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Spatial and Climatic Analysis of Chestnut Honey and Propolis Produced in Chestnut Forests and Their Potential Contribution to the Economy

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ABSTRACT

This study aimed to determine the effect of spatial and climatic factors on the productivity of chestnut honey and chestnut propolis produced in chestnut forests and to reveal the potential contribution of their production to the economy. The study area included the provinces of Artvin, Trabzon, Ordu and Samsun in the Eastern and Central Black Sea Region, and covered the beekeepers producing chestnut honey and chestnut propolis in chestnut forests. The primary data of the study were obtained from the yield measurements of chestnut honey and chestnut propolis obtained from the hives, whereas the secondary data were obtained from the surveys conducted with beekeepers. Analysis of variance, independent sample t-test and correlation analysis were used to analyze the statistical difference between the chestnut honey and chestnut propolis yields of the beehives in different provinces. It was determined that there was a negative relationship between the yield of chestnut honey and chestnut propolis, relative humidity and wind speed, and a positive relationship between yield and altitude, temperature and precipitation. The potential contribution of chestnut honey and propolis production was US $ 51.10 million to the Eastern and Central Black Sea Region economy.

INTRODUCTION

The main product is honey in apiculture activities. The type of honey varies based on the source of nectar. Chestnut honey content is richer when compared to other varieties (Kolaylı *et al*., 2016). During chestnut honey production, by-products such as propolis, pollen, royal jelly and bee venom could also be obtained. Propolis is a resinous mixture collected by bees from various herbal sources. Bees use propolis to protect hives against wind and rain by closing the entrance hole in order to prevent potential damages, to mummify dead invaders, and to plaster the interior of the hive to prevent fungi and bacteria (Bayram *et al*., 2015). Thus, bees provide a healthy environment for both the honey and their offspring with propolis (Atik and Gümüş, 2017). Propolis is also a very important bee by-product employed in apitherapy due to antimicrobial and anticarcinogenic properties (Choudhari *et al*., 2013). Commercial interest in propolis has increased in recent years (Bankova and Marcuccu, 2000); propolis demand has been increasing rapidly due to immune-system enhancing properties, especially after the Covid-19 pandemic (Araba and Özparlak, 2022). Brazilian beekeepers started to specialize in propolis production due to the increasing commercial demand in the 1990s (Lima *et al*., 2016). The North American, European and Asia Pacific nations are the main propolis producing countries (Anonymous, 2020a). Based on the 2018 data, global honey production was 1,850,868 tons. The highest honey producer was China with 446.900 tons, followed by Turkey with 114,113 tons (Anonymous, 2020b; Burucu and Bal, 2017). Since there is no statistical data on chestnut honey production in Turkey, the exact figures are not known. Similarly, commercial apiculture is conducted for honey and wax production in Turkey, and no data is available on bee byproducts (propolis, pollen, royal jelly, etc.) production.

Apiculture provides significant employment opportunities and income source for rural population in developing countries. Supporting beekeeping activity

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is an important tool of regional development, both economically and socially (Akın and Yılancı, 2021; Güler *et al*., 2018). Beekeeping is an activity that can be applied with low investments and using ready-made resources in nature without requiring much labor, as well as providing significant financial gain to the breeder (Karlıdağ and Köseman, 2015). Beekeeping, which is also suitable for small family businesses, can bring additional income to the household. For example, Onuç *et al*. (2019) determined that the average gross profit per hive in honey production was US $ 12.3, and Güngör and Ayhan (2016) determined that as of 2015, the income from honey production in Bartın, Turkey province was approximately US $ 6.6 million. In this context, beekeeping activities show an important development in the world and Turkey. Support for the rural population has been put into practice by the Ministry of Agriculture and Forestry in Turkey within the scope of the National Agriculture Strategy Rural Development Plan. Beekeeping also has an important place in forestry in terms of protecting biodiversity and transferring it to future generations.

Apiculture is generally conducted in forests and meadows in Turkey (Anonymous, 2013a). The production of chestnut honey and by-products is significant in Turkish forests. About 52% of the chestnut forests are located in Eastern Black Sea in Turkey, and the most prominent activity in chestnut forests is chestnut honey production (Anonymous, 2020c). Chestnut honey is produced in a small number of hives by forest villagers who generally reside near the chestnut forests. Most chestnut honey producers in the Eastern Black Sea region do not produce bee by-products. Thus, the bee by-product income remains very low when compared to chestnut honey (Bulut *et al*., 2017).

The lack of knowledge on the potential market value and demand for bee by-products limits the production. To increase apiculture income, by-product (beeswax, pollen, and propolis) production should also be increased (Al-Ghamdi *et al*., 2017; Özsayın and Karaman, 2018). The yield per hive is one of the most important economic indicators in apiculture. Although 75% of the global plant species and varieties with nectar are available in Turkey (Sıralı, 2010), the average honey yield per hive is quite low in Turkey (14.3 kg) when compared to China (50.6 kg) (Semerci, 2017). The geographical and climatic conditions and the flora have significant effects on honey production in Turkey (Sıralı, 2010; Cengiz, 2013). Climate change and global warming affect the phenology, local and regional distribution of plants and bees (Hegland *et al*., 2009). Therefore, this situation will cause changes in flower quality, nectar and secretion flow in honey plants, and may also affect colony development and colony harvest capacity. Since the result of these effects is not known precisely, it is significant to evaluate honey and bee products in terms of location and climate.

Although there are studies on flower honey production and its economy in the literature, the lack of sufficient studies on chestnut honey and propolis production and their economy reveals the importance of this study. In the present study, the provincial yield levels of chestnut honey and propolis, which are commonly produced in the Eastern and Central Black Sea regions, were compared based on spatial and climatic properties, and the contribution of chestnut honey and propolis production to the regional economy was determined. Improvement of both chestnut honey and propolis production and yield is important for the raw material demand of the food, cosmetics and especially pharmaceutical industries.

MATERIALS AND METHODS

Materials

Trabzon and Artvin provinces in the Eastern Black Sea region, and Ordu and Samsun provinces in the Central Black Sea region with pure and mixed chestnut forests were purposively selected as the study area (Fig. 1). The provinces with predominantly pure or mixed chestnut forests in the Eastern and Central Black Sea regions include Trabzon (68,926 ha), Giresun (30,702 ha), Artvin (27,520 ha) and Samsun (4,382 ha), and the total chestnut tree stock in these four provinces is 131,530 ha. 11% (14,508 ha) of the chestnut forests are pure chestnut forests, and 89% (117,022 ha) are mixed forests with other trees (Anonymous, 2013b).

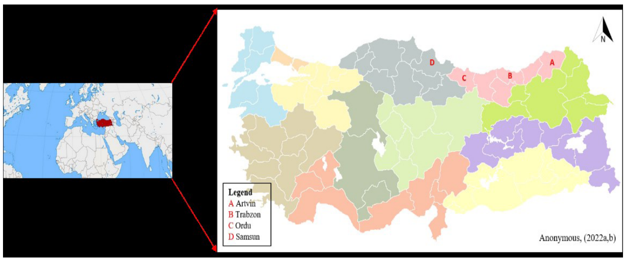

Fig. 1. Map of the study area.

The primary study data included chestnut honey and propolis yield measurements conducted on 20 hives of a beekeeper selected from Artvin, Trabzon, Ordu and Samsun provinces. The Langstroth hive size used in the study was 505 mm x 435 mm x 260 mm from outside to outside. There were 10 frames in each hive, whereas there were approximately 30,000 bees. The altitude of the hives of the selected producers was measured with a Global

Position System (GPS) instrument. The average climate data (temperature, relative humidity, precipitation, and wind speed) of the sample plots for the months of June, July and August were obtained from the nearest meteorology stations affiliated to the 11^{th} Regional Directorate of the General Directorate of Meteorology of the Ministry of Agriculture and Forestry. However, secondary data on the subject of the study consisted of the information obtained from the surveys carried out with 290 beekeepers.

Determination of chestnut honey and propolis yield

The determination of chestnut honey and propolis yield was conducted with the wooden hives, sieve-type polyethylene propolis traps, and Caucasian bees in the selected study areas. A total of 80 hives and propolis traps, i.e., 20 hives and propolis traps in each study area, were placed. The production of chestnut honey in the Eastern Black Sea region, in other words, the period between the placement of the hives in chestnut forests and their removal for wintering, was generally conducted for 60 days during June and July (Bulut *et al*., 2017). In the study, the hives and traps were placed in the study areas in early June 2018 and collected in late August 2018.

Chestnut honey was milked from the beehives, and the propolis raw material was collected from the traps by crushing. The weight of chestnut honey obtained from each hive was measured in kilograms, and the weight of the propolis raw material was measured in grams on a precision scale. Thus, the amount of chestnut honey and propolis per hive was determined.

Determination of the study area conditions

The altitudes of the study areas were determined by GPS. Climatic conditions such as temperature, relative humidity, precipitation, and wind speed are presented in Table I.

Table I. Spatial and certain climatic properties of the study areas.

Study area	Altitude (meter)	Temperature (°C)	Relative humidity (%)	Precipitation (mm)	Wind speed (m/s)
Trabzon-Yomra	468	16.97	91.47	105.73	1.90
Artvin-Arhavi	620	22	90.1	126.5	2.57
Samsun-Salıpazarı	729	23.47	76,67	152.97	2.27
Ordu-Perşembe	780	22.07	80.8	172.1	1.67

Interviews conducted with the beekeepers

In the study, the survey method was used to determine the presence of hive/propolis traps used in the production of chestnut honey and propolis and the product sales prices. The surveys were applied face to face with beekeepers who had been producing chestnut honey for at least two years until that time. The number of beekeepers to be surveyed was determined according to the sample size formula given below (Lemeshow *et al*., 1990; Miran, 2002; Daşdemir, 2021).

$$n \geq \frac{NxZ^2xpxq}{(N-1)xD^2 + Z^2xpxq}$$

In the formula, n is the sample size, N is the population size, Z is the confidence coefficient, p is the rate of presence of the feature to be measured in the population, q is the rate of not being in the population of the feature to be measured (q=1-p), and D is the sampling error. The number of beekeepers, who were the members Central Association of Turkish Beekeepers (TAB) that represent the interests of professional beekeepers, was 57,847 (Anonymous, 2020d). In Artvin, Trabzon, Ordu and Samsun provinces 1,680 beekeepers produced chestnut honey. Therefore, in calculating the sample size, the population size was taken as 1.680 beekeepers. The sample size was calculated at 95% confidence level with 5% margin of error (Z= 1.96; D=0.05; p=0.8; q=0.2) (Yazıcıoğlu and Erdoğan, 2004). As a result of the calculation, the sample size was found to be 215 beekeepers. However, this size was exceeded in the study and the survey was conducted with 290 beekeepers (Table II).

Table II. Chestnut honey and propolis producers.

	Eastern Black Sea		Central Black Sea		Total
	Artvin	Trabzon	Ordu	Samsun	
Number of chestnut honey producers	620	600	250	210	1,680
Number of interviewed beekeepers	105	105	45	35	290

Data analysis

Simple descriptive statistics (minimum, maximum and arithmetic mean) for study variables are presented in tables, and related discussion and comments are provided. In the study, chestnut honey and propolis yield per hive was determined, and analysis of variance was employed to compare the data. Duncan test was used to determine homogeneous subgroups when significant differences were determined with the analysis of variance.

The study area was divided into two regions: Eastern Black Sea Region (Artvin and Trabzon) and Central Black Sea Region (Samsun and Ordu). The significance of the differences between chestnut honey and propolis yield figures based on the regions was tested with independent sample t-test. Correlation analysis was conducted to determine the impact of altitude and certain climatic conditions (temperature, relative humidity, precipitation, and wind speed) in the study area (Artvin, Ordu, Samsun, Trabzon) on chestnut honey and propolis yield per hive.

RESULTS AND DISCUSSION

Chestnut honey and propolis yield

In the study, the minimum, maximum and average production yield of chestnut honey and propolis in pure or dominant chestnut forests were determined. Based on the study findings, the minimum chestnut honey yield per hive was 2.13 kg in the study areas, the maximum yield was 30 kg, and the average yield was 8.76 kg. The minimum chestnut propolis yield per hive was 19.20 g, the maximum yield was 348.60 g, and the average yield was 90.94 g (Table III).

Table III. The chestnut honey and propolis yield by province.

	Chestnut honey yield (kg/hive)		Chestnut propolis yield (gr/hive)	
	Min-Max	Average	Min-Max	Average
Artvin	2.13-10	6.28	19.20-132.30	61.38
Ordu	6-30	13.12	47.40-348.60	136.20
Samsun	5.33-17.50	8.93	25.50-290.49	105.99
Trabzon	5-9.52	6.71	30.09-102.90	60.18
Genel	2.13-30	8.76	19.20-348.60	90.94

Based on the analysis of variance results, there were statistical differences between the chestnut honey and propolis yield per hive based on the provinces (Artvin, Ordu, Samsun, Trabzon) (Table IV). Therefore, the Duncan test was conducted to determine the homogeneous subgroups. There were significant differences between chestnut honey and propolis yield based on the provinces at p= 0.05 significance level. The Duncan test results revealed that the chestnut propolis yield per hive constituted a dual homogeneous subgroup, whereas the chestnut honey yield constituted a triple homogeneous subgroup.

The lowest chestnut propolis yield in the double homogeneous group was observed in Trabzon (60.18 g), while the highest yield was observed in Ordu (136.20 g). The lowest chestnut honey yield in the triple homogeneous group was in Artvin (6.28 kg), and the highest yield was observed in Ordu (13 kg) (Table IV). Overall analysis revealed that Ordu exhibited the highest chestnut honey (13.12 kg) and propolis (136.20 g) yields. In a study conducted by Çukur (2014), it was determined that the average pine honey yield per hive was 14.39 kg in Muğla and 17.72 kg in Milas, 17.00 kg in Köyceğiz and 12.78 kg in Fethiye districts. Afrouzan *et al*. (2007) reported that the highest propolis yields per hive in two weeks were 11.63g and 8.79g, respectively, in poplar and cypress areas in Telo in Khojir, near Tehran, Iran, and that the propolis yield in Khojir was statistically higher when compared to the yield in Telo. Furthermore, it was also reported that propolis yield in poplar and cypress forests was of good quality and that the presence of poplar trees near beehives could improve propolis yield.

Based on the independent sampling t-test analysis conducted on the data for two regions, namely Eastern Black Sea (Artvin and Trabzon) and Central Black Sea (Samsun and Ordu) regions, there were significant differences between the chestnut honey and propolis yields based on regions (Table V).

Table IV. Duncan test results of chestnut honey and propolis yield by province.

Variable	Province	Mean (n=20)	F	Significance level	Homogenous group
Chestnut honey yield (kg)	Artvin	6.28	15.301	0.000	a
	Trabzon	6.71			ab
	Samsun	8.93			b
	Ordu	13.12			c
Chestnut propolis yield (gr)	Trabzon	60.18	8.966	0.000	a
	Artvin	61.38			a
	Samsun	105.99			b
	Ordu	136.20			b

Table V. Independent sample t-test results of chestnut honey and chestnut propolis yield by regions.

Variable	Region	Mean (n=40)	F	Significance level	Analysis result
Chestnut honey yield (kg/hive)	Eastern Black Sea	6.49	15.688	0.000	Different
	Central Black Sea	11.03			
Chestnut propolis yield (gr/hive)	Eastern Black Sea	60.78	20.033	0.000	Different
	Central Black Sea	121.09			

The lowest chestnut honey yield was determined in the Eastern Black Sea region (6.49 kg), while the highest yield was observed in the Central Black Sea region (11.03 kg).

The lowest chestnut propolis yield was determined in the Eastern Black Sea region (60.78 g), while the highest yield was observed in the Central Black Sea region (121.09 g) (Table V). The chestnut honey and chestnut propolis yield figures in the Central Black Sea region were higher when compared to the Eastern Black Sea region. Overall analysis of both regions revealed that the average chestnut propolis yield per hive was 90.94 g and that the average chestnut honey yield was 8.76 kg.

Marinkovic and Nedic (2010) reported that honey yield per hive was 11 kg in Srem region and 23 kg in Banat region, and that the yield might be affected by the beekeeping technique as well as by climate and pasture conditions. In other studies, it was determined that the average flower honey yield per hive was 17.58 kg in Gökçeada (Özsayın and Karaman, 2018), 13.44 kg in the Aegean region (Özbilgin *et al*., 1999), 16.22 kg in İzmir, and 24.85 kg in Muğla in Turkey (Saner *et al*., 2005).

Propolis production may also vary depending on bee type, hive type, plant diversity, trap types and climatic factors (Krell, 1996; Mountford-McAuley *et al*., 2021). In this study, Caucasian bee (*Apis mellifera caucasica*), wooden hive type and polyethylene propolis trap type were used and the data on propolis yield is supported by the literature. Smilarly, Pereira *et al*. (2009) reported that an average of 300 g of propolis was produced per beehive per month, Ceyhan *et al*. (2016) reported that 156 g propolis can be collected per colony. Kiziltas and Erkan (2020) obtained that the average propolis production figures for wooden, styrofoam and plastic hives were 6.72, 5.14 and 1.34 g, respectively. Sahinler and Gül (2005) found out the average propolis yield to be 27.34, 26.93, 26.12, 39.67 g for Caucasian (*Apis mellifera caucasica*), Carniolan (*Apis mellifera carnica*), Italian (*Apis mellifera ligustica*) and Anatolian (*Apis mellifera anatoliaca*) bee genotypes, respectively. Agussalim *et al*. (2020) found honey production by Indonesian stingless bee *Tetragonula laeviceps* between 79.2-328 g and propolis production between 15.4-77.2 g.

Correlation analysis was conducted to determine the impact of altitude and climatic conditions on chestnut propolis and honey yields. The correlation analysis revealed that there was a moderate and positive correlation between altitude and chestnut propolis yield and honey yield per hive. As the altitude increased, the chestnut propolis and chestnut honey yield per hive increased (Table VI). Pereira *et al*. (2009) reported that an additional source of variation affecting propolis production could be altitude. Schweitzer *et al*. (2013) and Pereira *et al*. (2009) reported that various climatic properties, such as annual rainfall, wind speed, temperature, relative humidity, and plant species, were effective on honey yield and nectar secretion.

There was a low and positive correlation between both temperature and chestnut propolis and honey yield per hive. Langowska *et al*. (2017) underlined that temperature had a dominant effect on honey yield. As the temperature increased, the chestnut propolis and chestnut honey yield per hive increased (Table VI). Schweitzer *et al*. (2013) reported that honey production would be higher in high temperatures, and that this could be due to the fact that woody plant species would flower at high temperatures. Similarly, in the study by Grogan (2020) a positive correlation was found between temperature and honey yield. Schweitzer *et al*. (2013) and Kajobé (2007) stated that there was a high correlation between temperature and nectar secretion. Pétanidou and Smets (1996), on the other hand, reported that plant nectar secretion increased up to 38°C as long as there was no water stress.

There was a moderate positive correlation between precipitation and chestnut propolis yield and honey yield per hive. As the total precipitation amount increases, the yield of chestnut propolis and chestnut honey increases per hive (Table VI). Schweitzer *et al*. (2013) found a positive correlation between precipitation and honey yield in their study, whereas Langowska *et al*. (2017) reported that the effect of precipitation was not found to be significant in

Table VI. The correlation matrix between chestnut honey and propolis yield and climatic factors.

Variable	Honey yield	Propolis yield	Altitude	Temperature	Relative humidity	Precipitation	Wind speed
Honey yield	1	0.271*	0.487**	0.249*	- 0.415**	0.551**	- 0.427**
Propolis yield	0.271*	1	0.453**	0.291**	- 0.427**	0.490**	- 0.286*
Altitude	0.487**	0.453**	1	0.879**	- 0.853**	0.980**	- 0.122
Temperature	0.249*	0.291**	0.879**	1	- 0.747**	0.766**	0.363**
Relative humidity	- 0.415**	- 0.427**	- 0.853**	- 0.747**	1	- 0.850**	0.175
Precipitation	0.551**	0.490**	0.980**	0.766**	- 0.850**	1	- 0.318**
Wind speed	- 0.427**	- 0.286*	- 0.122	0.363**	0.175	- 0.318**	1

*, Correlation was significant at 0,05 level (2-tailed); **, Correlation was significant at 0,01 level (2-tailed).

their studies. Pereira *et al*. (2009) found out a positive correlation between precipitation and propolis production in their study. Grogan (2020) stated that there was a negative correlation between precipitation and honey yield. Although rainy weather affects the exit mobility of bees from the hive (Lawson and Rands, 2019; Clarke and Robert, 2018), it is important for the vegetative development of plants. Pétanidou and Smets (1996) stated that precipitation would result in good vegetative development followed by more nectar flow.

There was a low and negative correlation between wind speed and chestnut propolis yield per hive, and a moderate and negative correlation between honey yield and wind speed. As the wind speed increased, the chestnut propolis and chestnut honey yield per hive decreased (Table VI). Hennessy *et al*. (2020) reported that with the increase of wind speed, there was a significant increase in the hesitancy of bees to take off and they visited significantly fewer flowers. Schweitzer *et al*. (2013) reported a positive correlation between wind speed and honey yield, and associated this with the wind speed level which did not prevent bee activity.

Schweitzer *et al*. (2013) reported that the correlation between average temperature and honey yield was higher than the correlation between the yield and precipitation and wind speed. However, in the present study, it was observed that the correlation between average temperature and honey yield was lower than the correlation between the yield and rain and wind speed.

There was a moderate and negative correlation between relative humidity and chestnut propolis and honey yield per hive. As the relative humidity increased, the chestnut propolis and chestnut honey yield per hive decreased (Table VI). Schweitzer *et al*. (2013) emphasized that relative humidity, a climatic factor, might have an effect on honey yield and that this effect should be investigated. Furthermore, Yavuz (2011) reported that external environmental conditions should be at suitable temperature and humidity for bees to soften, break and transport the propolis to the hive.

Table VII. The mean hive and propolis trap counts per apiculture business.

Equipment	Artvin	Ordu	Samsun	Trabzon	Genel
Hive	75.3	51.3	66.8	70.2	65.9
Propolis trap	8.6	7.4	10.7	12.5	9.8

The contribution of chestnut honey and propolis to regional economy

Based on the data collected with the interviews conducted with 290 chestnut honey producers in the study, the mean number of hives per beekeeping business in the region was 65.9, and the number of propolis traps was 9.8 (Table VII). According to the Turkish Statistical Institute data, the average number of hives per beekeeping business as of 2021 is 99.7 (Anonymous, 2021). The reason for the low number of hives in chestnut honey production is that most beekeepers producing chestnut honey are not mobile beekeepers. The mean chestnut honey market price in the region was US $ 52.55/kg and the mean raw propolis price was US $ 92.33/kg.

Based on the calculations conducted with the mean yield figures of 1,680 beekeepers in the chestnut forests of the Black Sea region, it was estimated that the contribution of chestnut honey production to the regional economy was US $ 50,964,941 (Table VIII). Similarly, based on the assumption that all 1,680 beekeepers in the region produced propolis, it was estimated that the contribution of propolis production to the regional economy was US $ 138,330.65 (Table IX). The total economic contribution of chestnut honey and propolis to the Eastern and Central Black Sea regions was US $ 51,103,271.

Table VIII. Potential chestnut honey production in Eastern Black Sea Region.

Number of apiculture businesses (a)	Mean hive count (hive/business) (b)	Hive yield*** (kg/hive) (c)	Production (kg) (d= a x b x c)	Price (US $) (e)	Production value (US $) (f= d x e)
1,680	65.9	8.76	969,837.12	52.55	50,964,940.7

***, Average chestnut honey production per hive obtained from the hives placed in the sample plots.

Table IX. Potential chestnut propolis production in Eastern Black Sea Region.

Number of apiculture businesses (a)	Mean propolis trap count (trap/business) (b)	Hive yield**** (kg/hive (c)	Production (kg) (d= a x b x c)	Price (US $) (e)	Production value (US $) (f= d x e)
1,680	9.8	0.091	1,498.22	92.33	138,330.65

****, Average propolis honey production per hive obtained from the hives placed in the sample plots.

CONCLUSION

The most important factor in beekeeping is the yield. In the study, it was determined that the chestnut honey and propolis yield per hive varied based on the province and the region. Certain spatial and climatic factors such as altitude, temperature, precipitation, humidity, and wind speed had direct or indirect effects on yield. It was observed that altitude, temperature and precipitation increased chestnut honey and propolis yield, while relative humidity and wind speed reduced the yield. The highest yield per hive was determined in Ordu province in the Central Black Sea region. This could be attributed to the fact that environmental and climatic factors did not interfere with nectar secretion or the labor of the bees in this province.

The chestnut honey yield is lower when compared to the mean honey yield in Turkey. It could be suggested that this was due to the short chestnut honey production season (two-three months) and the negative impact of certain climatic factors on the yield. However, a review of the market prices of flower honey and chestnut honey would demonstrate that the market price of chestnut honey is almost twice the price of flower honey. This could increase the income and eliminate the disadvantages caused by the difficulties in chestnut honey production.

Based on the present study findings, it could be suggested that the average chestnut propolis yield per hive was quite good. Thus, beekeepers who produce chestnut honey should be trained on propolis production, and their awareness about chestnut honey production should be raised. Increasing propolis production could fulfill the raw material demand in the health, food and cosmetics industries, and create additional income for beekeeping businesses.

Most honey produced in Turkey are recorded as flower honey, and the yields of various honey varieties are unknown. In the present study, chestnut honey and propolis yields were determined, and certain factors that affected the yield were identified. However, chestnut honey and chestnut propolis yields should be tested in different regions and in other honey varieties in future studies for further benefits for the apiculture industry.

Minimizing the constraints on beekeeping activities is essential for sustainable rural development. Considering the effects of climatic features on honey yield, studies are needed to investigate the possible effects of climate change on honey and propolis yield.

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IRB approval and ethical statement

The study was approval by the Republic of Turkey, Ministry of Agriculture and Forestry, the General Directorate of Forestry, the Eastern Black Sea Forestry Research Institute.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Afrouzan, H., Bankova, V., Tahmasebi, G., Bigdeli, M., and Popova, M., 2007. Comparison of gymnosperms and angiosperms plants on quality and quantity of propolis. *Malays. J. med. Sci.*, **14**: 106-107.

Agussalim, N., Umami, N., and Agus, A., 2020. The honey and propolis production from Indonesian stingless bee: *Tetragonula laeviceps*. *Livest. Res. Rural Dev.*, **32**: 121. https://doi.org/10.13057/biodiv/d220820

Akın, M.Ş., and Yılancı, A., 2021. The ımportance of beekeeping for rural development: Refahiye example. *İstanbul Sabahattin Zaim Üniv. Sosyal Bilimler Dergisi*, **9**: 33-48.

Al-Ghamdi, A., Adgaba, N., Herab, A.H., and Ansari, M.J., 2017. Comparative analysis of profitability of honey production using traditional and box hives. *Saudi J. biol. Sci.*, **24**: 1075-1080. https://doi.org/10.1016/j.sjbs.2017.01.007

Anonymous, 2013a. *Honey forest action plan*. Republic of Turkey Ministry of Agriculture and Forestry of General Directorate of Forestry, Ankara, Turkey.

Anonymous, 2013b. *Chesnut action plan*. Republic of Turkey Ministry of Agriculture and Forestry of General Directorate of Forestry, Ankara, Turkey. pp. 60.

Anonymous, 2020a. https://www.marketresearchfuture.com/reports/propolis-market-782 Access:

22.04.2020
Anonymous, 2020b. http://www.fao.org/faostat/en/#data Access: 18.04.2020
Anonymous, 2020c. http://www.ogm.gov.tr Access: 10.04.2020
Anonymous, 2020d. *Turkish association of beekeepers*. http://www.tab.org.tr/en/ Access:9.12.2019
Anonymous, 2021. *Turkish Statistical Institute*, https://data.tuik.gov.tr/Bulten/Index?p=Hayvansal-Uretim-Istatistikleri-Aralik-2021-45593 Access: 18.04.2020
Anonymous, 2022a. https://www.google.com/search?q=d%C3%BCnya+haritas%C4%B1+t%C3%BCrkiyeandtbm=ischandhl=trandsa=Xandved=2ahUKEwjUwd_77uj3AhWKi_0HHek9A8wQrNwCKAB6BQgBEPgBandbiw=1903andbih=880#imgrc=NuE01yymuHKX4M Access: 18.04.2020
Anonymous, 2022b. https://en.wikipedia.org/wiki/File:NUTS_Map_of_Turkey.png Access: 18.04.2020
Araba, S., and Özparlak, H., 2022. Propolis. *Selçuk Üniv. Fakül. Derg.*, **48**: 1-9. https://doi.org/10.35238/sufefd.1068425
Atik, A., and Gümüş, T., 2017. Potential uses of propolis in food industry. *Acad. Fd. J.*, **15**: 60-65. (Turkish, only abstract in English).
Bankova, V., and Marcucci, M.C., 2000. Standardization of propolis: Present status and perspectives. *Bee World*, **81**: 182-188. https://doi.org/10.1080/0005772X.2000.11099492
Bayram, R., Benek, S., Yavuz, M.Z., Benek, Ü., Gümüştekin, K., and Kaya, E., 2015. Can propolis support medical treatment?. *Eur. J. Hlth. Sci.*, **1**: 92-95. (Turkish, only abstract in English).
Burucu, V., and Bal, G.S., 2017. Current state of beekeeping and forecasting of honey production in Turkey. *J. Agric. Econ. Res.*, **3**: 28-37. (Turkish, only abstract in English).
Cengiz, M.M., 2013. The importance of natural pastures in beekeeping and organic honey production, *Bee Stud.*, **5**: 14-16. (Turkish, only abstract in English).
Ceyhan, V., Cinemre, H.A., Yeninar, H., Demiryürek, K., Bozoğlu, M., Kılıç, O., Öztürk, A.İ., Emir, M., Canan, S., Yıldırım, Ç., and Başer, U., 2016. *The current situation, problems and future of beekeeping in Turkey*. (1st ed.). Erol Publications, Samsun.
Choudhari, M.K., Haghniaz, R., Rajwade, J.M., and Paknikar, K.M., 2013. Anticancer activity of Indian stingless bee propolis: an in vitro study. *Evid. Based Complement. Altern. Med.*, **2013**: 1-10. https://doi.org/10.1155/2013/928280
Clarke, D., and Robert, D., 2018. Predictive modelling of honey bee foraging activity using local weather conditions. *Apidologie*, **49**: 386-396. https://doi.org/10.1007/s13592-018-0565-3
Çukur, F., 2014. *An evaluation on sustainability of beekeeping in Milas district of Mugla province*. XI. Ulusal Tarım Ekonomisi Kongresi, pp. 40-47. Konya. (Turkish, only abstract in English).
Daşdemir, İ., 2021. *Bilimsel araştırma yöntemleri (3rd ed.)*. 1536 Ankara: Nobel Publications.
Bulut, D.N., Bozlar, T., Gerçek, V., and Daşdemir, İ., 2017. *Determination of economic importance of chestnut honey production in Eastern Black Sea Region chestnut forests*. Research project no: 03.8208, Eastern Black Sea Forestry Research Institute. Trabzon, Turkey. https://doka.ogm.gov.tr/Yayinlar/Tek%20Yapraklar/2019-Trabzon-Kestane%20Bal%C4%B1%20Tek%20Yaprak.pdf (Access: 22.04.2020).
Grogan, H.K., 2020. *The impact of precipitation and temperature on honey yield in the United States*. Doctoral dissertation, Auburn University.
Güler, D., Engindeniz, S., Aydın Can, B., and Saner, G., 2018. *Evaluation of beekeeping in Turkey with multidimensional scaling analysis*. In: Proceedings of the 6th International Muğla Beekeeping and Pine Honey Congress. pp. 432-437.
Güngör, E., and Ayhan, A., 2016. Honey production potential and economic value of forest resources in Bartın Region. *Turk. J. For.*, **17**: 108-116. https://doi.org/10.18182/tjf.89126
Hegland, S.J., Nielsen, A., Lázaro, A., Bjerknes, A.L., and Totland, Ø., 2009. How does climate warming affect plant-pollinator interactions? *Ecol. Lett.*, **12**: 184-195. https://doi.org/10.1111/j.1461-0248.2008.01269.x
Hennessy, G., Harris, C., Eaton, C., Wright, P., Jackson, E., Goulson, D., and Ratnieks, F.F., 2020. Gone with the wind: effects of wind on honey bee visit rate and foraging behaviour. *Anim. Behav.*, **161**: 23-31. https://doi.org/10.1016/j.anbehav.2019.12.018
Kajobé, R., 2007. Botanical sources and sugar concentration of the nectar collected by two stingless bees species in a tropical African rain forest. *Apidologie*, **38**: 110-121. https://doi.org/10.1051/apido:2006051
Karlıdağ, S., and Köseman, A., 2015. The place and importance of beekeeping in Turkey and Malatya. *Arıcılık Araştırma Dergisi*, **7**: 27-31.
Kiziltas, H., and Erkan, C., 2020. The effects of different beehives on propolis production and quality. *Fd.*

Sci. Technol., **41**: 877-883. https://doi.org/10.1590/fst.20120
Kolaylı, S., Can, Z., Yıldız, O., Şahin, H., and Alpay, K.Ş., 2016. A comparative study of the antihyaluronidase, antiurease, antioxidant, antimicrobial and physicochemical properties of different unifloral degrees of chestnut (*Castanea sativa* Mill.) honeys. *J. Enzyme Inhib. med. Chem.*, **31**: 96-104. https://doi.org/10.1080/14756366.2016.1209494
Krell, R., 1996. Value-added products from beekeeping. *FAO Agric. Ser. Bull*., **124**.
Langowska, A., Zawilak, M., Sparks, T.H., Glazaczow, A., Tomkins, P.W., and Tryjanowski, P., 2017. Long-term effect of temperature on honey yield and honeybee phenology. *Int. J. Biometeorol.*, **61**: 1125-1132. https://doi.org/10.1007/s00484-016-1293-x
Lawson, D.A., and Rands, S.A., 2019. The effects of rainfall on plant–pollinator interactions. *Arthropod Pl. Interact.*, **13**: 561–569. https://doi.org/10.1007/s11829-019-09686-z
Lemeshow, S., Hosmer, Jr, D.W., Klar, J., and Lwanga, S.K., 1990. *Adequacy of sample size in health studies*. John Wiley and Sons Publications, NewYork.
Lima, M., Orsi, R.D.O., Costa, G.M., and Malaspina, O., 2016. Bralizian propolis by Africanizd bees (*Apis mellifera*). *Bee Word*, **92**: 58-68. https://doi.org/10.1080/0005772X.2015.1129229
Marinkovic, S., and Nedic, N., 2010. Analysis of production and competitiveness on small seekeeping farms in selected districts of Serbia. *Appl. Stud. Agribus. Commerce*, **4**: 65-70.
Miran, B., 2002. *Temel istatistik*. Ege Üniversitesi Publications, İzmir.
Mountford-McAuley, R., Prior, J., and Clavijo McCormick, A., 2021. Factors affecting propolis production. *J. Apic. Res*., **62**: 162-170. https://doi.org/10.1080/00218839.2021.1938456
Onuç, Z., Yanar, A., Saner, G., and Güler, D., 2019. An analysis on economical aspect of the beekeeping enterprise: A case of Kemalpaşa District-Izmir/Turkey. *Ege Univ. Ziraat Fak. Derg*., **56**: 7-14.
Özbilgin, N., Alataş, İ., Balkan, C., Öztürk, A.İ., and Karaca, Ü., 1999. Determination of main technıical and economical characteristics of beekeeping activities and the problems faced by beekeepers in Aegean Region. *J. Aegean Agric. Res. Inst.*, **9**: 149-171. (Turkish, only abstract in English).
Özsayın, D., and Karaman, S., 2018. *Determination of honey production costs in beekeeping enterprises*. Kırıkkale University, II. International Scientific and Vocational Studies Congress, Turkey, 592-598.
Pétanidou, T., and Smets, E., 1996. Does temperature induce nectar secretion in Mediterranean plants. *New Phytol*., **133**: 513-518. https://doi.org/10.1111/j.1469-8137.1996.tb01919.x
Pereira, R.G.C.O., Barchuk, A.R., and do Valle Teixeira, I.R., 2009. Environmental factors influencing propolis production by the honey bee *Apis mellifera* in Minas Gerais State. *Braz. J. Apic. Res.*, **48**: 176-180. https://doi.org/10.3896/IBRA.1.48.3.05
Sahinler, N., and Gul, A., 2005. The effects of propolis production methods and honeybee genotypes on propolis yield. *Pak. J. biol. Sci*., **8**: 1212-1214. https://doi.org/10.3923/pjbs.2005.1212.1214
Saner, G., Engindeniz, S., Çukur, F., and Yüksel, B., 2005. *A research on the technıcal and economıc structure and problems af beekeeping busınesses operatıng ın the provınces of Izmır and Muğla, Republic of Turkey*. Ministry of Agriculture and Forestry, Agricultural Economic And Policy Development Institute, no: 126, Ankara. (in Turkish).
Schweitzer, P., Nombré, I., and Boussim, J.I., 2013. Honey production for assessing the impact of climatic changes on vegetation. *Tropicultura*, **31**: 98-102.
Semerci, A., 2017. Overall situation of beekeeping in Turkey and future prospects. *Mustafa Kemal Univ. J. Agric. Sci.*, **22**: 107-118. (Turkish, only abstract in English).
Sıralı, R., 2010. *Importance of beekeeping for Turkey*. Republic of Turkey Ministry of Agriculture and Forestry, Apiculture Research Institute, https://www.researchgate.net/profile/Recep_Sirali/publication/322298875_ARICILIGIN_TURKIYE_ICIN_ONEMI/links/5a51e82b0f7e9bbc10548e4e/ARICILIGIN-TUeRKIYE-ICIN-OeNEMI.pdf Access: 15.03.2020
Yavuz, C., 2011. *Antimicrobial, antioxidant activities and the determination of bioactive components of propolis samples collected from some cities of Turkey*. Ordu University Graduate Institute of Natural and Applied Sciences, Ph.D. thesis, Ordu, Turkey. pp. 63.
Yazıcıoğlu Y., and Erdoğan, S., 2004. *SPSS applied scientific research methods*. Detay Publishing. No: 4, 448 p. Ankara, Turkey.