Citation: Çaçan E, Kutlu MA, Uçar R, Özdemir S, Kökten K, Mokhtarzadeh S, Ekmekçi M. Comparison of honey, pollen and propolis amounts and honey quality obtained from bee pasture and highland. U. Arı D. / U. Bee J. 2023, 23(2):190-201 DOI: 10.31467/uluaricilik.1344339

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

COMPARISON OF HONEY, POLLEN AND PROPOLIS AMOUNTS AND HONEY QUALITY OBTAINED FROM BEE PASTURE AND HIGHLAND

Arı Merası ve Yayladan Elde Edilen Bal, Polen ve Propolis Miktarları ile Bal Kalitesinin Karşılaştırılması

Erdal ÇAÇAN[1]*, Mehmet Ali KUTLU[1], Rıdvan UÇAR[2], Selim ÖZDEMİR[1], Kağan KÖKTEN[3], Sam MOKHTARZADEH[4], Muammer EKMEKÇİ[5]

[1]Department of Crop and Animal Production, Vocational School of Food, Agriculture and Livestock, Bingol University, Bingol, TÜRKİYE, Yazışma Yazarı / Corresponding author E-posta: ecacan@bingol.edu.tr, ORCID No: 0000-0002-9469-2495, E-posta: makutlu@bingol.edu.tr, ORCID No: 0000-0003-0862-9690, E-posta: sozdemir@bingol.edu.tr, ORCID No: 0000-0003-1840-9907

[2]Department of Field Crops, Faculty of Agriculture, Pamukkale University, Denizli, TÜRKİYE, E-posta: rucar@pau.edu.tr, ORCID No: 0000-0001-6365-7200

[3]Department of Plant Production and Technologies, Faculty of Agricultural Sciences and Technology, Sivas University of Science and Technology, Sivas, TÜRKİYE, E-posta: kkokten@bingol.edu.tr, ORCID No: 0000-0001-5403-5629

[4]Department of Field Crops, Faculty of Agriculture, Düzce University, Düzce, TÜRKİYE, E-posta: sam.mokhtarzadeh@gmail.com, ORCID No: 0000-0002-3927-0855

[5]Agricultural Application and Research Center, Bingol University, Bingol, TÜRKİYE, E-posta: mekmekci@bingol.edu.tr, ORCID No: 0000-0002-0610-8552

Geliş Tarihi / Received:16.08.2023 Kabul Tarihi / Accepted: 07.10.2023 DOI: 10.31467/uluaricilik.1344339

ABSTRACT

This study was carried out to determine the honey, pollen and propolis amounts and honey qualities obtained from the bee pasture established in Bingöl University between the years 2021-2022 and highland and to compare the bee pasture and the highland in terms of these characteristics. 10 beehives were used in the study. Five beehives were left in the bee pasture, and 5 of them were taken to the highland for comparison. The quantities of honey, pollen, and propolis per hive and the moisture, diastase, HMF, commercial glucose, C13 sugar, C4 sugar, and the difference between raw protein in honey and delta C13 sugar of honeys were determined for both locations. These quality parameters obtained were evaluated according to the Turkish Food Codex Honey Communiqué. As a result of the research, it was determined that there was no statistical difference between the amounts of pollen and propolis obtained from the bee pasture and the highland, and the amount of honey obtained from the highland was higher than the bee pasture. In addition, it has been determined that the honey obtained from both bee pasture and highland is at the "appropriate" level in terms of the limit values determined by the Turkish Food Codex Honey Communiqué in terms of quality criteria. In the light of these data, it has been understood that although the honey yield from bee pasture is low, it is sustainable and can be an alternative to migratory or highland beekeeping.

Keywords: Bee pasture, Honey yield, Honey quality, Settled beekeeping, Migratory beekeeping

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

ÖZ

Bingöl Üniversitesi bünyesinde 2021-2022 yılları arasında kurulan arı merası ile yayladan elde edilen bal, polen ve propolis miktarları ile bal kalitesinin belirlenmesi ve bu özellikler açısından arı merası ile yaylanın karşılaştırılması amacıyla bu çalışma yürütülmüştür. Araştırmada 10 adet arı kovanı kullanılmıştır. Arı kovanlarından 5 tanesi arı merasında bırakılmış, beş tanesi de karşılaştırma yapmak amacıyla yaylaya çıkarılmıştır. Her iki lokasyona ait kovan başına bal, polen ve propolis miktarları elde edilmiş ve yine her iki lokasyona ait balların nem, diastaz, HMF, ticari glikoz, C13 şekeri, C4 şekeri ve balda protein ile ham bal delta C13 şekeri arasındaki fark tespit edilmiştir. Elde edilen bu kalite parametreleri Türk Gıda Kodeksi Bal Tebliği'ne göre değerlendirilmiştir. Araştırma sonucunda arı merası ve yayladan elde edilen polen ve propolis miktarları arasında istatistiksel bir fark olmadığı, yayladan elde edilen bal miktarının arı merasından daha yüksek olduğu ve yine hem arı merası hem de yayladan elde edilen balların kalite kriterleri açısından Türk Gıda Kodeksi Bal Tebliği'nin belirlediği sınır değerler açısından "uygun" seviyede oldukları belirlenmiştir. Bu veriler ışığında arı merasından elde edilen bal veriminin düşük olmasına rağmen sürdürülebilir olduğu ve yayla arıcılığına ya da gezginci arıcılığa alternatif olabileceği sonucuna varılmıştır.

Anahtar kelimeler: Arı merası, Bal verimi, Bal kalitesi, Sabit arıcılık, Gezginci arıcılık

GENİŞLETİLMİŞ ÖZET

Amaç: Araştırmada gezginci arıcılık ile sabit arıcılıktan elde edilen bal, polen ve propolis miktarları ile bal kalitesinin belirlenmesi ve bu özellikler açısından gerek arı merasının gerekse de yaylanın karşılaştırılması amacıyla bu çalışma yürütülmüştür.

Gereç-Yöntem: Araştırma Bingöl Üniversitesi bünyesinde 2021-2022 yılları arasında kurulan arı merasında ve Bingöl il merkezi sınırları içerisinde yer alan Hasarek dağında (yayla) yürütülmüştür. Araştırmada 10 adet Langstroth tipi ahşap arı kovanı kullanılmıştır. Kolonilerin ana arıları Anadolu ekotipi ana arıları ile değiştirilmiştir. 2021 ve 2022 yıllarında bu arı kovanlarından 5 tanesi arı merasında bırakılmış, beş tanesi de karşılaştırma yapmak amacıyla Haziran ayının ilk haftasında yaylaya çıkarılmıştır. Her iki lokasyonda ve her iki yılda da ağustos ayında bal hasadı yapılmıştır. Yayladan ve arı merasından elde edilen bal miktarları kg, polen ve propolis miktarları ise g olarak tartılarak koloni başına ortalama bal, polen ve propolis verimleri elde edilmiştir. Ayrıca yayladan ve arı merasından elde edilen balların kalite özelliklerinden nem, diastaz, HMF (hidroksimetilfurfural), ticari glikoz, C13 ve C4 şekerleri ile balda protein ve ham bal delta C13 şekeri arasındaki fark tespit edilmiştir.

Arı merasında elde edilen balların kalitesini belirlemeye yönelik bu analizler, Bingöl Üniversitesi Merkezi Laboratuvar Uygulama ve Araştırma Merkezinde yapılmıştır. HMF analizi için IHC (Ch. 5.1), diastaz sayısı için TS 3036, nem içeriği için TS 13365, ticari glikoz için TS 3036, C13 ve C4 şekerleri ile balda protein ve ham bal delta C13 şekeri arasındaki fark için ise AOAC 998.12 analiz yöntemleri esas alınarak sonuçlar elde edilmiştir. Arı merası ve yayladan alınan ballarda tespit edilen nem, diastaz, HMF, ticari glikoz, C13 ve C4 şeker içerikleri ile balda protein ve ham bal delta C13 şekeri arasındaki fark, Türk Gıda Kodeksi Bal Tebliği'ne göre "uygun" seviyelerde olup, olmadığı değerlendirilmiştir. Yayladan ve arı merasından elde edilen verilere varyans analiz uygulanmış ve aralarındaki fark 0.05 seviyesinde LSD testi ile karşılaştırılmıştır.

Bulgular ve Sonuç: Araştırma sonucunda arı merası ve yayladan elde edilen polen ve propolis miktarları arasında istatistiksel bir fark olmadığı, yayladan elde edilen bal miktarının arı merasından, 2022 yılında elde edilen bal miktarının ise 2021 yılına göre istatistiksel olarak daha yüksek olduğu belirlenmiştir. Bal verimi açısından yıllar arasında ortaya çıkan bu farklılığın, 2021 yılında yaşanan kuraklıktan ileri geldiği ön görülmektedir. Balın kalite kriterleri açısından ise sadece C13 şekerinin arı merası ve yayla ile yıllar arasında istatistiksel olarak bir farklılık gösterdiği, diğer parametrelerin ise istatistiksel bir farklılık göstermediği belirlenmiştir.

Hem arı merası hem de yayladan elde edilen balların kalite kriterleri açısından Türk Gıda Kodeksi Bal Tebliği'nin belirlediği sınır değerler açısından "uygun" seviyede oldukları belirlenmiştir. Elde edilen veriler ışığında arı merasından elde edilen bal veriminin düşük olmasına rağmen sürdürülebilir

olduğu ve yayla arıcılığına ya da gezginci arıcılığa alternatif olabileceği sonucuna varılmıştır.

INTRODUCTION

As in many parts of the world, beekeeping has been practiced in Bingöl province of Türkiye for thousands of years. Bingöl province has a rich plant species diversity (Iranian-Turanian flora) due to its geographical location and creates a suitable potential for beekeeping (Sandal and Kan, 2013).

Beekeeping activities in Bingöl and its surroundings are generally carried out in the form of migratory beekeeping. In order not to be affected by colony losses, beekeepers overwinter their bees in Çukurova and similar places, and they come back to Bingöl and its surroundings at the end of April and the beginning of May. Beekeepers who spend the month of May in and around Bingöl take their beehives to the highlands in early June, before the main nectar flow, and they harvest honey in August. In general, beekeeping activities in the region are shaped on this method. This structure makes it impossible to do beekeeping for hobby purposes, to carry out beekeeping activities that will provide a livelihood in the rural area where the producer lives, or to engage in beekeeping activities for women entrepreneurs who are disadvantaged in the region. Because people in this situation do not have the opportunity to spend the winter in the Çukurova region, the spring in Bingöl and its surroundings, and the summer in the highlands.

In a study carried out in Bingöl, it was reported that 84% of beekeeping activities are carried out by migratory and 16% are settled and 78% of beekeepers engaged in migratory beekeeping activities have accommodation problems (Söğüt et al. 2019). Therefore, when a solution is sought for the problems of beekeepers in the region, it comes to the fore that priority should be given to finding solutions to problems directly related to accommodation or creating alternatives to migratory beekeeping. It is also obvious that migratory beekeeping is much more costly than settled beekeeping, as beekeepers have to stay in multiple places throughout the year and eventually migrate. In order to offer a solution to these problems, a bee pasture was established in Bingöl University research area between 2019-2022 (Project No: PİKOM-Bitki.2019.001) and an example of settled beekeeping activities was created as an alternative to migratory beekeeping. Within the scope of this study, bee products obtained from this bee pasture were compared with bee products obtained from migratory beekeeping.

According to 2022 statistics, there were 95.386 beekeeping enterprises in Turkey, and they produce 118.297 tons of honey annually with 8.984.676 hives. In the province of Bingöl, there were 1.033 beekeeping enterprises, and these enterprises produce 161.009 hives and 1.488 tons of honey annually (TUIK 2023). In the light of this information, when the amount of honey obtained was divided by the number of hives, it turns out that the honey yield per hive in Turkey was 13.16 kg, and the honey yield per hive in Bingöl was 9.24 kg. In a study conducted in Bingöl province, 87 beekeeping enterprises were handled, and it was reported that the average honey yield of the enterprises was 11.1 kg/colony (Söğüt et al. 2019).

It is seen that pH, moisture, acidity, HMF, diastase, proline, glucose, commercial glucose, fructose, sucrose, fructose/glucose, fructose + glucose, C4 sugar, protein in honey and "difference between raw honey delta C13 values" are considered as quality criteria of honey obtained in Türkiye (Çetin et al. 2011; Kutlu and Bengü, 2015; Karahan Yılmaz and Eskici, 2017; Bengü and Kutlu, 2018; Çiftçi and Parlat, 2018; Yaşar and Söğütlü, 2020; Gültekin Özgüven et al. 2020).

These previous studies generally focused on determining the quality characteristics of honey obtained from certain regions or organizations. The difference of current study from the other studies is that it presents a comparison between honey, pollen, propolis quantities and honey quality characteristics obtained from the traditional migratory beekeeping (highland beekeeping) in the region and honey, pollen, propolis quantities and honey quality characteristics obtained from bee pasture which is an alternative to migratory beekeeping.

In the light of this information, the aim of this study is to determine the honey, pollen and propolis yields and quality characteristics of honey obtained from bee pastures and highland and to compare migratory beekeeping and settled beekeeping in terms of these characteristics.

MATERIALS AND METHODS

Materials

The research was carried out in the bee pasture (38°, 48', 46" N, 40°, 32°, 26" E and 1078 meters altitude) located in the Bingöl University Agricultural Research and Application Center, and the highland area of the province of Bingöl, the Hasarek ski resort (38°, 53', 21" N, 40°, 17', 13" E and 1911 meters altitude) in 2021 and 2022.

The bee pasture consists of 10 decares and rapeseed, Hungarian vetch, sainfoin, thyme, basil, white clover, sage, buckwheat and lavender were sown and planted in the pasture area during the year. Rapeseed and Hungarian vetch were grown without irrigation and other plants were grown with irrigation conditions. When selecting the plants used in the bee pasture, care was taken to select species adapted to the region and to ensure a continuous flowering environment in the pasture from April to October. In addition, it was ensured that the plants were species that could be utilized after the flowering stage. For example, the residues of rapeseed, sainfoin and Hungarian vetch after flowering can be used as fodder plants, while other species can be used as medicinal and aromatic plants. In the research, 10 Langstroth type wooden beehives were used as material. The queen bees of the colonies were replaced with the Anatolian ecotype queens and the maintenance, control and fight against diseases/pests of the colonies were carried out periodically.

In the province of Bingöl, where the research was conducted, the annual average temperature value for many years is 12.3 °C. In January and February, the average temperature is below zero, and July and August are the hottest months. The average temperature was recorded as 14.2 °C in 2021 and 13.4 °C in 2022, when the research was conducted. The average annual total precipitation of Bingöl province for many years is 932 mm. The most precipitation is received during the winter months. July and August are the months with the least rainfall. The average precipitation amount was recorded as 668 mm in 2021 and 830 mm in 2022, when the research was conducted. It has been recorded that 2021 and 2022 are hotter and drier than the long-term average (MGM 2023).

Methods

Ten beehives were used in the study. In 2021 and 2022, five beehives were left in the bee pasture and five of them were taken to the highland in the first week of June in order to make comparisons. In both locations, honey harvest was done on 06.08.2021 in 2021 and on 15.08.2022 in 2022. The average honey yield per colony was determined by weighing the amount of honey obtained from the highland and bee pastures in kg. Pollen traps attached to the front of the hive were used to obtain pollen. Pollens obtained daily were stored on the hive basis and weighed. Propolis production was obtained with the help of a propolis grid attached to the colonies. Propolis production continued until October. In the last week of October, the propolis in the propolis grids were kept in the deep freezer for 12 hours, a large part of the plastic grid was bent, the remaining small part was excavated, and the colony yield was calculated by weighing.

The difference between moisture, diastase, HMF (hydroxymethylfurfural), commercial glucose, C13 and C4 sugars, protein in honey and delta C13 sugar in raw honey was determined from the quality properties of honey obtained from highland and bee pastures. These parameters were also used by Bengü and Kutlu (2018) to determine the quality criteria of honey. Analyses to determine the quality of honey obtained from bee pasture and highland were done at Bingöl University Central Laboratory Application and Research Center. IHC (Ch. 5.1) for HMF analysis, TS 3036 for diastase number, TS 13365 for moisture content, TS 3036 for commercial glucose, AOAC 998.12 to determine the difference between C13 and C4 sugars in honey and protein in honey and delta C13 sugar in raw honey, analysis methods used and the results were obtained.

Moisture, diastase, HMF, commercial glucose, C13-C4 sugar contents and "the difference between protein in honey and raw honey delta C13 sugar" detected in honey from bee pasture and highland were evaluated according to the Turkish Food Codex Honey Communiqué. According to the Turkish Food Codex Honey Communiqué, the quality criteria that flower honeys should have are given in Table 1 (TGKBT, 2020).

Statistical Evaluation

Variance analysis was applied to the data obtained from the highland and bee pasture, and the difference between them was compared with the Student's t-test at the 0.05 level (JMP 2018).

Table 1. According to the Turkish Food Codex Honey Communique, the quality criteria that flower honey must have

HMF (mg kg^{-1})	Max. 40 mg kg^{-1}
Moisture (%)	Max. %20
Diastasis (piece)	Min. 8 number
Commercial Glucose (%)	Negative (Shouldn't be)
C4 sugar (%)	Max. %7
C13 sugar (%)	-23 and more negative
Difference between protein in honey and delta C13 sugar in raw honey	-1.0 or more positive

RESULTS

Honey, pollen and propolis yields from bee pasture and highland

The amounts of honey, pollen and propolis taken from beehives in bee pasture and highland were given in Table 2. In 2021 and 2022, the amounts of honey, pollen and propolis obtained from bee pasture and highland did not show a statistical difference. However, in terms of years, only the amount of honey obtained in 2022 was statistically higher than in 2021, and in terms of bee pasture/highland, only the amount of honey obtained from the highland was statistically higher than the amount of honey obtained from the bee pasture.

Table 2. Amounts of honey, pollen and propolis per hive taken from beehives left on bee-pasture and highland in 2021 and 2022

	2021		2022		Year Average		Pasture/Highland Average	
	Pasture	**Highland**	**Pasture**	**Highland**	**2021**	**2022**	**Pasture**	**Highland**
Honey (kg)	5.41±0.4	5.58±0.8	6.46±1.1	13.98±3.4	5.50±0.6 B**	10.22±4.6 A	5.94±0.9 B*	9.78±5.0 A
Pollen (g)	272±38.3	293±19.8	282±45.4	316±39.1	283±30.8	299±43.8	277±10.1	305±31.6
Propolis (g)	17.4±4.3	21.3±6.4	16.3±2.1	17.3±2.5	19.4±5.6	16.8±2.28	16.9±3.3	19.3±5.1

The averages shown with the same letter are not different from each other within the error limits of *: P≤0.05 **: P≤0.01 according to the Student's t-test.

In this study, an average of 5.50 kg honey, 283 g pollen and 19.4 g propolis were taken per hive in the first year, while an average of 10.22 kg honey, 299 g pollen and 16.8 g propolis were taken per hive in the second year. As an average of two years, 5.94 kg of honey, 277 g of pollen and 16.9 g of propolis were taken from the bee pasture on average per beehive, while an average of 9.78 kg of honey, 305 g of pollen and 19.3 g of propolis were taken from the beehives brought to the highland. It has been observed that the amount of honey taken in 2022 is statistically higher than the amount of honey obtained from the highland compared to 2021, and the amount of honey obtained from the bee pasture (Table 2).

Quality characteristics of honey obtained from bee pasture and highland

The difference between the quality criteria of moisture, diastase, HMF, commercial glucose, C13 sugar, C4 sugar, protein in honey and delta C13 in raw honey, which are among the quality criteria of honey taken from beehives in bee pasture and highland in the years 2021 and 2022, were given in

Table 3. As seen in Table 3, it is evident that the "the difference between protein in honey and raw honey delta C13 sugar" content obtained from the bee pasture in 2022 is statistically higher than that in the highland. Regarding the years, it can be observed that the HMF content obtained in 2021 was higher than that in 2022, while the C13 sugar content was statistically lower. In terms of bee pasture/highland, it is noticeable that the C13 sugar content obtained from the highland was statistically higher than that obtained from the bee pasture.

Table 3. The difference between moisture, diastase, HMF, commercial glucose, C13 sugar, C4 sugar and protein in honey and delta C13 sugar in raw honey detected in honey obtained from bee pasture and highland in 2021 and 2022

	2021		2022		Year Average		Pasture/Highland Average	
	Pasture	**Highland**	**Pasture**	**Highland**	**2021**	**2022**	**Pasture**	**Highland**
Moisture (%)	15.0±1.2	15.4±1.0	15.5±0.6	14.8±0.6	15.2±1.0	15.2±0.7	15.3±0.9	15.1±0.8
Diastase (Number)	18.2±6.5	18.3±4.0	23.5±11.4	24.6±4.3	18.3±5.1	24.1±8.1	20.9±9.2	21.5±5.1
HMF (mg kg^{-1})	7.48±6.1	10.46±7.7	4.14±3.3	3.03±2.0	8.97±6.7 A*	3.59±2.6 B	5.81±4.9	6.75±6.6
Commercial Glucose (%)	-	-	-	-	-	-	-	-
Raw Honey Δ13C	-26.0±0.4	-25.7±0.4	-26.5±0.2	-26.1±0.2	-25.8±0.4 B*	-26.3±0.3 A	-26.3±0.4 B*	-25.9±0.3 A
C4 (%)	2.48±2.6	2.29±3.4	0.00±0.0	1.70±1.5	2.39±2.8	0.85±1.3	1.24±2.1	2.00±2.5
Δ13C Differ.	-0.28±0.6	-0.13±0.8	0.82±0.6 A*	-0.19±0.4 B	-0.21±0.6	0.32±0.7	0.27±0.8	-0.16±0.6

The averages shown with the same letter are not different from each other within the error limits of *: P≤0.05 according to the Student's t-test.

In this study, an average of 15.2% of moisture, 18.3 of diastase, 8.97 mg kg^{-1} of HMF, negative of commercial glucose, -25.8 of C13 sugar, 2.39% of C4 sugar and -0.21 of the difference between protein in honey and raw honey delta C13 sugars were taken per hive in the first year, while an average of 15.2% of moisture, 24.1 of diastase, 3.59 mg kg^{-1} of HMF, negative of commercial glucose, -26.3 of C13 sugar, 0.85% of C4 sugar and 0.32 of the difference between protein in honey and raw honey delta C13 sugars were taken per hive in the second year. As an average of two years, 15.3% of moisture, 20.9 diastase, 5.81 mg kg^{-1} of HMF, negative of commercial glucose, -26.3 of C13 sugar, 1.24% of C4 sugar and 0.27 of the difference between protein in honey and raw honey delta C13 sugars were taken from the bee pasture on average per beehive, while an average of 15.1% of moisture, 21.5 of diastase, 6.75 mg kg^{-1} of HMF, negative of commercial glucose, -25.9 of C13 sugar, 2.00% of C4 sugar and -0.16 of the difference between protein in honey and raw honey delta C13 sugars were taken from the beehives brought to the highland. It has been observed that the amount of "the difference between protein in honey and raw honey delta C13 sugar" taken in 2022 was statistically higher than the amount of "the difference between protein in honey and raw honey delta C13 sugar" obtained from the highland compared to 2021, and the amount of "the difference between protein in honey and raw honey delta C13 sugar" obtained from the bee pasture (Table 3).

DISCUSSION

In general, it is seen that the average amounts of honey, pollen and propolis taken from both the bee pastures and the highland in the first year are close to each other. However, it was observed that the amounts of honey, pollen and propolis taken from the bee pasture in the second year were lower than the amounts obtained from the highland. It is seen that the amount of honey taken from the highland in the second year is about twice the amount of honey

taken from the pasture. In the first year, drought was experienced in the whole region due to insufficient rainfall. The effect of this drought was felt both in the bee pastures and in the highlands. For this reason, it has been observed that the honey yields obtained from both bee pastures and highland in the first year are close to each other and low. In the second year, the highland showed its potential and thus higher honey amounts were obtained compared to bee pastures. Pollen yield was also lower than expected. The drought experienced throughout the country in 2021 caused the bees to not be able to carry enough nectar and pollen to the colonies as a result of affecting the plants that are the food source. As in other beekeeping products, pollen production was below the expected level.

Pollen is the male reproductive unit of plants and is used to develop offspring in the colony. It contains protein, fat, minerals, vitamins and sugars. Pollen is a nutrient for the protein need of the bee, and it is used as a feeding tool with honey in the 3-6 days period of the larva, as well as the nutrient that the worker bees consume with honey to ensure muscle development until the 18th day after they emerge from the cells in the honeycombs (Korkmaz 2013). Propolis is an important bee product. Bees use propolis for closing holes and cracks in hives, repairing frames, colony defense, narrowing the hive entrance, covering the colony pests that enter the hive but cannot be thrown out by bees, disinfection of honeycomb cells which are the brood production area, and bees carry an average of 10 mg of propolis to hive each time and propolis yield per colony varies between 50-250 g (Kumova et al. 2002).

Nicodemo et al. (2014) reported that the annual propolis yield per hive varied between 300 g and 1450 g, Bankova et al. (1982) and Tutkun (2000) reported that propolis yield varied between 10 g and 300 g per hive, depending on the breeds. Similarly, Kutluca et al. (2008) reported that propolis yield varied between 10-300 g on average and pollen yield varied between 219-236 g/colony in a study.

Similar to this study; Kekeçoğlu et al. (2014) reported average honey yield per colony in Düzce province between 2010 and 2011 as 7.79-8.83 kg, Emir and Ceyhan (2016) reported average honey yield per hive in Turkey as 19.8 kg, pollen yield as 1.13 kg and propolis yield as 0.16 kg, Onuç et al. (2019) determined the average honey yield per hive as 19.27 kg, pollen yield as 135 g and propolis yield as 5.71 g in İzmir province, Kutlu (2019) determined the average honey yield per hive as 10.4 kg in Şırnak province. Aktürk and Aydın (2019) reported that 1895 kg of honey, 64 kg of pollen and 2.14 kg of propolis were produced on average in Çanakkale province and honey yield per hive was 16.2 kg. Yıldız et al. (2022) determined the average honey yield per hive as 14.97 kg in Yozgat province and reported that other beekeeping products such as pollen and propolis are not produced enough to be commercially evaluated or recorded.

Although Turkey is among the leading countries in terms of the number of beehives and honey production, it is behind in terms of other beekeeping products such as pollen, propolis, bee venom and royal jelly (Kutlu 2019). It is seen that the amounts of pollen and propolis obtained in low amounts in our country, both from bee pastures and from the highland, are even lower when compared to other studies. Yavuz (2011) stated that factors such as climatic conditions, bee species and breed, plant source, and production and marketing are the factors affecting propolis production. Propolis yield increases or decreases in line with the suitability of these factors.

The importance of moisture content in honey is a quality criterion. High humidity causes the honey to ferment and shorten its shelf life. At the same time, high humidity gives an idea that honey is harvested before it matures in the comb, that is, early. The low humidity causes the honey to crystallize and a granular structure to form in the honey (Kaplan 2014). According to the Turkish Food Codex Honey Communique, the moisture content of honey is required to be at most 20%. In the first and second years of the study, the humidity rate was 15.2%, the moisture content of honey obtained from bee pastures was 15.3%, the moisture content of honey obtained from the highland was 15.1%, and the average moisture content of honey in general in the research was 15.2%. It is seen that the results regarding the humidity obtained from both the bee pastures and the highland are within the limit values determined by the Turkish Food Codex Honey Communique (Table 1, Table 3).

Previous studies determined that moisture content of flower honey offered for consumption in Turkey was 14.8%-21.6 (Çetin et al. 2011), moisture content of honeys from Eastern Anatolia and Eastern Black Sea Regions was 14.01-17.12% (Batu et al. 2013), moisture content of honey produced in Gaziantep was % 13.0-20.4 (Kutlu and Bengü 2015), moisture

content of honey produced in Erzincan province was 16.9-21.4% (Karahan Yılmaz and Eskici 2017), moisture content of honey from five different companies sold in markets in Konya region was 15.48-17.63% (Çiftçi and Parlat 2018), average moisture content of honey produced in Bingöl was 15.39% (Bengü and Kutlu 2018), moisture content of honey produced in Muğla was 14.6-20.9% (Belli 2019), moisture content of some honeys collected from 12 different regions was 16.4%-19.9% (Gültekin Özgüven et al. 2020), moisture content of honeys from Iğdır region was 13.55-16.75% (Yurt and Çakır 2020), moisture content of honeys from Çorum region was 14.5%-21.7% (Guzel and Bahçeçi 2020) and moisture content of honeys from Tokat region was between 13.0%-20.0% (Kara et al. 2022). It is understood that the results obtained from these previous studies are compatible with the current study findings and some of them were slightly above the limit values determined by the Turkish Food Codex Honey Communique.

Diastase is a natural enzyme found in honey. Diastase gives an idea about whether the honey is fresh or not. It is a parameter that helps to determine whether the honey is exposed to heat until it is packaged and reaches the consumer (Çiftçi 2014). According to the Turkish Food Codex Honey Communiqué, the number of diastases in honey should be at least 8. Diastase numbers were obtained as 18.3 in the first year of the study, 24.1 in the second year, 20.9 in bee pasture honeys, 21.5 in highland honeys and 21.2 in honeys as the general average of the research. It was determined that the results regarding the diastase numbers obtained from both bee pasture and highland were at an appropriate level according to the Turkish Food Codex Honey Communique (Table 1, Table 3).

Looking at the previous studies; diastase number of flower honeys offered for consumption in Turkey was 1.0-20.0 (Çetin et al. 2011), diastase number of honeys from Eastern Anatolia and Eastern Black Sea Regions was 8.30-17.9 (Batu et al. 2013), diastase number of honeys produced in Gaziantep was 2.5-38.5 (Kutlu and Bengü 2015), diastase numbers of honey produced in Erzincan province were 4.5-19.4 (Karahan Yılmaz and Eskici 2017), diastase numbers of honeys belonging to five different companies sold in markets in Konya region were 12.86-22.45 (Çiftçi and Parlat 2018), the average diastase number of honeys produced in Bingöl was 18.39 (Bengü and Kutlu 2018), the diastase number of honeys produced in Muğla province was 3.38-13.18 (Belli 2019), the diastase number of honeys taken from the center and districts of Bingöl was 1-17.9 (Yaşar and Söğütlü 2020), the diastase number of some honeys collected from 12 different regions was 9.0-25.4 (Gültekin Özgüven et al. 2020), the average diastase number in honey produced in Muş was 19.84 (Kutlu and Bengü 2020), the diastase number in honeys from Çorum region was 0.1-32.2 (Guzel and Bahçeçi 2020) and the diastase numbers of Tokat honeys were determined to be 0.0-10.9 (Kara et al. 2022). Some of the results obtained in these previous studies (Çetin et al. 2011; Kutlu and Bengü 2025; Karahan Yılmaz and Eskici 2017; Belli, 2019; Yaşar and Söğütlü 2020; Güzel and Bahçeci 2020; Kara et al. 2022) diastase numbers were found to be below the limit values determined by the Turkish Food Codex Honey Communique.

HMF (Hydroxy methyl furfurol) content gives information about the temperature applied to honey. Heat treatment is applied to neutralize the microorganisms that contaminate honey. Newly produced honey generally does not contain HMF. However, over time, the amount of HMF increases depending on the storage conditions and the heat treatment used (Kaplan 2014; Ceylan 2016). According to the Turkish Food Codex Honey Communique, the amount of HMF in honey should be at most 40 mg kg^{-1}. The HMF content was 8.97 mg kg^{-1} in the first year of the study and 3.59 mg kg^{-1} in the second year. It was observed that the amount of HMF obtained in the first year was statistically higher than the amount of HMF obtained in the second year. The average HFM content of the honey obtained from the bee-pasture was 5.81 mg kg^{-1}, the HMF content of the honey obtained from the highland was 6.75 mg kg^{-1}, and the general average of the study was 6.28 mg kg^{-1}. It is seen that the results regarding HMF obtained from both bee pasture and highland are in accordance with the Turkish Food Codex Honey Communique (Table 1, Table 3).

The literature review showed that HMF amount of honeys from Eastern Anatolia and Eastern Black Sea Regions was 0.14-24.39 mg kg^{-1} (Batu et al. 2013), HMF amount of honey produced in Gaziantep province was 14.3-51.5 mg kg^{-1} (Kutlu and Bengü 2015), honey produced in Erzincan province HMF amounts were 1.54-47.81 m kg^{-1} (Karahan Yılmaz and Eskici 2017), HMF content of honeys belonging to five different companies sold in markets in Konya region was 4.17-23.75 mg kg^{-1} (Çiftçi and Parlat

2018), average amount of HMF in honey produced in Bingöl province was 36.37 mg kg^{-1} (Bengü and Kutlu 2018), HMF content of honey produced in Muğla province was 0-93.8 mg kg^{-1} (Belli 2019), HMF amount of honey taken from central and districts of Bingöl was 27.01-42.2 mg kg^{-1} (Yaşar and Söğütlü 2020), the HMF content of some honeys collected from 12 different regions was 0.1-1.22 mg kg^{-1} (Gültekin Özgüven et al. 2020), the average amount of HMF in honey produced in Muş was 1.99 ppm (Kutlu and Bengü 2020), HMF amount in honeys of Iğdır region was 13.70-129.0 mg kg^{-1} (Yurt and Çakır 2020), HMF amount in honeys from Çorum region was 0.3-36.5 mg kg^{-1} (Guzel and Bahçeci 2020), HMF amounts in honeys from Tokat region was 0.05-8.69 mg kg^{-1} (Kara et al. 2022). In some of the results obtained in these previous studies (Karahan Yılmaz and Eskici 2017; Belli, 2019; Yaşar and Söğütlü 2020; Yurt and Çakır 2020), it was understood that the HMF amounts were above the limit values determined by the Turkish Food Codex Honey Communique.

Sugars constitute a large part of the composition of honey. The most proportional sugars in honey are fructose and glucose (Çetin et al. 2011). According to the Turkish Food Codex Honey Communique, it has been reported that the amount of fructose + glucose in flower honey should be at least 60% (TGKBT 2020). In a study, it was determined that the sum of fructose and glucose in honeys varied between 56.3% and 81.6% (Gültekin Özgüven et al. 2020). However, what is in question here is not the sugars that make up the natural structure of honey, but the commercial sugars or starches added to the honey afterwards. Commercial glucose or starches added to honey reduce the value of honey and endanger human health (Karadal and Yıldırım 2012).

According to the Turkish Food Codex Honey Communiqué, commercial glucose should not be present in honey (Table 1). Commercial glucose was not detected in honey obtained from bee pastures and highland in both years (Table 3). Similarly, in a study examining the physicochemical properties of some honeys collected from 12 different regions, it was reported that commercial glucose was not detected in the content of honey (Gültekin Özgüven et al. 2020).

In the past years, beet sugar (sucrose - tea sugar - granulated sugar) was used to feed honeybees, while in recent years, fructose and glucose syrups obtained from invert syrup or corn starch have been fed. In addition, in order to increase the amount of naturally produced honey and reduce the cost; corn syrups, which can be produced cheaply and have a taste and fluidity close to honey, are added to honey and honey-like products are obtained. The most common and reliable method of detecting cheating with these methods is carbon isotope (C13) analysis and C4 sugar ratio analysis in honey (Padovan et al. 2003). By analyzing the C13/C12 isotope ratios in honey, the sugar syrup (C4 sugar) ratio likely to be added to the honey can be determined (White and Winters 1989).

C13/C12 value varies between -22 and -33 in C3 plants, and C13/C12 value varies between -10 and -20 in C4 plants. Since most of the nectar plants are in the C3 group, the C13/C12 value in honey is around -25. If corn syrup is added to honey, this ratio goes up to -10. When corn syrup is added to honey, the carbon isotope ratio of honey changes, but the carbon isotope ratio of protein in honey does not change. For this reason, by comparing the carbon isotope ratios of honey and protein in honey, it can be determined whether corn syrup is added to honey and if the difference between these two values is more than -1, it is understood that corn syrup is added to honey (Gürel 2015).

According to the Turkish Food Codex Honey Communiqué, the C13 sugar in honey should be -23 or more negative, the C4 sugar ratio calculated from the C13 value should be at most 7%, and the difference between the protein and raw honey delta C13 values in honey should be -1.0 or more (TGKBT 2020). In the first year of the study, the average C4 sugar was 2.39%, C13 sugar -25.8, and the difference between protein in honey and raw honey delta C13 sugars was -0.21, in the second year the average C4 sugar was 0.85%, C13 sugar -26.3, and the difference between protein in honey and raw honey delta C13 sugars was 0.32. Average C4 sugar was 1.24%, C13 sugar -26.3 in honey, the difference between protein and raw honey delta C13 values was 0.27, average C4 sugar in highland honey was 2.00%, C13 sugar was -25.9 and the difference between protein and raw honey delta C13 values in honey was - 0.16. It was observed that the rate of C13 sugar was statistically higher in the second year compared to the first year, and the C13 sugar obtained from highland honey was statistically higher than the C13 sugar obtained from bee pasture. It was determined that the difference between C4 and C13 sugars obtained from both bee

pasture and highland and protein and delta C13 values in honey was at a suitable level according to the Turkish Food Codex Honey Communique (Table 1, Table 3).

The previous studies showed that, C4 sugar content of honey produced in Gaziantep province was 0.33-6.48% (Kutlu and Bengü 2015), the glucose ratio of the honeys sold in the markets in Konya region by five different companies was 29.65-35.22%, the C4 sugar ratio was 0.00-3.53%, the difference between protein and raw honey C13 value was -0.55 to -0.25 (Çiftçi and Parlat 2018), the average C4 sugar content of honeys produced in Bingöl was 1.37% (Bengü and Kutlu 2018), the C4 sugar content of honeys produced in Muğla was 0-16.8% and the difference between raw honey and C13 values was -0.28 to -2.52 (Belli, 2019) and the C4 sugar rate of the honeys of the Tokat region was 0.0-5.26%, the C13 sugar values of raw honey were -25.32 to -27.32, and the difference between the raw honey and C13 values was -0.84 to -1.23 (Kara et al. 2022). It has been observed that the difference between C4 sugar ratio and raw honey and C13 sugar in some honeys produced in Muğla province by Belli (2019) was high, and other honeys are within the limit values determined by the Turkish Food Codex Honey Communique.

Conclusion

The aim of the research is to determine the yield and quality of honey and other bee products obtained from bee pastures and highland. Five of the ten beehives used in the research were taken to the highland during the summer period, and five of them were left in the pasture for comparison purposes. Then, the amount of honey taken from both places and the quality of honey were determined. In addition, pollen and propolis amounts of ten beehives were determined. In this context, it has been determined that the average honey yields per colony obtained from the bee pasture and the highland in the first year are quite close to each other. However, the honey yield obtained from the bee pasture in the second year was lower than the honey yield obtained from the highland. Although honey yield is low, considering the transportation and housing costs, it has been understood that bee pasture is sustainable and an alternative to highland beekeeping. It was determined that the difference between HMF, moisture, diastase, commercial glucose, C4 and C13 sugar contents, protein in honey and delta C13 sugars in raw honey in honey taken from both bee pastures and highland were at an "appropriate" level according to the Turkish Food Codex Honey Communique.

Acknowledgement: We would like to thank the Pilot University Coordination Central Unit for the support given.

Author Contribution: The authors contributed equally.

Conflict of Interest: Not conflict of interest was declared by the authors.

Data availability: If requested, the raw data set will be sent by me**.**

Ethical Issue: Not applicable.

Source of Finance: This study was supported by Bingöl University Pilot University Coordination Center Unit (Project No: PİKOM-Bitki.2019.001).

REFERENCES

Aktürk D, Aydın B. Structural Characteristics of Beekeeping Enterprises and Beekeeping Activities in Çanakkale Province. Turkish Journal of Agriculture-Food Science and Technology, 2019;7(10):1618-1628

Bankova VS, Popov SS, Marekov NL. High Performance Liquid Chromatographic Analysis of Flavonoids from Propolis. J Chromatogr, 1982;242:135-143

Batu A, Küçük E, Çimen M. Determination of the Physicochemical and Biochemical Values of Flower Honeys Obtained from Eastern Anatolia and Eastern Black Sea Regions. Electronic Journal of Food Technologies, 2013;8(1):52-62.

Belli T. Some Physical and chemical properties of the honeys produced in Muğla. Pamukkale University, Institute of Science, Department of Food Engineering, Master's Thesis, Denizli, 2019

Bengü AŞ, Kutlu MA. Identification of Some Quality Criteria of Honey Produced in Bingöl. Turkish Journal of Nature and Science, 2018;7(1):7-10

Ceylan DA. The effects of heating temperature, heating and storage time on the HMF level and diastase number of different honey types. Mustafa Kemal University, Institute of

Science, Department of Zootechnics, Doctoral Thesis, Hatay, 2016

Çetin K, Akın E, Uçurum H. Determination of Quality Parameters of Flower Honey Sold on the Market. Journal of Food and Feed Science, 2011;11:49-56

Çiftci E. Comparison from the quality criteria terms of Konya highlands regional honey and puren honey. Selçuk University, Institute of Healthy, Department of Food Hygiene and Technology, Master's Thesis, Konya, 2014

Çiftçi M, Parlat SS. The Conformity of Chemical Composition of Some Commercial Flower Honey Samples Sold in Markets in the City of Konya, Turkey with Turkish Food Codex, Honey Communique. Selcuk Journal of Agricultural and Food Sciences, 2018;*32*(1):38-42. https://doi.org/10.15316/sjafs.2018.61

Emir M, Ceyhan V. Migration routes of beekeepers, productivity and prices of bee products in Turkey. XII. Ulusal Tarım Ekonomisi Kongresi, 25-27 Mayıs, 2016, p. 1615-1624

Gürel F. Balda Taklit ve Tağşiş. Arıcılık Araştırma Dergisi, 2015;7(13):2-4.

Gültekin Özgüven M, Demircan E, Ozçelik B. Determination of Physicochemical Properties of Flower Honeys Produced in Various Locations and Their Compliance with the Turkish Food Codex. European Journal of Science and Technology, 2020;20:321-326. https://doi.org/10.31590/ejosat.758399

Güzel N, Bahçeçi KS. Assesment of Some Chemical Quality Parameters of Honeys Produced in Çorum Province. The Journal of Food, 2020;45(2):230-241. https://doi.org/10.15237/gida.gd19129

JMP. Statistical Discovery from SAS, USA, 2018

TGKBT. Turkish Food Codex, Honey Communique, www.resmigazete.gov.tr, 2020

TUIK. Turkey Statistical Institute, Animal Production Statistics, http://www.tuik.gov.tr, 2023

Kaplan HB. Chemical properties of Aegean Region honeys. Pamukkale University, Institute of Science, Department of Food Engineering, Master's Thesis, Denizli, 2014

Kara F, Kaya C, Esin Yücel E, Topuz S, Bayram M. Determination of Some Physiochemical Properties of Honeys from Tokat Region and Their Compliance with the Turkish Food Codex. Uludag Bee Journal, 2022;22(2):148-165. https://doi.org/10.31467/uluaricilik.1092060

Karadal F, Yıldırım Y. The Quality Parameters and Nutritional and Health Effect of Honey. J Fac Vet Med Univ Erciyes, 2012;9(3):197-209

Karahan Yılmaz S, Eskici G. Biochemical Aspects of Honey Produce in Erzincan. Journal of Agricultural Faculty of Gaziosmanpasa University, 2017;34(2):36-42. https://doi.org/10.13002/jafag1120

Kekeçoğlu M, Göç Rasgele P, Acar F, Kaya ST. A Study on the Structure of Beekeeping and Beekeeping Activities in Düzce. Düzce University Journal of Science and Technology, 2014;2:1-15

Korkmaz A. Anlaşılabilir Arıcılık. Samsun Gıda Tarım ve Hayvancılık İl Müdürlüğü Yayınları, Samsun, 2013

Kumova U, Korkmaz A, Avcı BC, Ceyran G. An Important Bee Product: Propolis. U Arı D. / U Bee J., 2002;2(2):10-24

Kutlu MA, Bengü AŞ. Identification of the Quality Criteria of Honey Produced in Gaziantep. Turkish Journal of Nature and Science, 2015;4(1):48-53

Kutlu MA. A Study on the General Structure of Beekeeping Buildings of Uludere District. Turkish Journal of Agricultural and Natural Sciences, 2019;6(3):511-517. https://doi.org/10.30910/turkjans.595369

Kutlu MA, Bengü AŞ. Determination of Antibiotic and Pesticide Residues and Some Quality Criteria in Honey Produced in Muş Province. Bingol University Health Journal, 2020;1(1):1-6

Kutluca S, Genç F, Korkmaz A. Propolis. Samsun Provincial Directorate of Agriculture, Farmer Training and Extension Branch, Samsun, 2006, p. 57

MGM. Ministry of Agriculture and Forestry, General Directorate of Meteorology, http://www.mgm.gov.tr, 2023

Nicodemo D, Malheiros EB, Jong DD, Helena R, Couto N. Increased Brood Viability and Longer Lifespan of Honeybees Selected for Propolis Production. Apidologie, 2014;45: 269-275

Tutkun E. Teknik Arıcılık El Kitabı, TKV Yayın No: 6, Ankara, 2000, s.235

Onuç Z, Yanar A, Saner G, Güler D. An Analysis on Economical Aspect of the Beekeeping Enterprise: A Case of Kemalpaşa District-İzmir/Turkey. Ege Univ. Ziraat Fak. Derg., 2019;56(1):7-14. https://doi.org/10.20289/zfdergi.420370

Padovan GJ, De Jong D, Rodriques LP, Marchini JS. Detection of Adulteration of Commercial Honey Samples by the 13C / 12C Isotopic Ratio. Food Chemistry, 2003; 82: 633-636

Sandal EK, Kan C. Beekeeping Activities in Bingöl Province. Turkish Geographical Review, 2013;60:1-12

Söğüt B, Seviş HE, Karakaya E, İnci H. A Research on Present Situation, Basic Problems and Solution Proposals in Beekeeping Enterprices (A Case Study Bingol Province). U Arı D – U Bee J 2019;19(1):50-60

Yaşar S, Söğütlü İ. Investigation of Acidity, Diastase Number, HMF, Insoluble Dry Matter and Ash Percentage Values of Some Honey Samples Produced in Bingöl and Districts. Van Veterinary Journal, 2020;31(1):42-46. https://doi.org/10.36483/vanvetj.631565

Yavuz C. Antimicrobial, antioxidant activities and the determination of bioactive components of propolis samples collected from some cities of Turkey. Ordu University, Institute of Science, Department of Biology, Master's Thesis, Ordu, 2011

Yıldız AK, Ayyıldız M, Ayyıldız B, Arslan S. Technical and Socio-Economic Beekeeping Enterprises of Yozgat Province Investigation of Status. Turkish Journal of Agriculture-Food Science and Technology, 2022;10(5):846-852

Yurt B, Çakır S. Some Physicochemical Properties of Honey Produced in Iğdır and Region. Turkish Journal of Nature and Science, 2020;9(special issue):51-57. https://doi.org/10.46810/tdfd.761654

White JW, Winters K. Honey Protein as International Standard for Stable Isotope Ratio Detection of Adulteration of Honey. Journal of the Association of Official Analytical Chemists, 1989;72(6):907-911