Dicle Üniversitesi Veteriner Fakültesi Dergisi
Dicle University Journal of Faculty of Veterinary Medicine

e-ISSN:1308-0679
https://dergipark.org.tr/tr/pub/duvetfd

RESEARCH ARTICLE

Assessment of the Microbiological and Physicochemical Characteristics of Bee Pollen From Şanlıurfa Region, Türkiye

Ayşegül DEMİRCİOĞLU[1,a,✉], Mehmet Emin AYDEMİR[2,b], Emine Betül TUĞBAY[2,c], Migena GJONİ GÜNDEMİR[3,d]

[1]Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Bursa Uludağ University, Bursa, TÜRKIYE
[2]Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Harran University, Şanlıurfa, TÜRKIYE
[3]Institute of Graduate Studies, Istanbul University-Cerrahpaşa, Istanbul, TÜRKIYE

ORCID: [a]0000-0002-5121-2631, [b]0000-0002-5849-1741, [c]0009-0005-0677-6365, [d]0000-0002-6342-6063

✉ Corresponding Author

Ayşegül DEMİRCİOĞLU

Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Bursa Uludağ University, Bursa, TÜRKIYE

aysegulertekinn@hotmail.com

Received
15.10.2025

Accepted
18.12.2025

Published
31.12.2025

DOI

10.47027/duvetfd.1803968

How to cite: Demircioğlu A, Aydemir ME, Tuğbay EA, Gündemir MG (2025). Assessment of the Microbiological and Physicochemical Characteristics of Bee Pollen From Şanlıurfa Region, Türkiye. *Dicle Univ Vet Fak Derg.*, 18(2):166-172.

Abstract

Bee pollen is commonly consumed as a natural dietary supplement due to its rich nutritional content and bioactive components. However, consuming it directly without any processing steps can pose a potential risk to public health concerning microbiological safety. This study aimed to assess the microbiological quality and certain physicochemical properties of bee pollen available for sale in the Şanlıurfa region. In this context, a total of 12 different bee pollen samples were analyzed, collected from local herbalists and apiculture product sales outlets. In the physicochemical analyses, pH, moisture, and color (CIE *Lab**) values were determined using standard analytical methods. For the microbiological analyses, counts were conducted for total mesophilic aerobic bacteria (TMAB), coliform bacteria, *Escherichia coli*, *Enterobacteriaceae*, yeast, and mold. Additionally, analyses were performed to detect the presence of *E. coli* O157:H7, Salmonella spp., *Listeria monocytogenes*, and *Staphylococcus aureus*. The pH, moisture, and color (CIE *Lab**) values were found to be 4.24–5.33 (average 4.91 ± 0.29), 9.87–24.66% (average 14.18 ± 4.40), and *L** 23.30 ± 4.27, *a** 10.81 ± 3.30, *b** 27.43 ± 7.44, respectively. In the microbiological analyses, total mesophilic aerobic bacteria (TMAB) counts ranged from 4.38 to 5.28 log CFU/g, yeast–mold counts from 2.34 to 3.92 log CFU/g, coliform bacteria from 1.97 to 3.27 log CFU/g, and *Enterobacteriaceae* from 1.73 to 4.23 log CFU/g. *E. coli*, *S. aureus*, *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7 were not detected in any of the samples. These results indicate that bee pollen is safe in terms of pathogens, but mold development in some samples may pose a mycotoxin risk. In conclusion, it was determined that bee pollen sold in the Şanlıurfa region is generally of suitable quality but requires attention regarding microbiological safety. To consider bee pollen a safe functional food, it is necessary to improve hygiene conditions during production and storage processes and to establish microbiological quality standards.

Key Words: Bee pollen, microbiological quality, food safety, Şanlıurfa

Türkiye'nin Şanlıurfa İlinde Satılan Arı Polenlerinin Mikrobiyolojik ve Fizikokimyasal Özelliklerinin Değerlendirilmesi

Öz

Arı poleni, zengin besin içeriği ve biyoaktif bileşenleri nedeniyle doğal bir gıda takviyesi olarak yaygın şekilde tüketilmektedir. Ancak herhangi bir işlem basamağından geçmeden doğrudan tüketilmesi, mikrobiyolojik güvenlik açısından halk sağlığı için potansiyel risk oluşturmaktadır. Bu çalışma, Şanlıurfa bölgesinde satışa sunulan arı polenlerinin mikrobiyolojik kalitesi ile bazı fizikokimyasal özelliklerini belirlemek amacıyla gerçekleştirilmiştir. Bu kapsamda, yerel aktarlardan ve arıcılık ürünleri satış noktalarında toplam 12 farklı arı poleni örneği analiz edilmiştir. Fizikokimyasal analizlerde pH, nem ve renk (CIE *Lab**) değerleri standart analitik yöntemlerle belirlenmiştir. Mikrobiyolojik analizlerde toplam mezofilik aerobik bakteriler (TMAB), koliform bakteriler, *Escherichia coli*, *Enterobacteriaceae*, maya ve küf için sayımlar yapılmıştır. Ayrıca, *E. coli* O157:H7, *Salmonella* spp., *Listeria monocytogenes* ve *Staphylococcus aureus* varlığı tespit etmek için analizler yapılmıştır. pH, nem ve renk (CIE *Lab**) değerleri sırasıyla 4.24–5.33 (ortalama 4.91 ± 0.29), % 9.87–24.66 (ortalama 14.18 ± 4.40) ve *L** 23.30 ± 4.27, *a** 10.81 ± 3.30, *b** 27.43 ± 7.44 olarak belirlenmiştir. Mikrobiyolojik analizlerde toplam mezofilik aerobik bakteri (TMAB) sayıları 4.38–5.28 log CFU/g, maya–küf sayıları 2.34–3.92 log CFU/g, koliform bakteriler 1.97–3.27 log CFU/g ve Enterobacteriaceae 1.73–4.23 log CFU/g aralığında tespit edilmiştir. *E. coli*, *Staphylococcus aureus*, *Salmonella* spp., *L. monocytogenes* ve *E. coli* O157:H7 hiçbir örnekte belirlenmemiştir. Bu sonuçlar, arı polenlerinin patojen açısından güvenli olduğunu ancak bazı örneklerdeki küf gelişiminin mikotoksin riski oluşturabileceğini göstermektedir. Sonuç olarak, Şanlıurfa bölgesinde satışa sunulan arı polenlerinin genel kalite açısından uygun olduğu, ancak mikrobiyolojik açıdan dikkat gerektirdiği belirlenmiştir. Arı poleninin güvenli bir fonksiyonel gıda olarak değerlendirilebilmesi için üretim ve depolama süreçlerinde hijyen koşullarının iyileştirilmesi ve mikrobiyolojik kalite standartlarının oluşturulması gerekmektedir.

Anahtar Kelimeler: Arı poleni, mikrobiyolojik kalite, gıda güvenliği, Şanlıurfa

INTRODUCTION

Bee pollen is a substance produced through the agglutination of flower pollens with nectar and the salivary secretions of worker honeybees, and it is collected at the hive entrance (1). Historically, bee pollen has been utilized by humans as a rich nutritional source and is currently regarded as a significant product in the domains of health and nutrition (2-5). Owing to its substantial nutritional value, bee pollen is frequently characterized as "a complete and perfect food on its own." It contains carbohydrates, proteins, enzymes, fatty acids, carotenoids, phenolic compounds, flavonoids, sterols, terpenes, minerals, and vitamins, thereby holding a prominent position in human nutrition. Furthermore, it is notably abundant in essential amino acids and fatty acids, such as Omega-3 and Omega-6 (6).

Bee pollen is recognized as a natural product with significant nutritional and therapeutic benefits, attributed to its rich chemical composition. It comprises carbohydrates like fructose, glucose, and sucrose; fiber content ranging from 13–55%; protein levels between 9–40%; 4–10% lipids; and essential minerals such as potassium (K), phosphorus (P), magnesium (Mg), and calcium (Ca). The composition of bee pollen can vary considerably based on its botanical origin, the area of collection, processing techniques, and storage conditions. This suggests that the biological and nutritional value of pollen may fluctuate (7). Studies have identified that bee pollen contains over 250 bioactive compounds derived from plants. Notably, its phenolic compounds (including gallic, caffeic, ferulic, chlorogenic, and coumaric acids) and flavonoid compounds (such as quercetin, myricetin, kaempferol, and galangin) render this product a potent natural antioxidant source (8).

Bee pollen has garnered significant interest for its health benefits, making its safe consumption as a food crucial. With its rich nutritional profile and pharmacological properties, bee pollen holds substantial commercial promise and is favored as a food source due to its functional and nutritious components. Thus, it is vital to offer consumers bee pollen that is not only highly nutritious but also boasts superior organoleptic qualities and assured microbiological quality (9-10). Although ensuring the microbiological safety of bee pollen particularly the absence of molds and pathogenic microorganisms is a critical quality parameter, its high sensitivity from a microbiological standpoint means that direct exposure to environmental factors during production, collection, processing, and storage can lead to microbial contamination (11-13). Additionally, bacteria, yeasts, and molds can easily contaminate the collected pollen through soil, air, plant surfaces, and the bees' own microflora (6). Especially high humidity, improper storage conditions, or unhygienic collection methods can result in increased microbial growth and product spoilage (14,15).

The microbiological safety of the product, particularly the absence of mold and pathogenic microorganisms, should be regarded as a critical quality parameter (12,13). Although bacterial pathogens or potentially harmful microorganisms such as pathogenic Escherichia coli, *Salmonella* species, *Listeria monocytogenes*, and *Bacillus cereus* are infrequently detected, there have been reports of frequent mold contamination in bee pollen (13). However, studies investigating the microbiological quality of bee pollen are limited. Generally, research has concentrated more on physicochemical properties, especially antioxidant activity. This situation underscores the importance of microbiological evaluations for the safe consumption of pollen. Consequently, determining the microbiological quality of bee pollen is a fundamental requirement for both food safety and public health.

This study seeks to assess the microbiological and certain physicochemical properties of bee pollen available for sale in Şanlıurfa, a city in the Southeastern region of Turkey. The results obtained from this research are expected to offer valuable insights into the overall quality and food safety standards of bee pollen in the area, thereby aiding in the provision of safe and high-quality products to consumers.

MATERIAL AND METHODS

Collection of Pollen Samples

In this study, bee pollen samples were sourced from local herbalists and beekeeping product outlets located in the city center and districts of Şanlıurfa during September and October 2025. A total of 12 distinct bee pollen samples, each weighing approximately 100 g, were collected from both unpackaged products. The samples were collected randomly from different manufacturers. The samples were promptly transported to the laboratory under a cold chain, where analyses were commenced.

Microbiological Analyses

To prepare a 10^{-1} dilution, 10 g from each pollen sample was homogenized in 90 mL of buffered peptone water (Buffered Peptone Water, Oxoid, UK) using a stomacher device (Mayo Homogeniser HG400V, UK) for 2 minutes. Subsequent dilutions of the sample, up to 10^{-7}, were made using the same diluent and plated in duplicate series. After incubation, plates with 30–300 colonies were evaluated (16). The results were expressed as log cfu/g.

In the realm of microbiological analyses, inoculations for the total mesophilic aerobic bacteria (TMAB) count were conducted on Plate Count Agar (PCA, Merck, Darmstadt, Germany) medium. These were incubated at 35 °C for 48 hours, after which colony counts were performed (16). Coliform bacteria were counted on Violet Red Bile Agar (VRB) following incubation at 37 ± 1 °C for 24 hours, where typical dark red colonies were counted (17). For the identification of the Enterobacteriaceae group, Violet Red Bile Glucose Agar (VRBG) was employed; incubation occurred at 37 ± 1 °C for 24 hours, and red colonies were counted (18). Yeast and mold counts were conducted on Dichloran Rose Bengal Chloramphenicol (DRBC) Agar, incubated at 25 ± 1 °C for 5 days, followed by colony counts (ISO, 2008). For Escherichia coli counts, inoculations were made on Tryptone Bile X-Glucuronide Agar (TBX, Oxoid) medium, incubated at 44 °C for 24 hours, and green colonies were counted at the end of the incubation period (ISO 16649-2, 2001). In the case of *Staphylococcus aureus*, inoculations were performed on Baird Parker Agar (BP, Oxoid, England) medium, incubated at 37 °C for 24-48 hours, and colony counts were subsequently carried out.

To analyze Salmonella spp., *Listeria monocytogenes*, and *Escherichia coli* O157:H7, a standard presence/absence test was conducted on a 25 g pollen sample. Initially, the samples

were pre-enriched in Tryptic Soy Broth (BIOKAR Diagnostics, France) at 37 °C for 18–24 hours. Subsequently, streak plating was carried out on selective media: Xylose Lysine Deoxycholate Agar (BIOKAR Diagnostics, France) for *Salmonella* spp., Oxford agar (BIOKAR Diagnostics, France) for *Listeria monocytogenes*, and Cefixime Tellurite Sorbitol MacConkey (CT-SMAC) Agar for *Escherichia coli* O157:H7. The results were then evaluated after a 24-hour incubation at 37 °C (19-21).

Physical and Chemical Analyses

pH analysis

5 g from each pollen sample was weighed and mixed with 45 mL distilled water, then homogenized for 10 minutes using a magnetic stirrer. The pH value of the resulting suspension was measured with a pH meter (HANNA HI2002-02, Italy). Before measurements were taken from the samples on each analysis day, the pH meter was calibrated (pH 4, pH 7, and pH 10) (22).

Total Moisture analysis

By taking 5 g from each sample and weighing it into porcelain crucibles previously brought to constant weight, they were dried in a drying oven at 105 °C (Nüve FN 400P/500P, Turkey) for 1 hour, cooled, and weighed. The moisture content was calculated as a percentage based on the difference between the initial and final weights (22).

Color Analysis

The color of the pollen samples was assessed utilizing a CS-10° 8 mm portable digital colorimeter (Tuodapu, Inc., China) in accordance with the CIE Lab* system. Prior to each measurement session, the colorimeter was calibrated using a standard white tile. Measurements were conducted at three distinct points on each sample, and the values for L* (lightness), a* (red-green), and b* (yellow-blue) were reported as mean ± SD (6).

Statistical Analyses

The data collected from the research were analyzed utilizing SPSS 24.0 for Windows (SPSS Inc., NY, USA). Statistical evaluation was conducted on microbial counts, pH, moisture content, and color parameters (*L**, *a**, *b**). The microbiological data were logarithmically transformed prior to analysis. A one-way analysis of variance (ANOVA) was employed to ascertain differences among the samples, followed by the Tukey post-hoc test to identify significant differences. All analyses were performed in two independent replicates, with results expressed as mean ± standard deviation (±SD). Statistical significance was determined at a level of $P<0.05$.

RESULTS

The physicochemical analysis of the 12 distinct bee pollen samples investigated in this study demonstrated significant variability among the samples (Table 1, Figure 1). The *L**, *a**, and *b** values, assessed as color parameters, were determined to be 23.30±4.27, 10.81±3.30, and 27.43±7.44, respectively. This suggests that the pollen samples may differ in terms of color intensity and saturation. The notably high standard deviation in the *b** value indicates considerable diversity in yellow hues. The pH values ranged from 4.24 to 5.33, with an average of 4.91±0.29, indicating that the pollen samples are slightly acidic, a characteristic potentially significant for stability and microbial resistance. The total moisture content was measured at 14.18±4.40%, with some samples reaching up to 24.66%. This parameter is crucial for considerations related to product shelf life and microbial safety. The findings indicate that the physicochemical properties of pollen can vary substantially depending on their sources and environmental conditions.

Table 1. Some physicochemical properties of bee pollen samples

	Number of samples (n)	Minimum	Maximum	Mean ± SD
L*	12	16.65	28.61	23.30±4.27
a*	12	5.66	18.47	10.81±3.30
b*	12	18.64	45.26	27.43±7.44
pH	12	4.24	5.33	4.91±0.29
Total moisture content (%)	12	9.87	24.66	14.18±4.40

SD: Standard deviation

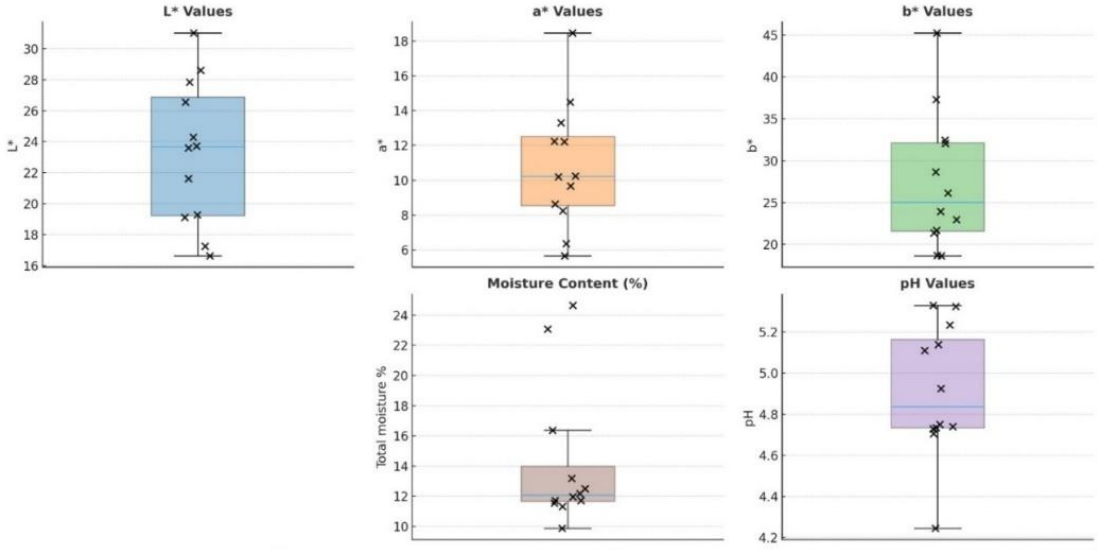

Figure 1. Some physicochemical properties of bee pollen samples

The microbiological analysis results of the bee pollen samples are presented in Table 2. Total mesophilic aerobic bacteria (TMAB) counts ranged from 4.38 to 5.28 log CFU/g. Yeast and mold counts were found to be between 2.34 and 3.92 log CFU/g. While total coliform counts were below 1.00 log CFU/g in some samples, they ranged from 1.97 to 3.27 log CFU/g in positive samples. Similarly, total Enterobacteriaceae counts were detected between less than 1.00 and 4.23 log CFU/g. In contrast, *E. coli* and *S. aureus* counts were consistently below 1.00 log CFU/g in all samples. Furthermore, specific pathogen analyses revealed that E. coli O157:H7, *Salmonella* spp., and *Listeria monocytogenes* were not detected in any of the samples.

Table 2. Microbiological quality parameters of bee pollen samples (log CFU/g)

Sample No	TMAB log CFU/g	Total yeast-mold log CFU/g	Total coliform log CFU/g	Total Enterobacteriaceae log CFU/g	E. coli log CFU/g	S. aureus log CFU/g
1	4.72±0.06^{bcd}	3.59±0.01^{ab}	2.23±0.08^{ef}	2.75±0.02^{bc}	<1.00±0.00	<1.00±0.00
2	4.89±0.07^{ab}	3.80±0.70^{a}	<1.00±0.00^{h}	<1.00±0.00^{e}	<1.00±0.00	<1.00±0.00
3	4.43±0.05^{d}	3.15±0.63^{b}	2.65±0.06^{cd}	2.06±0.02^{cd}	<1.00±0.00	<1.00±0.00
4	4.98±0.01^{ab}	2.84±0.20^{c}	2.14±0.04^{f}	1.73±0.05^{d}	<1.00±0.00	<1.00±0.00
5	5.01±0.08^{ab}	2.34±0.79^{c}	1.97±0.03^{g}	1.95±0.06^{cd}	<1.00±0.00	<1.00±0.00
6	5.28±0.15^{a}	3.62±0.95^{ab}	2.43±0.05^{de}	2.57±0.04^{bcd}	<1.00±0.00	<1.00±0.00
7	4.38±0.12^{d}	2.62±0.88^{c}	<1.00±0.00^{h}	<1.00±0.00^{e}	<1.00±0.00	<1.00±0.00
8	4.71±0.08^{bcd}	3.92±0.77^{a}	2.57±0.04^{d}	2.23±0.08b^{cd}	<1.00±0.00	<1.00±0.00
9	4.69±0.12^{bcd}	3.86±0.26^{a}	2.87±0.04^{b}	3.03±0.79^{b}	<1.00±0.00	<1.00±0.00
10	4.70±0.14^{bcd}	3.61±0.96^{ab}	3.27±0.03^{a}	4.23±0.08^{a}	<1.00±0.00	<1.00±0.00
11	4.85±0.06^{bc}	3.22±0.78^{b}	<1.00±0.00^{h}	<1.00±0.00^{e}	<1.00±0.00	<1.00±0.00
12	4.47±0.11^{cd}	3.49±0.71^{ab}	2.82±0.02^{bc}	2.65±0.06^{bcd}	<1.00±0.00	<1.00±0.00

$^{a-h}$: Mean values shown with different letters in the same column are significantly different (P<0.05).

DISCUSSION AND CONCLUSION

According to the Turkish Food Codex communiqué on bee products, the moisture content of bee pollen should be 22 %m/m, while that of dried bee pollen should be 10 %m/m (23). Among the tested samples, seven had moisture levels close to these standard values, whereas two samples exhibited significantly higher moisture content (24.66, 23.10) (Figure 1). Similar findings have been reported in other studies. Çelik and Öncü (6) observed that the moisture content of pollen in Muğla ranged from 15.033% to 32.114%. In Istanbul, the moisture content of 12 pollen samples was reported to range between 1.17% and 5.80% (24). Belhadj et al. (25) noted that pollen moisture content varied from 18.11% to 36.29%. Keskin and Özkök (26) found that the moisture content of bee pollen samples ranged from 6.23% to 20.62%. Moisture content is crucial for the shelf life and organoleptic properties of pollen. High moisture levels can primarily lead to microbial contamination by yeast and mold and may also hinder the drying process. The moisture content is influenced by the timing of pollen collection from the pollen trap. Due to its hygroscopic nature, pollen can easily absorb moisture if not harvested daily by beekeepers, especially in high-humidity conditions. Furthermore, low moisture content (below 3%) can cause undesirable effects such as discoloration, browning, Maillard reactions, fructose dehydration, loss of volatile compounds, and lipid oxidation, all of which can affect pollen quality (27,28).

The pH value of bee pollen plays a crucial role in determining its texture, stability, and shelf life during storage (29). In this study, the pH values of the pollen samples ranged from 4.24 to 5.33, indicating their acidic nature (Table 1). These findings align with those reported for samples collected from Muğla (3.71-5.66), Istanbul (3.75-4.30), and Portugal (4.3-6.33, 4.3-5.2) (6, 24, 28, 30).

The color of a food is the most important aspect of customer preference because it is often the first element noticed in the appearance of a food product (31). Pollens can be seen in many colors, ranging from cream to brown, yellow, orange, red, green, and black due to their botanical taxa and chemical composition (32). The color values of all samples were determined using the *L**, *a**, and *b** scale. The *L**, *a**, and *b** results ranged between 23.30±4.27, 10.81±3.30, and 27.43±7.44, respectively. According to the results, the tested pollen samples tended to be reddish and yellowish. Yook et al. (33) calculated the color values using the Hunter method. The *L** value was 74.5, indicating that their samples were lighter than ours. In the same study, the *a** and *b** values were reported as 4.2 and 30.8. In another study, the *L**, *a**, and *b** values were recorded as 42.8-58.4, 8.4-11.3, and 43.7-56.1, respectively (34). Dulger Altıner et al. (35) analyzed the colors of 20 bee pollen samples collected from Istanbul and found *L**; 56.42, *a**; 4.22, and *b**; 23.94. Çelik and Öncü (6) reported that the L*, *a**, and *b** results of pollens from Muğla ranged from 52.095 to 59.783, 3.71 to 13.605, and 14.790 to 37.065, respectively. The differences in pollen colors between studies can be attributed to factors such as plant diversity, source, drying temperature, drying duration, and so on (27).

Based on the results of the physicochemical analysis, notable differences were identified in the pH, moisture, and color values of the pollen samples. These variations are believed to stem from environmental factors such as botanical origin, collection time, regional climatic conditions, and storage methods. The data obtained highlighted the physicochemical values of the pollen available for sale in the Şanlıurfa region.

While the Turkish Food Codex does not specifically regulate the microbiological criteria for pollen or beekeeping products, the appendix titled 'Pathogenic Microorganism Limits' in the Turkish Food Codex Regulation on Microbiological Criteria is employed to evaluate the product's adherence to legal limits (36). According to this regulation, none of the five samples of ready-to-eat foods should contain Salmonella, *L. monocytogenes*, or *E. coli O157:H7* in 25 g/mL. For

coagulase-positive staphylococci, a maximum of two out of five samples may contain 10^2–10^3 cfu/g in 25 g/mL. Bee pollen samples comply with the pathogenic criteria of the regulation due to the absence of *L. monocytogenes*, *E. coli* O157:H7, *Salmonella* spp., and *S. aureus*. National pollen standards are present in only a few countries worldwide, including Switzerland, Argentina, Bulgaria, Brazil, and Poland. According to Argentine regulations, the total count of aerobic bacteria and yeasts-molds should not exceed $150x10^3$ CFU/g (5.17 log CFU/g) and 10^2 CFU/g (2 log CFU/g), respectively (37). Additionally, pathogenic bacteria must not be present in pollen products (38). The absence of pathogens in the tested pollen samples indicates compliance with these regulations. Although all tested pollen samples met the TMAB criteria of this regulation, none complied with the yeast-mold criteria.

TMAB counts are often utilized as a measure of food safety and sanitation. A high count of mesophilic bacteria in a product suggests processing and storage conditions that may foster the growth of pathogens originating from humans or animals. This also indicates a likelihood of the product containing these pathogens (39). In the current study, TMAB counts in bee pollen ranged from 4.38 to 5.28 log CFU/g. Specifically, bee pollen samples from Muğla showed a TMAB count of 4.43 log CFU/g, whereas samples from Istanbul had TMAB counts ranging from; 1.00 to 3.48 log CFU/g (23). Consequently, the TMAB counts observed in bee pollen were consistent with those from Muğla but exceeded those from Istanbul.

In this study, yeast and mold counts were found to range from 2.34 to 3.92 log CFU/g. The total yeast count in bee pollen samples from Muğla was reported as 2.72 log CFU/g (6), whereas the yeast and mold count in samples from Istanbul was reported as <1.00–2.04 log CFU/g (23). Nogueira et al. (9) noted that yeast and mold were detected in 50% of eight bee pollen samples. It is noteworthy that the yeast and mold counts obtained in this study are higher than those reported in some previous studies. This discrepancy can primarily be attributed to the environmental conditions during pollen collection, the plant source, and the bees' access to vegetation. Pollen collected from regions with high humidity or during rainy seasons provides more favorable conditions for microbial growth, naturally increasing the microbial load. Additionally, the drying time, method, and storage conditions post-collection can directly impact the microbial load. Insufficient drying or unhygienic storage conditions can promote the proliferation of microorganisms such as yeast and mold. A high mold count in a product increases the likelihood of mycotoxins, thereby raising health risks (39).

The presence of coliforms and Enterobacteriaceae, particularly in products sold openly or stored under unsuitable conditions, can indicate environmental contamination. Coliform bacteria, commonly found in both the intestine and nature (such as soil and plants), are regarded as indicators of sanitation in the food industry. High levels of coliform microorganisms in bee pollen suggest that essential hygienic measures were not observed during the collection, production, storage, and sale processes. Coliforms and Enterobacteriaceae were detected in all tested samples except for three. In studies by Sandıkçı Altunatmaz and Aksu (23) and Anjos et al. (40), no coliform bacteria were found in the tested bee pollen. However, consistent with our findings, Serra Bonvehi and Escolà Jordà (41) identified coliform bacteria in 55% of bee pollen samples, while Çelik and Öncü (6) reported coliform bacteria levels ranging from 1.98 log MPN/g to 3.74 log MPN/g, and Hani et al. (42) reported levels between 3–5.47 log CFU/g.

However, the absence of pathogenic microorganisms such as *E. coli* O157:H7, Salmonella spp, and *L. monocytogenes* in bee pollen indicates that hygienic collection and processing conditions are generally maintained. Consistent with our findings, other studies have also reported the non-detection of *E. coli*, *S. aureus*, E. coli O157:H7, *Salmonella* spp., and *L. monocytogenes* in bee pollen (6,23,28,43). Campos et al. (12) further emphasized that from a microbiological standpoint, Salmonella spp., E. coli, and S. aureus should not be present in pollen. Nevertheless, Belhadj et al. (24) found that in 7 out of 15 pollen samples sourced from beekeepers (2 samples) and local markets (13 samples), *Salmonella* spp. were detected, *Listeria* spp. in 10 samples, and *S. aureus* in 14 samples. Although these pathogens were not found in bee pollen sold in Şanlıurfa, it is evident that bee pollen could pose a risk concerning these pathogens if hygiene protocols are not adhered to.

This study aimed to uncover the physicochemical properties and microbiological quality of bee pollen available for sale in the Şanlıurfa region. The findings indicated that while the pollen samples generally exhibited good physicochemical characteristics. They were subject to a certain level of microbiological contamination. Microbiological analyses revealed variations in the levels of total aerobic mesophilic bacteria, yeast and mold, coliform bacteria. *Enterobacteriaceae* across different samples. The absence of major foodborne pathogens such as *Salmonella* spp. *Listeria monocytogenes*, *Escherichia coli O157:H7* and *Staphylococcus aureus* in any of the samples suggests that the pollen meets basic food safety standards for consumption. However, the presence of mold in some samples is concerning due to the potential risk of mycotoxin contamination. Given that improper production. Drying and storage conditions can encourage mold and toxin formation. it is crucial to manage these processes within hygienic standards. The results underscore the critical importance of microbiological quality for public health, as bee pollen is a directly consumed and unprocessed product. Therefore, before recommending pollen as a functional food or supplement, a microbiological risk assessment should be conducted. and standard quality criteria should be established to ensure safe consumption. Additionally, setting microbiological limits and legal regulations for bee pollen in our country is essential to protect consumer health. In conclusion, this study highlights that while bee pollen marketed in the Şanlıurfa region is generally of good quality, there is a pressing need for careful control and appropriate storage conditions to prevent microbiological contamination. It is believed that such studies will contribute to the development of standardization and quality assurance systems for bee products in our country.

FINANCIAL SUPPORT

No support was received from any organization in the conduct of this research

CONFLICT OF INTEREST

There is no conflict of interest to be declared by the authors

AUTHOR CONTRIBUTIONS

AD, took part in the study planning and sample collection. Experimental studies were carried out by AD, MEA, MGG and EBT. The writing of the study and final checks were carried out with the contributions of all authors.

ETHICAL STATEMENT

According to the Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees (13), Article 8 19-k, since live animals are not used and the study is conducted on products sold in the market, there is no need for ethics committee approval for the study.

REFERENCES

1. **Bouazza S, Demmouche A, Mai H, Brikhou S, Bensaoud S, Djabour F (2020).** Expert survey on bee pollen uses in Sidi Bel Abbes (Algeria). Bee World. 97(1):6-9.
2. **González G, Hinojo MJ, Mateo R, Medina A, Jiménez M (2005).** Occurrence of mycotoxin producing fungi in bee pollen. *Int J Food Microbiol*., 105(1):1–9.
3. **Kacániová M, Hleba L, Dzugan M et al (2012).** Microbiological properties and antimicrobial effect of Slovakian and Polish honey having regard to the water activity and water content. *J Microbial Biotechnol Food Sci*., 2(1):272-281.
4. **Estevinho LM, Rodrigues S, Pereira AP, Feás X (2012).** Portuguese bee pollen: Palynological study. Nutritional and microbiological evaluation. *Int J Food Sci.,* 47:429–435.
5. **Matuszewska E, Klupczynska A, Maciołek K, Kokot ZJ, Matysiak J (2021).** Multielemental analysis of bee pollen. Propolis. and royal jelly collected in west-central Poland. *Molecules*, 26(9):1-18.
6. **Çelik M, Öncül N (2022).** Microbiological quality and nutritional values of honey bee pollen. *JFSFQ*., 73(5):142-151.
7. **Mărgăoan R, Özkök A, Keskin S, Mayda N, Urcan AC, Cornea-Cipcigan M (2021).** Bee collected pollen as a value-added product rich in bioactive compounds and unsaturated fatty acids: a comparative study from Turkey and Romania. *LWT Food Sci. Technol.,* 149:111925
8. **Stajko AR, Stajko J, Kurek-Gorecka A et al (2015).** Polyphenols from bee pollen: Structure, absorption, metabolism and biological activity. *Molecules,* 20(12):21732-49.
9. **Nogueira C, Iglesias A, Feás X, Estevinho LM (2012).** Commercial bee pollen with different geographical origins: A comprehensive approach. *Int J Mol Sci.,* 13(9):11173-11187.
10. **Barbieri D, Gabriele M, Summa M, Colosimo R, Leonardi D, Domenici V, Pucci L (2020).** Antioxidant, nutraceutical proper ties, and fluorescence spectral profiles of bee pollen samples from different botanical origins. *Antioxidants*, 9(10):1001.
11. **Erol İ (2007).** Gıda Hijyeni ve Mikrobiyolojisi. Ankara: Pozitif Matbaacılık. pp.172-84.
12. **Campos. MGR, Bogdanov S, de Almeida-Muradian LB, Szczesna T, Mancebo Y, Frigerio C, Ferreira F (2008).** Pollen composition and standardisation of analytical methods. *J Apic Res.,* 47:154–161.
13. **Nuvoloni R, Meucci V, Turchi B, Sagona S, Fratini F, Felicioli A, Cerri D, Pedonese F (2021).** Bee-pollen retailed in Tuscany (Italy): Labelling, palynological, microbiological, and mycotoxicological profile. *LWT Food Sci. Technol.,* 140:1-9.
14. **Mauriello G, De Prisco A, Di Prisco G, La Storia A, Caprio E (2017).** Microbial characterization of bee pollen from the Vesuvius area collected by using three different traps. *PLoS One.,* 12(9):1-17.
15. **Cabello JR, Serrano S, Rodríguez I, García-Valcárcel AI, Hernando MD, Flores JM (2021).** Microbial decontamination of bee pollen by direct ozone exposure. *Foods,* 10(11):1-11.
16. **USDA/FSIS. (2011).** "Microbiology Laboratory Guidebook. Metot 3.01. Quantitative analysis of bacteria in foods as sanitary indicators."
17. **ISO 4832. (2006).** "Microbiology of food and animal feeding stuffs-Horizontal method for the enumeration of coliforms-Colony-count technique."
18. **ISO 21527-1. (2008).** "Microbiology of food and animal feeding stuffs: horizontal method for the enumeration of yeasts and moulds."
19. **Hitchins. AD (2003).** Detection and enumeration of Listeria monocytogenes in foods. Bacteriological Analytical Manual. FDA. Laboratory Methods. Chapter: 10.
20. **International Organization for Standardization (ISO) 16649-2. 2001:** Microbiology of food and animal feding stuffs-Horizontal method for the detection and enumeration of β-glucuronidase-positive Escherichia coli. Part 2. Colony-count technique a 44°C using 5-brome-4chloro-3-indoly-betaDglucuronide. Geneve. Switzerland.
21. **International Organization for Standardization. ISO 6579:2002-A1:2007.** Microbiology of Food and Animal Feeding Stuffs. Horizontal Method for the Detection of Salmonella spp. International Standardization Organization ed. Geneva. Switzerland.
22. **AOAC (1997).** Official Methods of Analysis of AOAC International (16th. Pub). Arlington. VA.USA.
23. **TGK (2024).** Tarım ve Orman Bakanlığı Türk Gıda Kodeksi Arı Ürünleri Tebliği (Tebliğ No: 2024/6) https://kms.kaysis.gov.tr/Home/Kurum/24308110, access date: 28.09.2025
24. **Dulger Altıner D, Sandikci Altunatmaz S, Sabuncu M, Aksu F, Sahan. Y (2020).** In-vitro bioaccessibility of antioxidant properties of bee pollen in Turkey. *FS&T.,* 41(suppl 1):133-141.
25. **Belhadj H, Harzallah D, Dahamna S, Khennouf S (2014)**. Microbiological quality control of marketed pollen. *Der Pharmacia Lettre*, 6(2):37-42.
26. **Keskin M, Özkök A (2020).** Effects of drying techniques on chemical composition and volatile constituents of bee pollen. *Czech J Food Sci.,* 38(4):203-208.
27. **Kieliszek M, Piwowarek K, Kot AM, Błażejak S, Chlebowska-Śmigiel A, Wolska I (2018)**. Pollen and bee bread as new health-oriented products: A review. *TIFS.,* 71. 170-180.
28. **Estevinho LM, Rodrigues S, Pereira AP, Feás. X (2012).** Portuguese bee pollen: Palynological study, nutritional and microbiological evaluation. *IJFST.,* 47(2):429-435.
29. **Nogueira C, Iglesias A, Feás X, Estevinho LM (2012).** Commercial bee pollen with different geographical origins: a comprehensive approach. *Int J Mol Sci.,* 13(9):11173–11187.
30. **Feás X, Vázquez-Tato MP, Estevinho L, Seijas JA, Iglesias A (2012)**. Organic bee pollen: Botanical origin, nutritional value, bioactive compounds, antioxidant activity and microbiological quality. *Molecules,* 17(7):8359-8377.
31. **Fellows PJ (2000).** Food Processing Technology. CRC Press. Boca Raton. Florida. USA.

32. **Almeida-Muradian. LBD, Pamplona LC, Coimbra S, Barth OM (2005).** Chemical composition and botanical evaluation of dried bee pollen pellets. *J Food Compos Anal.,* 18(1):105-111.
33. **Yook HS, Lim SI, Byun MW (1998).** Changes in microbiological and physicochemical properties of bee pollen by application of gamma irradiation and ozone treatment. *JFP.,* 61(2):217-220.
34. **De-Melo AAM, Estevinho MLMF, Sattler JAG, Souza BR, da Sil va Freitas A, Barth OM, Almeida-Muradian LB (2016).** Effect of processing conditions on characteristics of dehydrated bee pollen and correlation between quality parameters. LWT-Food Scı Technol 65:808–815.
35. **Dulger Altıner D, Sandikci Altunatmaz S, Sabuncu M, Aksu F, Sa han Y (2020).** In-vitro bioaccessibility of antioxidant properties of bee pollen in Turkey. *Food Sci Technol.,* 41:133–141.
36. **TGK (2025).** Türk Gıda Kodeksi Mikrobiyolojik Kriterler Yönetmeliği https://kms.kaysis.gov.tr/Home/Kurum/24308110, access date: 28.09.2025
37. **Boletín Oficial de la República Argentina. Resolución Conjunta** 24/2025 (Boletín Oficial n.° 324381). Recuperado de https://www.boletinoficial.gob.ar/detalleAviso/primera/324381/20250424
38. **Krell R (1996).** Value-added products from beekeeping. Food and Agriculture Organization of the United Nations (FAO) Agri cultural Services Bulletin No. 124 M-24, ISBN 92-5-103819-8, Rome.
39. **Ünlütürk A, Turantas¸ F (2003).** Gıda Mikrobiyolojisi. İzmir: Meta Basım Matbaacılık Hizmetleri.
40. **Anjos O, Paula, VB, Delgado T, Estevinho LM (2019).** Influence of the storage conditions on the quality of bee pollen. *Zemdir byste-Agriculture* 106:87–94.
41. **Serra Bonvehi J, Escolà Jordà R (1997).** Nutrient composition and microbiological quality of honeybee-collected pollen in Spain. *J Agric Food Chem.,* 45(3):725–732
42. **Hani B, Dalila B, Saliha D, Daoud H, Mouloud G, Seddik K (2012).** Microbiological sanitary aspects of pollen. *Adv Environ Biol.,* 6(4):1415–1420.