation. A total of 26 samples were gathered from various locations, and beekeepers were interviewed about their honey-production techniques and bee-feeding practices. The samples underwent analysis to determine parameters such as moisture content, total solids, pH, acidity, ash content, proteins, electrical conductivity, and dissolved solids content %. Notably, the physicochemical properties of honey differed significantly across the regions. Moisture content ranged from 15.02% to 18.80%, with the lowest found in Ferizaji and the highest in Sharri. Dissolved solids content % concentration at 20°C varied from 79.50% to 82.60%, with Sharri exhibiting the lowest and Prishtina displaying the highest value. The acidity and pH levels of all honey samples were measured between 4.97 and 5.63, and 3.56 to 5.60, respectively. Additionally, the Pfund scale was employed to evaluate the color of the honey, indicating white hues for Sharri, extremely light white or white for Prishtina and Ferizaj, and exceptionally white for Skenderaj. This study concludes that geographical location, feeding systems, nectar sources, honey age, and beekeeper processing methods significantly impact the physicochemical and nutritional properties of honey, including its color.

Keywords: Honey, Kosovo region, Physicochemical composition, Nutritional aspects, Color grading

ÖZ

Bu makale Kosova'nın farklı bölgelerinde üretilen balın fizikokimyasal ve besinsel özelliklerini incelemektedir. Bu çalışmanın amacı, Kosova'nın çeşitli bölgelerinden elde edilen balın fizikokimyasal özelliklerini ve besinsel özelliklerini araştırarak bileşimini ve kalitesini etkileyen faktörlere ışık tutmaktır. Ayrıca yerel arıcıların bal üretiminin sürdürülmesi ve çevrenin korunmasındaki öneminin altını çizmektedir. Çeşitli yerlerden toplam 26 örnek toplanmış ve arıcılarla bal üretim teknikleri ve arı besleme uygulamaları hakkında görüşülmüştür. Numuneler nem içeriği, toplam katı madde, pH, asitlik, kül içeriği, proteinler, elektrik iletkenliği ve % çözünmüş katı madde içeriği gibi parametreleri belirlemek üzere analize tabi tutulmuştur. Balın fizikokimyasal özellikleri bölgeler arasında önemli ölçüde farklılık göstermiştir. Nem içeriği %15,02 ile %18,80 arasında değişmekte olup en düşük Ferizaji'de ve en yüksek Sharri'de bulunmuştur. 20°C'deki çözünmüş katı madde içeriği % konsantrasyonu %79,50 ile %82,60 arasında değişirken, en düşük değeri Sharri, en yüksek değeri ise Prishtina göstermiştir. Tüm bal örneklerinin asitlik ve pH seviyeleri sırasıyla 4.97 ila 5.63 ve 3.56 ila 5.60 arasında ölçülmüştür. Ayrıca, balın rengini değerlendirmek için Pfund ölçeği kullanılmış ve Sharri için beyaz tonlar, Prishtina ve Ferizaj için son derece açık beyaz veya beyaz ve Skenderaj için son derece beyaz tonlar belirlenmiştir. Bu çalışma, coğrafi konum, besleme sistemleri, nektar kaynakları, bal yaşı ve arıcı işleme yöntemlerinin balın rengi de dahil olmak üzere fizikokimyasal ve besinsel özelliklerini önemli ölçüde etkilediği sonucuna varmaktadır.

Anahtar Kelimeler: Bal, Kosova bölgesi, Fizikokimyasal bileşim, Besinsel özellikler, Renk derecelendirmesi

GENIŞLETİLMİŞ ÖZET

Amaç: Bu kapsamlı çalışmanın amacı, gelişen arıcılık endüstrisi ile tanınan Kosova'ya odaklanarak balın çok yönlü dünyasını incelemektir. Çalışma, balın çeşitli özelliklerini ve kökenlerini ve hem mutfaktaki hem de geleneksel tıptaki rolünü keşfetmeyi amaçlamaktadır. Ayrıca, özellikle Kosova'nın arıcılık endüstrisi bağlamında, balın metal kirliliğini tespit etmek için çevresel bir uyarıcı olarak önemini vurgulamayı amaçlamaktadır.

Gereç ve yöntem: Çalışmada, Kosova'nın 10 farklı bölgesinden 26 bal örneğini incelemek için titiz yöntemler kullanılmıştır. Bal örneklerinin çeşitli özelliklerini değerlendirmek için hem fiziksel hem de kimyasal analizler yapılmıştır. Fiziksel analizler nem içeriği, % briks konsantrasyonu, pH, titre edilebilir asitlik, kül içeriği, toplam proteinler, iletkenlik ve Pfund ölçeği kullanılarak bal rengini kapsamaktadır. Kimyasal analizler toplam protein, kül ve sodyum, manganez, potasyum, kalsiyum, magnezyum, bakır, demir ve çinko gibi mineral elementlerin konsantrasyonları incelenmiştir.

Bulgular: Çalışmanın sonuçları, bal örneklerinin fiziksel özelliklerinde coğrafi farklılıkları yansıtan önemli farklılıklar olduğunu ortaya koymuştur. Nem içeriği %15,02 ile %18,80 arasında değişirken, %briks konsantrasyonu %79,5 ile %82,6 arasında değişmiştir. pH, Titre edilebilir asitlik ve Pfund ölçeği kullanılarak yapılan renk analizi de örnekler arasında farklılıklar göstermiştir. Ayrıca, kimyasal analizler, %0,03 ile %3,17 arasında değişen toplam protein içeriği ve %0,01 ile %0,78 arasında değişen kül içeriği ile farklı profiller ortaya koymuştur. Sodyum, manganez, potasyum, kalsiyum, magnezyum, bakır, demir ve çinko dahil olmak üzere mineral element konsantrasyonları bal örnekleri arasında önemli farklılıklar sergilemiştir.

Tartışma ve sonuç: Bu çalışma, Kosova'da gelişen arıcılık endüstrisine özel olarak odaklanarak balın çok yönlü dünyasına ilişkin değerli bilgiler sunmaktadır. Balın benzersiz özelliklerini, hem mutfak hem de geleneksel tıptaki rolünü ve metal kirliliğini tespit etmek için çevresel bir uyarıcı olarak önemini vurgulamaktadır. Bal örneklerinin fiziksel ve kimyasal özelliklerinde gözlemlenen farklılıklar, balın coğrafi kökenini anlamanın öneminin altını çizmektedir. Bu bulguların hem Kosova'daki arıcılık endüstrisi hem de daha geniş çevresel izleme alanı için etkileri vardır.

Sonuç olarak, Kosova'da yürütülen bu çalışma, ülkenin farklı yerlerinden toplanan balların fizikokimyasal özellikleri ve besinsel yönleri hakkında değerli bilgiler sağlamaktadır. Bulgular, balın fiziksel ve kimyasal özelliklerinin arıların beslendiği bölgeye ve o bölgenin coğrafi özelliklerine bağlı olarak değiştiğini göstermektedir. Çalışma, balın nem içeriği, çözünmüş katı madde içeriği %

konsantrasyonu, asitliği ve pH'sının bölgeden bölgeye değiştiğini ve Kosova'da balın rengini belirlemek için Pfund ölçeğinin kullanıldığını ortaya koymuştur. Balın rengi, nektar kaynağı, balın yaşı ve arıcının işleme yöntemleri de dahil olmak üzere çeşitli faktörlerden etkilenmektedir. Çalışma ayrıca Sharri'den toplanan balın beyaz renkli olduğunu, Prishtina'dan toplanan balın ise özellikle açık beyaz ve ekstra beyaz olduğunu göstermektedir. Çalışmanın sonuçları, iyi besin değerine sahip yüksek kaliteli bal üretiminde yerel arıcıları desteklemek için kullanılabilir.

Bu çalışmanın bazı sınırlamalarını kabul etmek önemlidir. Örneklem büyüklüğü, Kosova'nın çeşitli bölgelerini temsil etse de nispeten küçüktür. Gelecekte daha büyük bir örneklem büyüklüğüyle yapılacak araştırmalar, bal özelliklerindeki coğrafi farklılıklar hakkında daha kapsamlı bilgiler sağlayabilir. Ayrıca, bu çalışma bal bileşimindeki bu farklılıklarla ilişkili potansiyel sağlık faydalarını araştırmamıştır. İleride yapılacak araştırmalar Kosova'nın farklı bölgelerinden elde edilen balların besleyici ve tıbbi özelliklerini inceleyebilir.

INTRODUCTION

Honey is a natural sweetener made by bees from floral nectar. It has been utilized for thousands of years because of its distinct flavor and several health benefits. Honey is a complex blend of sugars, enzymes, amino acids, vitamins, and minerals that contribute to its particular flavor and therapeutic benefits (Kasprzyk, et al. 2018,Bernolo 2020). Honey is available in a range of hues and tastes, depending on the type of floral nectar gathered by the bees. Clover honey, wildflower honey, and Manuka honey are some of the most prevalent varieties of honey. Each type of honey has a distinct flavor and nutritional value (Nascimento, et al. 2018,Bucekova, et al. 2018,Cheung, et al. 2019).

Honey is a common component in many different cuisines across the world. It is a natural sweetener that may be used in tea, coffee, and baked products. It may also be used as a meat glaze, a vegetable marinade, and a topping for yogurt and porridge (Magdalena Kunat-Budzyńska 2023,Gela, et al. 2021,Noiset, et al. 2022). Honey is well-known for its numerous health advantages in addition to its culinary applications. Honey has been used for generations in traditional medicine to cure a number of diseases, including sore throats, coughs, and wounds (Karabagias, et al. 2014,Karabagias and Karabournioti 2018). It has a high concentration of antioxidants, which can help protect the body from free radical damage and lower the risk of chronic illnesses including cancer and heart disease. Honey is also recognized for its anti-inflammatory characteristics, which can aid in the reduction of inflammation in the body and the relief of symptoms associated with illnesses such as arthritis (Alaerjani, et al. 2022,Pauliuc, et al. 2022).

Overall, honey is a tasty and healthy natural sweetener with several health advantages. Honey is a flexible and pleasant complement to any diet, whether consumed raw or used in cooking and baking. Because of its unique qualities, it is an important element in both traditional and modern medicine (McLoone, et al. 2016,Pasupuleti, et al. 2017). Many studies have demonstrated that particular physicochemical characteristics and mineral content in various locations across the world, together with chemometric analysis, can be a valuable tool in determining the botanical or geographical origin of honey that enters the market. Moisture, sugar, hydroxy-methyl furfural (HMF), mineral composition, and a variety of other factors influence honey quality in terms of both sugar and microbiological qualities (Beretta, et al. 2007,Gasparrini, et al. 2017).

Kosovo is landlocked and located in the heart of the Balkan Peninsula in Southeast Europe, with a diverse climate and a high concentration of nectar-giving plants (Ibrahimi and Hajdari 2020). Kosovo offers good breeding circumstances; according to the Statistical Agency of Kosovo (ASK 2015), the number of beehives has steadily grown, resulting in higher production from year to year. In 2015, local output totaled 2,120 tons, an increase over the previous year's total of 1,568 tons (Rama, et al. 2022). Because bees collect nectar from flora within a 3-5 km radius, tracing the origin of honey can offer vital information about probable contamination of the region from where the honey production material derives is a useful indication for environmental pollution from hazardous metals. Honey can be utilized as an indication of metal pollution, particularly harmful contaminants, due to its bio accumulative capacity (Dizman, et al. 2020).

Honey is being promoted in Kosovo as a pure natural product. Although finding honey from the blooms of a single plant species, known as miofloral honey, is almost impossible, beekeepers understand the

major nectar sources of their region and frequently design crops to keep the really great ones distinct. As a consequence, chestnut honey, acacia honey, mountain honey, meadow honey, and other honeys may be found in markets (Mladenović and Simeonova 2014). The Codex Alimentarius standard (Codex Alimentarius Commission 2001) and the EU Honey Directive (Council Directive 2001/110 of the Council of the European Union, 2001) govern the standards for the identity and quality of honey. Kosovo wants to boost agri-food industry competitiveness in conformity with EU veterinary, phytosanitary, and food safety requirements. Consequently, the physicochemical and microbiological qualities of specific food items are evaluated in various ways (Rysha, et al. 2022,Kastrati, et al. 2021).

MATERIALS AND METHODS

Reagents and chemicals

Reagents and chemicals of analytical quality, as well as deionized distilled water, were employed throughout this investigation.

Sampling

A total of 26 samples of honey from semi-commercial producers were collected from 10 different towns in Kosovo between March and September 2022. Decan, Drenas, Skenderaj, Pristina, Peja, Obiliq, Fushe-kosove, Rahovec, Sharri, Ferizaji, and Shtime were chosen as example locations. The samples were collected in clean, washed plastic bottles and delivered to the laboratory for examination. A questionnaire was designed and filled during personal interviews with the owners to obtain information regarding herd size, geographical location, bees transportation, health state, honey numbers, and honey sell site. Honey samples were utilized in triplicate to create a valid and consistent data set, and their average results were assessed.

Physical analysis

The physical properties of several honey samples were evaluated soon after they arrived at the laboratory. All determinations were made using the AOAC (2000) procedures. In a nutshell, moisture content was calculated by subtracting the known weight of the honey sample from the determined weight of the whole solid after evaporating the liquid component of the honey sample on a hot plate. The International Honey Harmonized Methodologies Commission was used to analyze the physicochemical parameters electrical electrical conductivity (EC), free acidity (FA), moisture, ash, and dissolved solids content % (Juszczak, et al. 2009).

In summary, a digital pH-meter (HI 8314, Hanna Instruments, Italy) calibrated with pH 4 and 7 buffers was used to test pH and electric electrical conductivity. Titratable acidity was calculated as a percentage of lactic acid using the titrimetric technique. The conventional procedures were used to determine specific gravity, and electrical conductivity. Electric electrical conductivity is a characteristic that determines an ion's capacity to conduct an electric current between two electrodes. Titrimetric analysis was used to assess free acidity. The honey sample (10 g diluted with 75 mL of distilled water) is titrated with 0.1 N sodium hydroxide in the presence of phenolphthalein as an indicator in this procedure.

An ABBE refractometer 220 V BOE 32,400 Model RMT was used to evaluate moisture content. At a constant temperature of 20 °C, the refractive index of the sample was measured using a refractometer. The quantity of water (% m/m) was determined using a table based on the refractive index. If the index was not determined at 20°C, the temperature correction was applied, and the values were decreased to that temperature (JAOAC Official Method 52.729). Brix levels were calculated using the BRIX Method using a Refractometer -AABE Atago at a temperature of 20ºC, +/- 2ºC, and the results were read immediately on the instrument.

The color of the honey samples was analyzed using a spectrophotometer according to the Pfund scale according to the USDA categorization by measuring the absorbance at 560 nm and multiplying it by the factor 3.15 compared to the procedures of the Codex Alimentarius Commission Standards (2001). As a control, honey samples were evaluated against deionized water. To compare to the Sample result range, the absorbance of the sample is measured at 560 nm and multiplied by a factor of 3.15.

Chemical analysis

The nitrogen concentration (N) in honey samples was determined using the Kjeldahl (1983) technique, and crude protein content was calculated as N6.25 using the AOAC 969.37 method using a Kjeldahl Apparatus (FOSS Kjeltec 8420 autosampler

systems) (Magida Tabbara 2022). Whereas, according to the AOAC 920.181 method, Ash is assessed by using 10 g of honey sample and adding 10 mL warm distilled water, evaporation (100-300 °C), and Ash in an electrical furnace (Protherm) at 550 °C until Ash is complete.

The honey samples were collected and digested with two liters of concentrated nitric acid for mineral analysis. After adding one volume of perchloric acid, the contents were gently cooked on a hot plate before being vigorously heated until dry (about 12 ml). This digestive method makes no attempt to dissolve any silicate-based substance found in the samples. The digested materials were quantitatively transferred to a flask after cooling and diluted to 100 ml with deionized double distilled water before being filtered. The collected samples are homogenized and placed in another 10.0mL of 65% HNO3 and 1 mL of 35% H2O2 in the Teflon microwave tube (vessel) after mineralization and dilution, then placed in the microwave for mineralization of the samples. MPAES 4200 atomic absorption spectrophotometer (Microwave Plasma Atomic Emission) For mineral examination, spectroscopy with conventional burner, air-acetylene flame, and hollow cathode lamps was utilized as a radiation source.

Statistical analysis

The results were reported as the mean SD of three different determinations. The statistical tool SPSS 17.0 was used to analyze the data (SPSS Statistics for Windows, Version 17.0. SPSS Inc., Chicago, IL, USA).

RESULTS

Physical characteristics

Kosovo has a varied geographical location with hilly mountains, grassland regions, and meadows and mountains. In total, 26 samples of honey were utilized in Kosovo from March to September 2022, and they were spread over 10 distinct locations of the country. All of the farmers were originally farmers who produced honey for the local market or for sale inside Kosovo (different regions or municipality). First, the farmers were interviewed and questioned about the health benefits of the bees as well as the location in which they fed the bees. Six farmers out of the 26 interviewees had feed bees in difficult mountains, which are largely covered with tree and mountain flora. 7 out of 26 farmers are instructed that bees are always fed in grassland regions that dominate this sort of flower (*Vicia cracca*, V*. pannonica*, *Trifolium pratense*, *T. repens*, *T. medium*, *Medicago sativa*, *Robinia pseudoacacia*, *Helianthus tuberosus*, *Cardus crispus*, *Centaurea stoebe*, *Taraxacum officinale*, *Cirsium arvense*, *C. vulgare*, *Prunella vulgaris*, *Mentha longifolia*, *M. Aquatica*, *Ajuga reptans*, *Origanum vulgare*, *Teucrium montanum*, *T. chamaedrys*, *Sinapis alba*, *Malva sylvestris*, *Knautia arvensis*, *Verbascum thapsus*, *V, phlomoides*, *V. blattaria*, *Melampyrum pratensae*, *M. nemorosum*), however the remaining 13 out of 26 samples feed the bees in mixed areas such as grassland, steep mountains, and grasslands areas.

Moisture, total solids, pH, titratable acidity, Ash content, total proteins, electrical conductivity, and dissolved solids content % are significant metrics to consider while examining the physicochemical composition and nutritional aspects of honey. Table 1 displays the physical properties of the various honey samples gathered throughout Kosovo. The moisture content of the samples ranged from (15.0220%) to (18.802%). The lowest values were discovered in the Ferizaji municipality, where bees are departing between grassland areas and mountains, while the greatest values were discovered in the Sharri municipality, where the terrain is mountains with an ideal height of roughly 1200-1500 meters.

The dissolved solids content % concentration range at 20 ^{o}C ranged from (79.5±0.23 %) to (82.6±0.2 %), as shown in Table 1. The lowest values were observed in the Sharri area where the bees feed in the mountainous highlands (79.5±0.23)% followed by honey bees from the same places with the same feeding system, and the highest in the Prishtina municipality with a range of 82.6±0.2%.

The specific acidity and pH of all honey samples were determined to be 4.97±0.2 to 56.3±0.2 and 3.560±.2 to 5.60±.2, respectively (Table 1). All of the honey samples had minor differences in the two metrics. The changes in specific acidity and pH are considerable. The sample acidity and alkalinity of honey bees are determined by these two criteria.

Table 1. Chemical parameters of honeys in Kosovo.

Location	Moisture %	Brix % at 20ºC	Acidity mmol/kg	pH at 20ºC	Electrical conductivity μS cm^{-1} 20°C	Total proteins (1g/100g)	Ash content (%)
SH-1	16.8±0.1	81.8±0.01	25.7±0.01	4.53	652.5±2.5	0.35±0.01	0.32±0.01
SH-2	18.8±0.1	79.5±0.01	27.0±0.01	4.57	607.8±2.5	0.4±0.01	0.51±0.01
SH-3	18.0±0.1	79.5±0.01	36.8±0.01	3.89	419.7±2.5	0.23±0.01	0.04±0.01
SH-4	17.8±0.1	80.7±0.01	14.6±0.01	5.18	645±2.5	0.11±0.01	0.2±0.01
SH-5	16.4±0.1	82.2±0.01	36.2±0.01	3.86	254.9±2.5	0.33±0.01	0.08±0.01
PE-1	16.2±0.1	82.3±0.01	26.4±0.01	4.35	713.2±2.5	0.51±0.01	0.39±0.01
PZ-1	17.0±0.1	81.5±0.01	25.3±0.01	4.06	580.4±2.5	0.67±0.01	0.41±0.01
DE-1	18.0±0.1	80.5±0.01	27.4±0.01	5.06	1375.0±2.5	0.49±0.01	0.78±0.01
PR-1	18.0±0.1	80.5±0.01	4.97±0.01	4.03	41.22±2.5	0.34±0.01	0.01±0.01
ST-1	16.0±0.1	82.5±0.01	43.1±0.01	4.07	509.1±2.5	0.49±0.01	0.28±0.01
SK-1	16.2±0.1	82.3±0.01	47.4±0.01	4.15	488.0±2.5	0.5±0.01	0.31±0.01
SK-1	15.8±0.1	82.7±0.01	48.1±0.01	4.32	690.4±2.5	0.75±0.01	0.34±0.01
DR-1	18.2±0.1	80.2±0.01	8.28±0.01	3.77	59.42±2.5	0.35±0.01	0.37±0.01
DR-3	17.2±0.1	81.2±0.01	14.0±0.01	4.01	206.9±2.5	0.28±0.01	0.1±0.002
PR-2	15.8±0.1	82.6±0.01	42.0±0.01	4.45	640.8±2.5	0.47±0.01	0.47±0.01
OB-1	16.8±0.1	81.7±0.01	33.5±0.01	3.8	412.0±2.5	0.62±0.01	0.13±0.001
OB-2	18.2±0.1	80.2±0.01	33.2±0.01	3.69	389.6±2.5	1.84±0.01	0.13±0.002
OB-3	17.2±0.1	81.3±0.01	29.8±0.01	3.78	341.5±2.5	0.63±0.01	0.12±0.01
DR-2	16.6±0.1	81.9±0.01	15.7±0.01	3.81	194.4±2.5	0.36±0.01	0.09±0.01
RV-1	16.2±0.1	82.3±0.01	17.6±0.01	3.63	169.6±2.5	0.41±0.01	0.07±0.01
FK-1	17.8±0.1	80.7±0.01	20.2±0.01	3.77	284.2±2.5	0.87±0.01	0.02±0.001
FK-2	16.6±0.1	81.9±0.01	18.1±0.01	3.56	57.58±2.5	0.03±0.01	0.01±0.001
FZ-1	15.0±0.1	79.6±0.01	56.3±0.01	4.07	733.8±2.5	3.17±0.01	0.68±0.01
FZ-2	16.0±0.1	82.4±0.01	37.2±0.01	4.54	620.8±2.5	1.75±0.01	0.29±0.01
FZ-3	17.6±0.1	81.0±0.01	14.5±0.01	3.81	171.6±2.5	0.19±0.01	0.35±0.01
FZ-4	16.8±0.1	81.7±0.01	13.9±0.01	4.29	181.5±2.5	0.24±0.01	0.27±0.01

SH-Sharri, PZ-Prizren; PR-Prishtina, FZ-Ferizaj; OB-Obiliq, FK-Fushë Kosova, SK-Skenderaj, DR-Drenas. Each reading represents the mean standard deviation of three replicate studies.

Color Determination

The Pfund scale is a color grading method for honey that is used to identify its color. Wilbur L. Pfund invented it in the early twentieth century, and it is still frequently used today. The scale goes from 0 to 140, with 0 being the lightest and 140 representing the darkest. A honey sample is placed in a Pfund color grader, which is a glass tube about 5 inches long and 1 inch in diameter, to determine the hue of honey using the Pfund scale. The honey is next tested against a set of colored glass standards ranging from water white to dark amber.

The quantity of light that goes through the sample in relation to the colored glass standards determines the hue of the honey. The Pfund scale is based on the honey sample's light absorption, with darker honey absorbing more light than lighter honey. Water white or very light amber honey is honey that

falls between 0 and 34 on the Pfund scale. Honey in the 35-50 range is light amber, whereas honey in the 51-85 range is medium amber. Honey in the 86-114 range is dark amber, while honey in the 115-140 range is very dark amber or virtually black.

The color of honey may be impacted by a number of factors, including the nectar source, the age of the honey, and the beekeeper's processing processes. Lighter honey is often thought to have a gentler flavor, but darker honey is more powerful and may have a stronger flavour. Several color grading schemes, in addition to the Pfund scale, can be used to identify the hue of honey. The USDA color grading system, which goes from Grade A (light) to Grade C (dark), and the European Commission color grading system, which goes from Extremely White to Dark, are two examples.

The honey samples collected at Sharri had a Pfund interval of 24.58 - 33.129 mm. This signifies that the honey collected in Sharri is white in hue. The mean interval of the honey samples collected in Prishtina was a Pfund interval of 13.074 - 38.32 mm. This signifies that honey from the Prishtina region is particularly light white and extra white. The honey samples collected in the Prizren area are white in hue.

The honey samples collected at Ferizaj had a Pfund interval of 22.73 - 38.32 mm. This signifies that the honey gathered in the Ferizaj area is white or extremely light white in hue. The honey samples obtained at the Obiliq area had a Pfund interval of 28.3 - 30.53 mm. This signifies that the honey collected in the Obiliq area is white. The mean spacing of the honey samples collected in Fushe-Kosovo a Pfund interval of 30.52 - 35.72 mm. This signifies that the honey obtained in the Fushe-Kosovo region is white or extremely light white in hue.

The mean interval of the honey samples collected at Skenderaj had a Pfund interval of 13.074 - 30.158 mm. This signifies that the honey gathered from the Skenderaj site is white and exceptionally white in hue. The honey samples collected in the Drena area had a Pfund interval of 33.87 - 36.1 mm. This signifies that the honey gathered in the Drena area is white or especially light white in hue.

Chemical components

The honey samples were analyzed for several chemical components, including total proteins, ash, and mineral elements (Na, Ca, K, Mg, Mn, Fe, Cu, and Zn), as shown in Table 3. We attempted to analyze Cr, As, Pb, and Cd but were unable to do so since the levels were below the detection limit. The chemical properties of the samples differed significantly, and each sample excelled in one or more areas. The amount of total protein was found to be in the range of (0.03±0.001%) to (3.17±0.02%). Most of the samples has the lowest range (17 samples) until 0.5, other groups until 1g/100g are 6 samples and 3 honey samples are more then 1g/100g and that are; 1.75, 1.84 and 3.17, respectively (Table 3).

Similarly, the ash content range are slightly significant and between (0.01±0.01%) to (0.78±0.02%). The lowest values are coming from Prishtina municipality 0.01±0.01% while the highest from Decani municipality 0.78±0.02%. The lowest level of ash contains are coming from are where bees located on the grasslands area (area combined with the meadows and several type of flowers) while the highest level are from the area which bees are feedings from hilly mountains (combined with mountains, grasslands area located with trees).

The concentration of Na is in range (170.03±0.001 mg/kg) to (600.00±0.02 mg/kg) and concentration of Mn it was differently. 3 out of 26 samples was not detected, 3 below 0.1 and others are in range (0.11±0.001%) to (18.2±0.02%).

Table 2. The determination color of honey based on a Pfund scale.

Location	USDA colour Standard designation	Color scale,Pfound (mm)
SH-1	White	33.129
SH-2	White	32.015
SH-3	White	30.27
SH-4	White	24.58
SH-5	White	31.272
PE-1	White	21.987
PZ-1	White	26.44
DE-1	White	32.75
PR-1	Extra light white	38.32
ST-1	White	22.73
SK-1	White	30.158
SK-1	Extra white	13.074
DR-1	Extra light white	36.1
DR-3	white	34.98
PR-2	Extra white	13.074
OB-1	White	28.67
OB-2	White	28.3
OB-3	White	30.53
DR-2	White	33.87
RV-1	Extra light white	41.67
FK-1	White	30.52
FK-2	Extra light white	35.72
FZ-1	white	22.73
FZ-2	white	33.129
FZ-3	Extra light white	38.32
FZ-4	White	29.043

SH-Sharri, PZ-Prizren; PR-Prishtina, FZ-Ferizaj; OB-Obiliq, FK-Fushë Kosova, SK-Skenderaj, DR-Drenas

Compared to Na and Mn, higher significant differences were found in K. The range of K are in range concentration of K was detected on honey and in range of (19.4±0.001 mg/kg) to (1898.00±0.02 mg/kg).

Concentration of Ca was found to be (89.2±0.001 mg/kg) to (295.7±0.02 mg/kg). The lower level was shown from honey which bees has feed in grasslands are while highest are in Obiliq municipality indicated for grasslands and contaminated area. Level of Mg variate in range (5.05±0.001 mg/kg) to (97.9±0.02 mg/kg). There are significant differences between the lower level and the higher level, 92.85 mg/kg being the highest level.

Table 3. Concentration of heavy metals (mg/kg) in honey samples from Kosovo.

Location code	Zn 213.857 nm	Ca 430.253 nm	Fe 371.993 nm	Cu 324.754 nm	K 769.897 nm	Mg 383.829 nm	Mn 403.076 nm	Na 589.592 nm	Description
SH-1	2.44	183.2	0.4	0.28	1719	53.4	2.28	600	Hilly-mountainous
SH-2	3.24	227.3	n.d.	<0.1	1642	50.7	1.99	516	Hilly-mountainous
SH-3	3.19	207.5	n.d.	0.17	1050	37.6	1.34	446	Hilly-mountainous
SH-4	3.37	121.3	n.d.	0.55	1739	28.6	1.25	388	Hilly-mountainous
SH-5	4.05	217.6	n.d.	0.52	631	26.4	0.66	558	Hilly-mountainous
PE-1	5.34	289	1.19	0.44	1898	64.5	3.33	251	Hilly-mountainous
PZ-1	3.16	256	0.55	0.31	1406	57.1	3.53	366	Grassland
DE-1	6.17	459.7	1.06	0.2	3484	43.5	11.4	765	Hilly-mountainous
PR-1	2.24	145.8	n.d.	n.d.	19.4	5.81	n.d.	409	Grassland
ST-1	4.64	326.6	1.89	0.28	1197	82.3	7.29	554	Hilly-mountainous
SK-1	4.22	186.8	0.19	0.25	1201	43.1	3.15	415	Mixed
SK-1	3.45	136.4	0.39	0.39	1759	102	10	190	Mixed
DR-1	2.28	146.4	n.d.	n.d.	33.2	13.4	n.d.	298	Mixed
DR-3	5.09	127.8	1.89	n.d.	265	29.6	1.19	362	Mixed
PR-2	3.53	261.3	1.74	0.37	1764	76.2	3.66	345	Grassland
OB-1	3.64	144	2.8	n.d.	807	39.5	2.99	153	Grassland
OB-2	3.58	181.3	3.46	0.05	765	46.4	3.71	290	Grassland
OB-3	3.89	295.7	n.d.	n.d.	638	45.2	0.11	457	Grassland
DR-2	3.71	196.9	1.58	n.d.	278	43.3	1.04	428	Mixed
RV-1	4.51	112.4	n.d.	n.d.	293	9.98	<0.1	352	Grassland
FK-1	3.32	149.8	0.03	n.d.	429	19	<0.1	326	Grassland
FK-2	3.01	89.2	n.d.	n.d.	22.3	5.05	n.d.	171	Grassland
FZ-1	6.2	234.1	0.98	0.58	1739	97.9	13.4	469	Mixed
FZ-2	3.41	184	1.61	0.7	1532	139	18.2	321	Mixed
FZ-3	3.84	116	22.37	n.d.	356	10.5	<0.1	252	Mixed
FZ-4	3.44	166.1	n.d.	0.64	457	21.6	1.75	354	Mixed

Level of Cu in 10 out of 26 samples was not able to detect, 1 sample was below 0.1 and others are in range (0.17.03±0.001) to (0.58±0.02). Concentration of Fe in honey level it was different. Total 10 out of 26 samples not able to detect, while others are in range (0.19±0.001) to (22.37±0.02). The result indicates significant differences because differences level is 22.18mg/kg. Higher level of Fe is shown from one sample in capital of Kosovo-Pristina, Ferizaj, Obilic and Peja.

The level of Zn is detected to all of the samples and significant differences it ranges from (2.44±0.001) to (6.2±0.02) mg/kg. highest level was from Decani municipality from where bees are feed from hilly mountains included different trees.

DISCUSSION

The results of this study provide valuable insights into the physical characteristics and chemical composition of honey samples collected from various regions in Kosovo. The discussion section will delve into the implications of these findings, their significance in the context of honey production, and potential implications for consumer health. One of the noteworthy observations from this study is the geographical variation in honey characteristics across different regions of Kosovo. Kosovo's diverse topography, comprising hilly mountains, grassland regions, and meadows, significantly influences the composition of honey. This variation can be attributed to the differing flora and foraging patterns of bees in these regions.

The moisture content of honey is a crucial parameter as it impacts its shelf life and overall quality. In this study, honey samples from various regions of Kosovo exhibited moisture content ranging from 15.02% to 18.80%. Notably, honey from the Ferizaji municipality, characterized by bees foraging in grassland areas and mountains, had the lowest moisture content. Conversely, honey from the Sharri municipality, where bees forage in mountainous terrains, had the highest moisture content. The variation in moisture content can be attributed to environmental factors, such as humidity levels and temperature, which affect the rate of water evaporation in nectar. Lower moisture content is generally desirable as it contributes to the preservation of honey. However, excessively low moisture content can result in crystallization, impacting the honey's texture and appearance. Therefore, beekeepers in regions with higher moisture content may need to employ strategies to reduce moisture levels.

The standard moisture content in honey is around 17-18%, but it can vary based on several factors, including environmental conditions, floral sources, and harvesting methods. If the moisture content is too high (above 20%), the risk of fermentation and spoilage increases, leading to a reduced shelf life and undesirable flavor changes. On the other hand, honey with excessively low moisture content (below 16%) tends to crystallize rapidly, affecting its texture and making it less appealing to consumers (Keckes, et al. 2013).

The dissolved solids content of honey is closely related to its sweetness and nutritional value. In this study, the concentration of dissolved solids ranged from 79.5% to 82.6%. Honey from the Sharri municipality had the lowest dissolved solids content, whereas honey from the Prishtina municipality had the highest. The variation in dissolved solids content may be attributed to the diversity of nectar sources available to bees in different regions. Bees foraging in areas with a wide variety of floral sources may produce honey with higher dissolved solids content, resulting in a richer flavor profile. Understanding these variations is essential for beekeepers seeking to market honey with specific taste profiles.

The pH and acidity of honey are critical parameters that influence its taste and stability. The honey samples in this study exhibited pH values ranging from 3.56 to 5.60 and specific acidity values ranging from 4.97 to 56.3. While these values remained within acceptable ranges for honey, it is essential to note that even minor differences in pH and acidity can significantly impact flavor and shelf life. The observed variations in pH and acidity can be attributed to differences in the nectar sources and bee foraging behaviors across the regions. Honey from areas with a prevalence of specific types of flowers may exhibit distinct pH and acidity profiles, leading to unique flavor characteristics. Beekeepers may consider these variations when marketing honey for specific culinary or medicinal purposes.

The pH of honey typically falls in the range of 3.2 to 4.5, making it acidic in nature. This low pH contributes to honey's long shelf life by inhibiting the growth of many microorganisms. Honey's natural acidity also lends to its distinct flavor profile. The specific pH value of a honey sample can vary based on several factors, including the floral sources bees forage from and the geographical region of production (Annamaria Perna 2013).

Honey color is a prominent attribute that influences consumer preferences and marketability. In this study, the Pfund scale was used to determine honey color, with the results indicating variations across different regions of Kosovo. Honey from the Sharri, Prishtina, and Prizren municipalities exhibited white to extra white hues, while honey from Ferizaj, Obiliq, and Fushe-Kosovo regions ranged from white to extremely light white. Skenderaj and Drena regions also produced honey with exceptionally light white hues. These variations in honey color can be attributed to several factors, including the types of flowers and plants visited by bees, the age of the honey, and the beekeeping practices employed. Consumers often associate lighter honey with milder

flavors, while darker honey is perceived as having a more robust taste. Beekeepers can leverage these color variations to cater to different consumer preferences.

The chemical composition of honey, including its total protein, ash content, and mineral elements, provides insights into its nutritional value and potential health benefits.

Total protein content in honey is relatively low, typically ranging from 0.03% to 3.17%. Most honey samples in this study fell within the lower end of this range, with 17 samples containing less than 0.5g of total protein per 100g of honey. Only six samples had protein content between 0.5g and 1g per 100g, while three samples had protein content exceeding 1g per 100g. The variation in total protein content can be attributed to the diversity of nectar sources. Honey produced from the nectar of certain plants may have higher protein content. While honey is not a significant source of dietary protein, it may still contribute to overall nutrient intake.

In the different studies, the total protein content in honey is relatively low compared to other components like sugars and water. The protein content typically ranges from 0.02% to 0.5% of honey's total composition, making it a minor but significant fraction (Pasupuleti, et al. 2017).

The ash content of honey, which ranged from 0.01% to 0.78%, reflects the presence of mineral elements in the honey. Honey from Prishtina had the lowest ash content, while honey from Decani exhibited the highest. The ash content is influenced by both the floral sources of nectar and the geographical characteristics of the regions. Honey produced in grassland areas, where mineral-rich soil may be more prevalent, could exhibit higher ash content. Understanding these variations can help beekeepers and consumers make informed choices based on their nutritional preferences. The ash content of honey is a significant aspect of its composition, representing the inorganic mineral and trace element content. Ash content typically accounts for a small fraction of honey, generally ranging from 0.02% to 0.5% (da Silva, et al. 2016).

The presence of various mineral elements in honey, including sodium (Na), manganese (Mn), potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe), and zinc (Zn), contributes to its nutritional value. Sodium content in honey ranged from 170.03mg/kg to 600.00mg/kg, reflecting differences in the mineral composition of the regions. Similarly, manganese levels varied, with some samples exhibiting concentrations below 0.1mg/kg and others ranging from 0.11% to 18.2mg/kg. Potassium levels exhibited significant differences, with concentrations ranging from 19.4mg/kg to 1898.00mg/kg. These variations may be attributed to the types of plants and soil compositions in the respective regions. Calcium content ranged from 89.2mg/kg to 295.7mg/kg, with lower levels observed in honey produced in grassland areas and higher levels in honey from regions with hilly terrain.

Magnesium levels varied between 5.05mg/kg and 97.9mg/kg, with some regions exhibiting substantial differences. The highest magnesium levels were observed in a sample, highlighting the potential impact of geological factors on mineral content. Copper levels varied, with ten samples showing concentrations below detection limits and others ranging from 0.17mg/kg to 0.58mg/kg. Iron content displayed significant differences, with concentrations ranging from 0.19mg/kg to 22.37mg/kg. Higher iron levels were observed in several samples, with notable concentrations in the capital city of Pristina and other regions.

Zinc levels ranged from 2.44mg/kg to 6.2mg/kg, with the highest levels detected in honey produced in the Decani municipality. The variations in mineral elements can be attributed to the specific geological and environmental conditions in each region. Soil composition, mineral deposits, and plant diversity all play roles in influencing the mineral content of honey. Consumers seeking honey with specific mineral profiles can use this information to make informed choices.

It is important to acknowledge some limitations of this study. The sample size, while representative of various regions in Kosovo, is relatively small. Future research with a larger sample size could provide more comprehensive insights into geographical variations in honey characteristics. Additionally, the study did not investigate the potential health benefits associated with these variations in honey composition. Further research could explore the nutritional and medicinal properties of honey from different regions in Kosovo.

Conclusion

In conclusion, the study conducted in Kosovo provides valuable information on the physicochemical properties and nutritional aspects of honey gathered from different locations in the

country. The results indicate that the physical and chemical properties of honey vary depending on the region where the bees feed and the geographical characteristics of that area. The study found that the moisture content, dissolved solids content % concentration, acidity, and pH of honey vary from region to region, and the Pfund scale is used to determine the color of honey in Kosovo. The color of honey is affected by various factors, including the nectar source, age of the honey, and beekeeper's processing methods. The study also shows that honey collected from Sharri is white in color, while honey from Prishtina is particularly light white and extra white. The results of the study can be used to support local beekeepers in producing high-quality honey with good nutritional value.

Overall, the study highlights the importance of understanding the properties of honey from different regions to determine its nutritional value and quality. It also emphasizes the significance of local beekeepers who play a crucial role in maintaining the bee population, producing honey, and preserving the environment. By supporting these beekeepers, we can not only ensure the availability of high-quality honey but also contribute to environmental conservation efforts. The study provides a starting point for future research that can explore further the factors that affect the physicochemical properties and nutritional value of honey in Kosovo and other regions.

Authors' contributions: The authors made an equal contribution to this study. They collaborated on study design, data collection and analysis, manuscript composition, and revision.

Conflict of interest: The authors declare that they have no conflicts of interest to be reported.

Data availability: All data and materials utilized and/or analyzed during the current study are accessible within this manuscript.

Ethical issue: Not applicable, as this study pertains to honey and does not involve animals or humans.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Source of Finance: Not applicable, as there is no funding source for this study.

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