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Palynological analysis of honey produced in the East Kazakhstan Region of the Republic of Kazakhstan

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Abstract. Verifying the botanical origin of natural honey is one of the key tasks in modern quality control of beekeeping products, as the reliability of information regarding its floral origin determines its consumer value, confirms its authenticity and helps to prevent adulteration. This issue is of particular relevance to regions with high floristic diversity, including the East Kazakhstan Region of the Republic of Kazakhstan, where natural conditions give rise to a wide range of honey-producing vegetation and create favourable conditions for the production of honey of various botanical origins. The aim of the study was to establish the actual botanical origin of samples of natural honey based on a palynological analysis of their pollen composition, and to assess the consistency of the results obtained with the floral composition declared by the producers. The study focused on 18 samples of natural honey obtained from various districts of the East Kazakhstan Region and labelled by the producers as polyfloral, buckwheat and sunflower honey. The study was carried out using light microscopy, followed by the identification of pollen grains based on a set of morphological characteristics. For each sample, the taxonomic composition of the pollen was determined, the dominant nectar-producing plants were identified, and the results of the palynological analysis were compared with the declared botanical origin of the product. It was found that in 88.9% of the samples examined, the declared floral composition corresponded to the actual pollen composition, whilst in 11.1% of cases, discrepancies were identified between the labelling and the results of the palynological analysis. The pollen most frequently identified in the samples was that of sunflower (*Helianthus annuus*), buckwheat (*Fagopyrum esculentum*), currant (*Ribes* spp.), angelica (*Angelica archangelica*), echinops (*Echinops* spp.), as well as a number of other nectar-producing plants characteristic of the flora of the East Kazakhstan Region. The data obtained indicate a significant diversity in the forage base of honey bees in the region under study and confirm the high informative value of palynological analysis in determining the botanical origin of honey. The practical value of this study lies in demonstrating the use of palynological analysis as an effective tool for the laboratory verification of the botanical origin of natural honey, for monitoring its authenticity, and for improving the reliability of labelling. The results

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obtained can be used in veterinary and sanitary inspections, the development of regional databases of pollen spectra, the improvement of the quality control system for beekeeping products, and the promotion of Kazakhstani honey on domestic and international markets

Keywords: honey; melissopalynology; honey authenticity; pollen profile; nectar-producing plants; honey authentication

Introduction

The quality and safety of honey depend directly on its botanical and geographical origin, the environmental conditions during honey collection, the bee breed, climatic characteristics and production methods. Therefore, verifying the authenticity of natural honey, confirming its botanical origin and identifying counterfeit products is one of the most important areas of scientific research in the fields of beekeeping and food safety. On the global market, there are increasingly frequent cases of natural honey being adulterated, various sugar syrups being added, and the product's origin being misrepresented. In this context, palynological analysis occupies a special place amongst the scientific methods used to determine the authenticity of honey. This method makes it possible to determine the plants from which the honey was collected and the geographical region of production by means of microscopic examination of the pollen grains contained in the honey. Furthermore, palynological analysis is recognised worldwide as one of the most reliable methods for determining the botanical origin of honey. A significant number of studies have been devoted to the issues of determining the botanical origin and authenticating honey. For example, C. Pita-Calvo & M. Vázquez (2018) demonstrated that the botanical and geographical origin of honey has a decisive influence on its chemical composition, organoleptic properties and commercial value, and that palynological analysis is one of the most informative methods for confirming these characteristics.

X. Wang *et al.* (2022) noted in a systematic review that the most reliable results in determining the origin of honey are achieved through the combined use of melissopalynological analysis, physico-chemical parameters and modern analytical methods, including metabolomics and chemometrics. According to O. Escuredo & M.C. Seijo (2022), determining the botanical origin of honey is of great importance not only for confirming its authenticity, but also for assessing the biological activity, quality and consumer value of the product. The authors emphasise that the pollen spectrum remains one of the main criteria for identifying monofloral and polyfloral honey varieties. A study by Z. Shakoori *et al.* (2023) showed that a combination of melissopalynological and physico-chemical analysis allows for an objective assessment of honey quality, confirmation of its botanical origin and the detection of possible cases of adulteration.

In the Republic of Kazakhstan, beekeeping is one of the most dynamically developing sectors of agriculture. The country's diverse natural and climatic zones provide favourable conditions for the growth of a wide variety of honey plants. The East Kazakhstan Region, in particular, is characterised by its floral diversity, ecological purity and the development of beekeeping. In this region, buckwheat, sunflowers, raspberries, hawthorn, rose hips, currants, lime trees, angelica, alfalfa and many other honey plants are widespread. As a result, the region produces high-quality varieties of polyfloral and monofloral honey. A study by G. Moldakhmetova *et al.* (2023), focusing on honey from various natural and climatic zones of Kazakhstan, found that the pollen composition of the samples reflects the regional characteristics of the honey-producing flora and can be used to determine the botanical and geographical origin of the product. The findings highlight the potential of melissopalynological analysis for assessing the quality of Kazakhstani honey. Determining the botanical composition of honey is important not only from a scientific perspective, but also from economic and veterinary-sanitary standpoints. Determining the actual origin of the product boosts consumer confidence, ensures compliance with international trade requirements and enhances export potential. Furthermore, the results of palynological analysis make it possible to assess the resources of honey plants in a specific region, locate beekeeping operations effectively and improve the honey quality control system.

Recent research confirms that melissopalynological analysis is one of the main methods for determining the botanical and geographical origin of honey. When combined with physico-chemical methods, it enables reliable product authentication, quality assessment and the detection of possible adulteration (Pita-Calvo & Vázquez, 2018; Xagoraris *et al.*, 2021; Escuredo & Seijo, 2022). According to J. Louveaux *et al.* (1978), the methodology of melissopalynological analysis was developed to determine the botanical origin of honey. Subsequently, W. Von der Ohe *et al.* (2004) refined the methodology, proposing harmonised approaches to the interpretation of results and its application in studies of honey authenticity. Recent studies confirm the relevance of this approach (Pita-Calvo & Vázquez, 2018; Wang *et al.*, 2022; Shakoori *et al.*, 2023). In Kazakhstan, the number of studies examining the palynological composition of honey has been increasing in recent years. According to G. Moldakhmetova *et al*. (2023), palynological analysis of honey samples from various natural and climatic zones of Kazakhstan revealed considerable diversity in pollen composition, reflecting the characteristics of the nectar-producing flora in different regions of the country. The results obtained confirmed the possibility of using the pollen spectrum to determine the botanical and geographical origin of honey.

The aim of the study was to determine the botanical origin of samples of natural honey produced in the East Kazakhstan Region of the Republic of Kazakhstan by analysing their palynological composition, followed by an assessment of the authenticity and quality of the product. Research objectives: (1) to determine the palynological composition of honey samples produced in the East Kazakhstan Region; (2) to investigate the species composition of pollen grains in honey using microscopic analysis; (3) to identify the botanical origin of the honey; (4) scientific assessment of the authenticity and quality of the honey based on the results of palynological analysis.

Literature Review

Honey is one of the most valuable products of beekeeping, the quality and biological value of which are determined by the botanical origin of the nectar, the geographical characteristics of the region, climatic conditions, the composition of the nectar-producing vegetation, and the production methods used (Machado De-Melo *et al*., 2018). In recent decades, with the expansion of the global market for natural honey, the importance of methods for verifying its authenticity and its botanical and geographical origin has increased significantly. One of the most informative and widely recognised methods for identifying the origin of honey is palynological analysis (melissopalynology), which is based on the study of plant pollen grains contained in the honey samples under investigation (Von der Ohe *et al*., 2004).

This method makes it possible to determine the composition of the nectar-producing flora, establish the botanical origin of the product, and confirm its geographical provenance, which is particularly important for the certification of honey and the detection of cases of adulteration (Persano Oddo & Piro, 2004). Pollen grains enter the honey during the collection of nectar by honeybees and retain the characteristic morphological features of the plants from which the nectar was collected. Thanks to the high stability of their outer shell (exine), pollen grains remain preserved for a long time, making them reliable subjects for study. The morphology of pollen from each plant species differs in terms of size, shape, number and structure of apertures, surface texture and other diagnostic features, which allow plant taxa to be identified down to the genus and, quite often, down to the species. It is for this reason that palynological analysis is regarded as a kind of "biological passport" indicating the origin of honey.

In international practice, melissopalynology is used not only to determine the botanical origin of honey, but also to address a wide range of scientific and applied problems. These include assessing the condition of the bees' forage resources, studying the biodiversity of vegetation, monitoring changes in flora under the influence of climatic factors, determining bee migration routes, quality control of beekeeping products, detecting adulteration, and environmental monitoring of areas disturbed by human activity (Barth, 2004). In many European countries, palynological analysis is a mandatory step in confirming the botanical origin of monofloral honey varieties. According to the recommendations of the International Commission on Apicultural Botany and the International Commission on Honey, the results of microscopic examination should be considered in conjunction with the physico-chemical parameters of the product, as different plant species are characterised by varying degrees of pollen representation in honey (Louveaux *et al*., 1978; Bogdanov, 2009).

Recent research indicates that melissopalynology remains one of the most accessible and informative methods for honey quality control. Despite the rapid development of molecular genetic methods, including DNA metabarcoding, it is palynological analysis that remains the international benchmark for determining the botanical origin of honey (Hawkins *et al*., 2015; Keller *et al*., 2015; Bell *et al*., 2016). For the Republic of Kazakhstan, palynological analysis is of particular importance due to the high diversity of natural and climatic zones and the abundance of honey-producing flora (Rib, 2013). The East Kazakhstan Region is considered the most valuable region for beekeeping, as it combines mountainous, forest, meadow and steppe ecosystems. This diversity ensures the formation of a unique pollen spectrum in honey, which can be used to confirm its regional origin and enhance the competitiveness of Kazakhstani products on the international market.

Palynology emerged as an independent scientific discipline in the early 20th century following the development of light microscopy techniques and the accumulation of knowledge regarding the morphological characteristics of pollen from various plant species (Traverse, 2007). Melissopalinology is currently undergoing rapid development thanks to the introduction of digital microscopy, automated image recognition and molecular biology techniques. However, despite the emergence of new analytical technologies, classical palynological analysis remains the primary method for determining the botanical origin of honey and is used in most European laboratories for product certification. Based on botanical origin, more than 150 different types of honey are distinguished, which differ from one another in terms of taste, colour, aroma, acidity, diastase activity, the ratio of glucose, sucrose and fructose, and the quantitative content of minerals.

Studies focusing on determining the botanical origin of honey have shown that its identification can be based on a combination of physico-chemical and palynological indicators. R. Fernández-Torres *et al*. (2005) established that the mineral composition of honey is closely linked to its botanical origin and can be used as an additional criterion for identifying different varieties. R.G. Kurmanov & A.R. Ishbirdin (2013) investigated the botanical and geographical origin of honey available on the Siberian market and demonstrated the possibility of determining the regional origin of the product based on its pollen spectrum. Subsequently, R.G. Kurmanov (2019) summarised data on the botanical and geographical origin of Russian honey, systematised the palynological characteristics of Bashkir honey, and presented an atlas of pollen from the main honey plants, used to determine its botanical origin. Thus, the literature confirms the high informative value of melissopalynological analysis for establishing the botanical origin of honey and justifies the need to conduct similar studies for various regions of Kazakhstan.

Materials and Methods

The study involved 18 samples of natural honey collected between May and August 2022 from apiaries in the East Kazakhstan Region of the Republic of Kazakhstan. Of these, 8 samples (44.4%) were declared by the producers as sunflower honey, 7 samples (38.9%) as polyfloral honey and 3 samples (16.7%) as buckwheat honey. The studies were carried out at the State Specialised Enterprise "Republican Veterinary Laboratory" of the Committee for Veterinary Control and Supervision under the Ministry of Agriculture of the Republic of Kazakhstan (Astana). Melissopalinological analysis is based on determining the qualitative and quantitative composition of pollen grains contained in honey, which makes it possible to establish its botanical and geographical origin.

Taxa were identified by comparing the morphological characteristics of pollen grains with atlases and identification guides for honey plant pollen (Louveaux *et al*., 1978; Sawyer, 1988; Agashe & Caulton, 2019). To prepare the micro-slides, 10.0 g of honey was dissolved in 20 ml of distilled water at a temperature not exceeding 40°C until completely dissolved. The resulting solution was centrifuged for 10 minutes at a speed of 2,500-3,000 rpm. After removing the supernatant, approximately 10 ml of distilled water was added to the pellet and the mixture was centrifuged again for 5 minutes. The supernatant was then removed, and the entire pellet was transferred to a microscope slide, spread evenly over its surface, dried at a temperature not exceeding 40°C, and mounted in glycerine-gelatine for subsequent microscopy.

Microscopic examination was carried out using Leica DM500 and Mikromed-3 light microscopes at a magnification of ×1,000. During the analysis, pollen grains were identified by displaying the image on a computer screen for recording and subsequent processing of the results. For each sample, at least 500 pollen grains were counted, after which the percentage of each taxon in the total pollen spectrum was determined. Honey was classified as monofloral if the dominant pollen type accounted for at least 45% of the total number of pollen grains counted. The results obtained were used to determine the botanical origin of the honey, assess its authenticity and verify its compliance with regulatory requirements. The process of microscopic examination and identification of pollen grains in honey samples is illustrated in Figure 1.

Figure 1. Palynological analysis of honey using a light microscope
Source: authors' photo

Figure 1 illustrates the methodology for conducting a palynological analysis of honey using a light microscope. This method is based on the detection and identification of pollen grains present in the honey, which makes it possible to determine its botanical and geographical origin. During the study, prepared slides were examined under a microscope, with the images displayed on a computer screen for subsequent recording and processing of the results. Analysis of the pollen spectrum made it possible to determine the species composition of the honey plants that contributed to the formation of the product under investigation. Based on these data, an assessment of the honey's authenticity was carried out, and conclusions were drawn regarding its quality and compliance with regulatory requirements.

Results and Discussion

To characterise the material under investigation, Table 1 presents details of the sampling locations and the declared botanical origin of the honey. The study included 18 samples collected from apiaries in seven districts of the East Kazakhstan Region. The largest proportion consisted of samples declared as sunflower honey (n = 8; 44.4%), whilst polyfloral (n = 7; 38.9%) and buckwheat (n = 3; 16.7%) honey were represented in smaller numbers. This distribution allows for a comparison of the declared botanical origin with the results of the melissopalinological analysis.

Table 1. Characteristics of the honey samples studied (sampling area and declared botanical origin)

Sample No.	District	Declared floor area
1	2	3
1	Altai District	Polyfloral
2		Buckwheat
3		Sunflower
4	Glubokovsky District	Polyfloral
5		Sunflower
6	Kurchumsky District	Polyfloral
7		Sunflower
8		Sunflower
9	Katon-Karagay District	Polyfloral
10		Buckwheat
11		Sunflower
12	Ridder District	Polyfloral
13		Buckwheat
14		Sunflower
15	Urjar District	Polyfloral
16		Sunflower
17	Shemonoikhinsky District	Polyfloral
18		Sunflower

Source: compiled by the authors

As can be seen from the data in Table 1, the samples were collected in areas characterised by a variety of natural and climatic conditions and nectar-producing vegetation. This made it possible to assess the correspondence between the declared floral composition and the actual pollen composition of the honey, and to carry out a comparative analysis of the botanical origin of samples from various districts of the East Kazakhstan Region. The data obtained during the study of the floral composition of the honey are summarised in Table 2.

Table 2. Results of the melissopalynological analysis of the honey samples studied

No.	Botanical composition	Declared floor area	Result
1	Common buckwheat (*Fagopyrum esculentum* Moench.) – 89.9%; Medicinal angelica (*Angelica officinalis*) – 3.6%; Daurian rhododendron (*Rhododendron dauricum* L.) – 2.6%; Spiked currant (*Ribes spicatum* Robson.) – 3.9%.	Buckwheat	Buckwheat
2	Annual sunflower (*Helianthus annuus* L.) – 15.8%; Common groundsel (*Aegopódium podagrária*) – 10.2%; Field buckwheat (*Fagopyrum esculentum* Moench.) – 18.6%; Berry apple (*Malus baccata* Borkh.) – 11.3%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 12.6%; Sweet clover (*Melilotus officinalis* (L.) Lam) – 13.3%; Blackcurrant (*Ribes nigrum* L.) – 18.2%.	Polyfloral	Polyfloral
3	Annual sunflower (*Helianthus annuus* L.) – 88.6%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 6.3%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 3.6%; (*Scabiosa comosa* Fisch.) – 0.9%; Raspberry (*Rubus idaeus* L.) – 0.3%; Tansy-leaved cinquefoil (*Potentilla tanacetifolia* Willd.) – 0.3%.	Sunflower	Sunflower
4	Common buckwheat (*Fagopyrum esculentum* Moench.) – 91.3%; Blackcurrant (*Ribes nigrum* L.) – 3.9%; Berry apple (*Malus baccata* (L.) Borkh.) – 2.9%; Blood-red hawthorn (*Crataegus sanguinea* Pallas.) – 0.9%; Tansy-leaved phacelia (*Phacelia tanacetifolia* Benth.) – 0.5%; Annual sunflower (*Helianthus annuus* L.) – 0.3%; Narrow-leaved fireweed (*Chamerion angustifolium* (L.) Holub.) – 0.2%.	Polyfloral	Buckwheat
5	Annual sunflower (*Helianthus annuus* L.) – 88.3%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 5.2%; Narrow-leaved fireweed (*Chamerion angustifolium* (L.) Holub.) – 3.3%; Blackcurrant (*Ribes nigrum* L.) – 1.9%; Apple tree (*Malus baccata* (L.) Borkh.) – 0.9%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 0.2%; Blood-red hawthorn (*Crataegus sanguinea* Pallas.) – 0.1%; Medium spirea (*Spiraea media* Fr. Schmidt.) – 0.1%.	Sunflower	Sunflower
6	Medicinal angelica (*Angelica officinalis*) – 33.3%; Annual sunflower (*Helianthus annuus* L.) – 36.1%; Spiked currant (*Ribes spicatum* Robson.) – 22.6%; Blood-red hawthorn (*Crataegus sanguinea* Pallas.) – 8%.	Polyfloral	Polyfloral

Table 2. Continued

No.	Botanical composition	Declared floor area	Result
7	Annual sunflower (*Helianthus annuus* L.) – 86.9%; Medicinal sweet clover (*Melilotus officinalis* (L.) Lam.) – 9.1%; Two-spined currant (*Ribes diacantha* Pallas.) – 2%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 1.5%; Norway maple (*Acer platanoides*) – 0.5%.	Sunflower	Sunflower
8	Annual sunflower (*Helianthus annuus* L.) – 90.1%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 4.1%; Spiked currant (*Ribes spicatum* Robson.) – 2.6%; Narrow-leaved fireweed (*Chamerion angustifolium* (L.) Holub.) – 1.6%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 1.6%.	Sunflower	Sunflower
9	Annual sunflower (*Helianthus annuus* L.) – 33.3%; Spiked currant (*Ribes spicatum* Robson.) – 36.6%; Scabious (*Scabiosa comosa* Fisch.) – 30.1%.	Polyfloral	Polyfloral
10	Common buckwheat (*Fagopyrum esculentum* Moench.) – 89.1%; Annual sunflower (*Helianthus annuus* L.) – 9.1%; Blood-red hawthorn (*Crataegus sanguinea* Pallas.) – 0.6%; Medicinal sweet clover (*Melilotus officinalis* (L.) Lam.) – 1.2%.	Buckwheat	Buckwheat
11	Annual sunflower (*Helianthus annuus* L.) – 90.1%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 4.1%; Spiked currant (*Ribes spicatum* Robson.) – 2.6%; Narrow-leaved fireweed (*Chamerion angustifolium* (L.) Holub.) – 1.6%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 1.6%.	Sunflower	Sunflower
12	Medium spirea (*Spiraea media* Fr. Schmidt.) – 33.3%; Medicinal sweet clover (*Melilotus officinalis* (L.) Lam.) – 29.1%; Common groundsel (*Aegopódium podagraria*) – 31.3%; Medicinal angelica (*Angelica officinalis*); Common buckwheat (*Fagopyrum esculentum* Moench.) – 3.1%; Thyme (*Thymus dahuricus* L.) – 3.2%.	Polyfloral	Polyfloral
13	Common buckwheat (*Fagopyrum esculentum* Moench.) – 89.9%; Medicinal angelica (*Angelica officinalis*) – 3.6%; Daurian rhododendron (*Rhododendron dauricum* L.) – 2.6%; Spiked currant (*Ribes spicatum* Robson.) – 3.9%.	Buckwheat	Buckwheat
14	Annual sunflower (*Helianthus annuus* L.) – 86.6%; Berry apple (*Malus baccata* (L.) Borkh.) – 6.7%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 3.3%; Dandelion (*Taraxacum* sp.) – 2.1%; Field mint (*Mentha arvensis*) – 1.3%.	Sunflower	Sunflower
15	Annual sunflowers (*Helianthus annuus* L.) – 80.6%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 10.3%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 3.6%; Dandelion (*Taraxacum* sp.) – 3.1%; Field mint (*Mentha arvensis*) – 2.4%.	Sunflower	Sunflower
16	Blackcurrant (*Ribes nigrum* L.) – 25.6%; Dandelion (*Taraxacum* sp.) – 15.1%; Broad-leaved Echinops (*Echinops latifolius* Tausch.) – 14.3%; Daurian rhododendron (*Rhododendron dauricum* L.) – 11.3%; Buckwheat (*Fagopyrum esculentum* Moench.) – 8.8%; Annual sunflower (*Helianthus annuus* L.) – 6.5%; Apple tree (*Malus baccata* (L.) Borkh.) – 5.9%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 5.4%,	Polyfloral	Polyfloral
17	Annual sunflower (*Helianthus annuus* L.) – 87.1%; Common buckwheat (*Fagopyrum esculentum* Moench.) – 3.1%; Spiked currant (*Ribes spicatum* Robson.) – 5.3%; Thyme (*Thymus dahuricus* L.) – 3.2%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 1.3%.	Polyfloral	Sunflower
18	Annual sunflower (*Helianthus annuus* L.) – 81.6%; Berry apple (*Malus baccata* (L.) Borkh.) – 5.7%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 4.3%; Narrow-leaved fireweed (*Chamerion angustifolium* (L.) Holub.) – 2.6%; Broad-leaved echinops (*Echinops latifolius* Tausch.) – 2.6%; Field mint (*Mentha arvensis*) – 3.2%.	Sunflower	Sunflower

Source: compiled by the authors

The results of the palynological analysis showed that 16 out of the 18 samples examined (88.9%) corresponded to their declared botanical origin, whilst 2 samples (11.1%) did not correspond to the information provided by the manufacturers. In particular, sample No. 4, declared as polyfloral, was found to contain 91.3% *Fagopyrum esculentum* Moench. pollen and was classified as buckwheat honey. Sample No. 17, declared as polyfloral, contained 87.1% *Helianthus annuus* L. pollen, which allowed it to be classified as sunflower honey.

The results obtained are consistent with data from numerous studies, according to which melissopalinological analysis is one of the most informative methods for determining the botanical origin of honey and verifying the accuracy of its labelling (Louveaux *et al.*, 1978; Sawyer, 1988; Kurmanov, 2019). Studies carried out in various regions of Russia and Kazakhstan also show that identifying the dominant pollen type makes it possible to distinguish between monofloral and polyfloral honey varieties with a high degree of certainty (Kurmanov & Ishbirdin, 2013; Kurmanov, 2019; Moldakhmetova *et al.*, 2023). The discrepancies identified may be due to several reasons. The most likely causes are the mixing of batches of honey during extraction or storage, errors in product labelling, and variations in honey collection during different flowering periods. In some cases, the cause may be the deliberate labelling of a product category that is more appealing to consumers, as multifloral honey is often perceived as more valuable due to the diversity of its botanical origins. Another possible cause may be the bees' selectivity when collecting nectar: during the mass flowering of a single nectar-producing plant, the bees predominantly visit that species, leading to a predominance of pollen from a single taxon in the final product, even when other flowering plants are present in the honey-harvesting area.

The proportion of samples with labelling discrepancies in this study was 11.1%, which is comparable to the results of international studies, in which the frequency of discrepancies between the declared and actual botanical origin of honey is typically 5-20%, depending on the region, the honey varieties studied and the control methods used (Fernández-Torres *et al.*, 2005; Wang *et al.*, 2022; Escuredo & Seijo, 2022). The data obtained indicate a fairly high degree of accuracy in the labelling of the honey samples studied from the East Kazakhstan Region; however, they confirm the need for mandatory palynological verification of the botanical origin of the product during veterinary and sanitary inspections and quality assessments.

Conclusions

The melissopalynological analysis carried out on 18 honey samples collected from apiaries in the East Kazakhstan Region confirmed the effectiveness of the palynological method for determining botanical origin and verifying the accuracy of product labelling. It was found that 16 out of 18 samples (88.9%) corresponded to their declared botanical origin. In two samples (11.1%), discrepancies were identified between the declared and actual floral composition: sample No. 4, labelled as polyfloral, was classified as buckwheat honey according to the analysis results, whilst sample No. 17 was classified as sunflower honey. The pollen of annual sunflower (*Helianthus annuus* L.) and common buckwheat (*Fagopyrum esculentum* Moench.) was the most frequently encountered in the samples studied, indicating their predominant role in determining the botanical origin of honey from the East Kazakhstan Region. Pollen from currants (*Ribes* spp.), globe thistle (*Echinops latifolius* Tausch.), angelica (*Archangelica officinalis*), fireweed (*Chamerion angustifolium* (L.) Holub.) and other honey plants was also regularly detected in the polyfloral samples. The results obtained can be used in veterinary and sanitary inspections, in confirming the botanical origin of honey, in improving the certification system for beekeeping products in the Republic of Kazakhstan, and in export quality control and authenticity checks for honey. Prospects for further research include extending the geographical scope of sampling to other regions of Kazakhstan, increasing the sample size, conducting seasonal monitoring of pollen composition, and carrying out a comprehensive comparison of the results of melissopalynological analysis with the physico-chemical quality indicators of honey.

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Кыргыз Республикасынын Чыгыш Казакстан облусунда өндүрүлгөн балдын палинологиялык анализи

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Аннотация. Табигый аары балынын ботаникалык келип чыгышын верификациялоо аарычылык продукциясынын сапатын заманбап контролдоонун негизги багыттарынын бири болуп саналат, анткени гүлдүк келип чыгышы жөнүндө ишенимдүү маалымат анын керектөөчүлүк баалуулугун аныктап, продукциянын аныктыгын тастыктап жана жасалмалоонун алдын алууга мүмкүндүк берет. Бул маселе өзгөчө өсүмдүктөрдүн түрдүк ар түрдүүлүгү жогору болгон Казакстан Республикасынын Чыгыш Казакстан облусу үчүн актуалдуу болуп саналат, анткени аймактын табигый шарттары ар кандай ботаникалык келип чыгыштагы балды өндүрүүгө ыңгайлуу шарттарды түзөт. Изилдөөнүн максаты палинологиялык анализдин негизинде табигый аары балынын үлгүлөрүнүн чыныгы ботаникалык келип чыгышын аныктоо жана алынган жыйынтыктардын өндүрүүчүлөр көрсөткөн гүлдүк келип чыгышына шайкештигин баалоо болду. Изилдөөнүн объектиси катары Чыгыш Казакстан облусунун ар түрдүү райондорунан алынган жана өндүрүүчүлөр тарабынан көп гүлдүү, гречиха жана күн карама балы катары белгиленген 18 үлгү колдонулду. Изилдөө жарык микроскопиясынын жардамы менен жүргүзүлүп, чаңча бүртүкчөлөрү морфологиялык белгилеринин негизинде идентификацияланды. Ар бир үлгү боюнча чаңчанын таксономиялык курамы аныкталып, басымдуу нектар берүүчү өсүмдүктөр белгиленип, палинологиялык анализдин жыйынтыктары өндүрүүчүлөр көрсөткөн ботаникалык келип чыгыш менен салыштырылды. Изилденген үлгүлөрдүн 88,9 %ында көрсөтүлгөн гүлдүк келип чыгышы чыныгы чаңча курамына туура келгени аныкталса, 11,1 %ында маркировка менен палинологиялык изилдөөнүн жыйынтыктарынын ортосунда айырмачылыктар табылды. Үлгүлөрдө эң көп күн караманын (*Helianthus annuus*), гречиханын (*Fagopyrum esculentum*), карагаттын (*Ribes* spp.), дягилдин (*Angelica archangelica*), мордовниктин (*Echinops* spp.) жана Чыгыш Казакстан облусуна мүнөздүү башка нектар берүүчү өсүмдүктөрдүн чаңчалары аныкталды. Алынган маалыматтар изилденген аймакта бал аарыларынын азыктык базасынын жогорку ар түрдүүлүгүн көрсөтүп, балдын ботаникалык келип чыгышын аныктоодо палинологиялык анализдин жогорку маалыматтуулугун тастыктайт. Изилдөөнүн практикалык мааниси палинологиялык анализди табигый балдын ботаникалык келип чыгышын жана аныктыгын лабораториялык верификациялоонун, маркировканын ишенимдүүлүгүн жогорулатуунун натыйжалуу куралы катары негиздөөгө байланыштуу. Алынган жыйынтыктар ветеринардык-санитардык экспертиза жүргүзүүдө, чаңча спектрлеринин аймактык маалымат базаларын түзүүдө, аарычылык продукциясынын сапатын контролдоо системасын өркүндөтүүдө жана Казакстандын балын ички жана эл аралык рыноктордо илгерилетүүдө колдонулушу мүмкүн

Негизги сөздөр: аары балы; мелиссопалинология; балдын аныктыгы; чаңча профили; бал берүүчү өсүмдүктөр; балды аутентификациялоо

Палинологический анализ меда, произведенного в Восточно-Казахстанской области Республики Казахстан

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Аннотация. Верификация ботанического происхождения натурального пчелиного меда является одной из ключевых задач современного контроля качества продукции пчеловодства, поскольку достоверность информации о флористическом происхождении определяет ее потребительскую ценность, подтверждает подлинность и способствует предупреждению фальсификации. Особую актуальность данная проблема приобретает для регионов с высоким флористическим разнообразием, к которым относится Восточно-Казахстанская область Республики Казахстан, где природные условия формируют широкий спектр медоносной растительности и создают благоприятные предпосылки для производства меда различного ботанического происхождения. Цель исследования заключалась в установлении фактического ботанического происхождения образцов натурального пчелиного меда на основе палинологического анализа их пыльцевого состава, а также в оценке соответствия полученных результатов заявленной производителями флорности. Объектом исследования послужили 18 образцов натурального пчелиного меда, полученных из различных районов Восточно-Казахстанской области и маркированных производителями как полифлорные, гречишные и подсолнечниковые. Исследование выполняли методом световой микроскопии с последующей идентификацией пыльцевых зерен по комплексу морфологических признаков. Для каждого образца определяли таксономический состав пыльцы, выделяли доминирующие медоносные растения и сопоставляли результаты палинологического анализа с заявленным ботаническим происхождением продукции. Установлено, что в 88,9 % исследованных образцов заявленная флорность соответствовала фактическому пыльцевому составу, тогда как в 11,1 % случаев выявлены расхождения между маркировкой и результатами палинологического исследования. Наиболее часто в образцах была идентифицирована пыльца подсолнечника (*Helianthus annuus*), гречихи (*Fagopyrum esculentum*), смородины (*Ribes* spp.), дудника (*Angelica archangelica*), мордовника (*Echinops* spp.), а также ряда других медоносных растений, характерных для флоры Восточно-Казахстанской области. Полученные данные свидетельствуют о значительном разнообразии кормовой базы медоносных пчел в исследуемом регионе и подтверждают высокую информативность палинологического анализа при определении ботанического происхождения меда. Практическая ценность исследования заключается в обосновании применения палинологического анализа в качестве эффективного инструмента лабораторной верификации ботанического происхождения натурального меда, контроля его подлинности и повышения достоверности маркировки. Полученные результаты могут быть использованы при проведении ветеринарно-санитарной экспертизы, разработке региональных баз данных пыльцевых спектров, совершенствовании системы контроля качества продукции пчеловодства и продвижении казахстанского меда на внутреннем и международном рынках

Ключевые слова: пчелиный мед; мелиссопалинология; подлинность меда; пыльцевой профиль; медоносные растения; аутентификация меда