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## QUALITY OF MONOFLORE SUNFLOWER HONEY FROM DIFFERENT REGIONS OF UKRAINE

**Actuality.** Sunflower honey is one of the most popular honeys in the world and in Ukraine. On the world market, sunflower honey makes up the largest percentage of Ukraine's export supplies. As a rule, beekeepers receive it in an amount that is 2–3 times higher than the honey harvest of other varieties. Constantly high commodity demand for honey is one of the reasons for its falsification. Since there is no approved method for detecting monofloral honey in Ukraine, solving this problem is important and relevant at the moment.

**Study purpose.** The purpose of the study is to evaluate the quality of monofloral sunflower honey based on the determination of its organoleptic, physicochemical indicators and the content of pollen grains.

**Material and methods.** Sampling of honey, analysis of organoleptic and physicochemical parameters was carried out in accordance with DSTU 4497: 2005 "Natural honey. Technical conditions". Melisopalynological analysis and the ratio of fructose to glucose were carried out according to generally accepted international methods.

**Research results.** 165 samples of sunflower honey from different regions of Ukraine were analyzed. Evaluation criteria for monofloral sunflower honey in Ukraine have been established. The degree of monoflorality of sunflower honey can range from 45.0% to 89.0%, with an average of 64.5%. Secondary pollens are mainly pollen from the legume family (peanut (*Vicia* spp.), clover (*Trifolium* spp.), pollen grains from the Cruciferae family, common goldenrod (*Solidago virgaurea* L.). According to organoleptic indicators, sunflower honey has a faint aroma of sunflower flowers, has a color from light yellow to dark yellow shades, consistency depending on the season (liquid, viscous, very viscous, dense). According to physical and chemical indicators: moisture – 18.5%, proline – 233.38 ± 53.76 mg/kg, electrical conductivity – 0.35 ± 0.04 mS/cm, fructose to glucose ratio – 1.12 ± 0.07, diastase 18.55 ± 2.97 un. Goethe the content of reducing sugars is 87.72 ± 1.96%, sucrose in the range of 0.6–4.2%, with an average of 2.91 ± 0.81%.

**Conclusion.** A comprehensive approach to the identification and evaluation of the quality of monofloral sunflower honey has been developed and the main criteria have been determined according to the degree of monoflorality (main pollen in the range of 45% and more), organoleptic and physicochemical indicators.

**Key words:** sunflower honey, monoflorality, quality, organoleptic indicators, physicochemical parameters, proline, radionuclides, heavy metals.

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## **ЯКІСТЬ МОНОФЛОРНОГО МЕДУ ІЗ СОНЯШНИКА РІЗНИХ РЕГІОНІВ УКРАЇНИ**

**Актуальність.** Мед із соняшника належить до найбільш популярних медів у світі й Україні. На світовому ринку мед із соняшника становить найбільший відсоток експортних поставок України. Як правило, пасічники отримують його в обсязі, який у 2–3 рази перевищує медовий урожай інших сортів. Постійний високий товарний попит на мед є однією з причин його ретельного дослідження й установлення критеріїв виявлення монофлорного меду із соняшника. Розв'язання цієї проблеми є важливим та актуальним завданням сьогодні.

**Мета дослідження** – оцінювання якості монофлорного соняшникового меду на основі визначення його органолептичних, фізико-хімічних показників і вмісту пилкових зерен.

**Матеріал і методи.** Відбір проб меду, аналіз органолептичних і фізико-хімічних показників якості здійснювали згідно з ДСТУ 4497: 2005 «Мед натуральний. Технічні умови». Мелісопалінологічний аналіз і визначення співвідношення фруктози до глюкози проводили за загальноприйнятими міжнародними методами.

**Результати дослідження.** Проаналізовано 165 зразків соняшникового меду з різних областей України. Установлено критерії оцінювання монофлорного соняшникового меду в Україні. Ступінь монофлорності соняшникового меду може становити від 45,0% до 89,0%, у середньому 64,5%. Вторинними пилками переважно є пилки родини бобових (горішок (*Vicia* spp.), конюшини (*Trifolium* spp.), пилкові зерна родини хрестоцвітів (*Cruciferae*), золотарнику звичайного (*Solidago virgaurea* L.). За органолептичними показниками мед із соняшника володіє слабко вираженим ароматом квіток соняшника, має колір від світло-жовтого до темно-жовтого відтінку, консистенцію залежно від пори року (рідка, в'язка, дуже в'язка, щільна). За фізико-хімічними показниками: вологість – 18,5%, пролін – 233,38±53,76 мг/кг, електропровідність – 0,35±0,04 мС/см., співвідношення фруктози до глюкози – 1,12±0,07, діастаза 18,55±2,97 од. Гоме, вміст відновлювальних цукрів – 87,72±1,96 %; сахарози в межах – 0,6–4,2% із середнім показником 2,9±0,81 %.

**Висновок.** Розроблено комплексний підхід до ідентифікації й оцінювання якості монофлорного соняшникового меду, визначено основні критерії за ступенем монофлорності (основний пилко – у межах від 45% і більше), органолептичними та фізико-хімічними показниками.

**Ключові слова:** соняшниковий мед, монофлорність, якість, органолептичні показники, фізико-хімічні показники, пролін, радіонукліди, важкі метали.

**Introduction.** Beekeeping products, in particular, honey, due to its highly nutritious and medicinal properties, are widely used in the nutrition of the population of Ukraine, as well as in European countries (Miguel et al., 2017; Dzugan et al., 2020; Hroshovyi et al., 2021). The analysis of honey consumption indicates a growing demand for this product (Ignjatijević et al., 2019).

The consumption of honey by the population increases especially when it is used as a natural means of prevention and treatment of various diseases (Papounidis, 2023). The positive effect of sunflower honey on the human body has been established, in particular, in increasing immunity, improving the work of the digestive system, preventing arthrosis, preventing atherosclerosis, strengthening the cardiovascular system, reducing the level of harmful cholesterol and stimulating the regenerative properties of cells (Basa et al., 2016; Durazzo et al., 2021).

There are three types of honey – floral, fall and mixed, the first of which bees produce from nectar-pollen-bearing plants, the second – from honeydew and secretions of honey aphid, and the third – from both nectar and honeydew and secretions of honey aphid (Münstedt et al., 2009).

Bees produce flower honey from nectar-pollen-bearing crops, the chemical composition and properties of which depend significantly on the botanical origin. A certain dependence of the chemical composition of honey was also found on the breed of bees, raw materials for its production, maturity, collection period, natural and climatic conditions, etc. (Schievano et al., 2016).

Nectar-pollen-bearing plants that grow on the territory of Ukraine are conventionally divided into forest park, agricultural and meadow grasses. Each group of nectar-pollinating plants is characterized by a certain period of flowering – nectar productivity, duration of flowering, availability of nectar for bees and its chemical composition (Solomakha et al., 2022; Ibatullin et al., 2020)]. Nectar productivity of agricultural plants ranges from 45 kg/ha to 140 kg/ha, duration of flowering – from 14 days to 40 days, flowering period – from April to August. Nectar productivity of forest park plants ranges from 25 kg/ha to 1000 kg/ha, duration of flowering – from 7 days to 18 days, flowering period – March-May. Nectar productivity of meadow grass varies from 20 kg/ha to 400 kg/ha, the duration of flowering is from 6 days to 60 days, the flowering period is from March to September. That is, under such a condition, nectar productivity and the flowering period of nectar-pollen-bearing plants created conditions for the production of polyfloral honey, while monofloral honey is limited (Kovka, 2019).

The nectar-pollen base and the natural and climatic conditions of Ukraine make it possible to produce both monofloral and polyfloral honey. Monofloral honey is in the highest demand among the population (Da Silva et al., 2016; Bilandžić et al., 2017). Among the monofloral honeys of Ukraine, it is necessary to single out acacia, linden, buckwheat and sunflower honey (Schievano et al., 2016). Monofloral sunflower honey is the most popular in Ukraine and accounts for the largest percentage of export supplies. In particular, Ukraine exported 48,000 tons of honey to various European countries in 2022 alone.

Sunflower honey is characterized by a high glucose content, which causes its high calorie content, it consists of average 78% carbohydrates, 4% proteins, 17% water, 1% ash and other biologically active substances, in particular, vitamins, macro- and microelements, enzymes, amino acids and polyunsaturated fatty acids (Sari et al., 2012). Sunflower honey contains vitamins C, E, PP, micro- and macroelements – iodine, potassium, phosphorus, calcium, copper, sodium, manganese, magnesium, aluminum, cobalt, selenium, enzymes – catalase, invertase and phosphatase (Sari et al., 2012).

It is known that honey, in addition to useful substances, can also contain harmful substances – toxicants, the concentration of which in this product depends on the ecological state of the nectar-pollen-bearing lands. The current state of nectar-pollen-bearing lands in certain territories of Ukraine is characterized by soil contamination with various toxicants (radionuclides, heavy metals), which can lead to a decrease in the quality and safety of beekeeping products (Razanov et al., 2022; Razanov et al., 2023a; Snitynskyi et al., 2023; Razanov et al., 2023b). Therefore, under such conditions, there is a need for constant monitoring of compliance of honey quality and safety with existing standards.

**The purpose of our study** was to evaluate the quality of monofloral sunflower honey based on the determination of its organoleptic, physicochemical indicators and the content of pollen grains, radionuclides, heavy metals.

**Material and methods.** The research material was 165 samples of bee honey from different regions of Ukraine in 2021, which were sent to the laboratory as sunflower honey. All samples were declared by the manufacturers as monofloral sunflower honey. The samples were stored as far as possible from sunlight at room temperature before the start of the study. Sampling of honey was carried out in accordance with SSU 4497:2005 “Natural honey. Technical conditions” (Natural honey. Technical conditions: SSU 4497-2005 2007).

The analysis of organoleptic and physicochemical indicators was carried out according to DSTU 4497:2005

“Natural honey. Technical conditions” (Natural honey. Technical conditions: SSU 4497-2005 2007) namely consistency, taste, aroma, crystallization, mass fraction of water, diastase activity, mass fraction of reducing sugars and sucrose, acidity, proline content, electrical conductivity. Research on the ratio of the amount of fructose to glucose was carried out according to generally accepted international methods using the D-Glucose/D-Fructose UV method test system. Determination of the species composition of pollen grains was carried out by the microscopic method. The identification of honey bee pollen grains was carried out using an atlas and using electronic pollen databases (PalDat). The specific activity of Cesium-137 in honey was determined by the gamma spectrometric method, Strontium-90 by the chemical method, and lead and cadmium by the atomic sorption method. The obtained data were processed statistically using the Microsoft Excel 15.0 program to calculate the arithmetic mean (M) and standard error (m) (Mazur, 1997).

**Research results.** The obtained results (fig. 1) showed that the compliance of the investigated honey with organoleptic characteristics in accordance with the typical characteristics of sunflower honey ranged from 73 to 100%, in particular, in terms of color – 100%, consistency – 95%, and taste – 73%.

It was established that in 86 studied samples, the percentage of sunflower pollen grains was 45% or higher. Namely, it varied in the range from 45.0% to 89.0%, which was 64.5% on average. In 52% of the analyzed bee honey samples, pollen grains from various grasses were found.

Our research showed that in 6 samples of honey, pollen from the legume family (*Vicia spp.*) was found – 13.2–17.6%, clover (*Trifolium spp.*) – 19.4–33.0%, pollen was observed in 2 samples grains of the cruciferous family (*Cruciferae*) – 15.5%, in 9 samples were found pollen

grains of common goldenrod (*Solidago virgaurea L.*) – 27.8–36.3%.

Important secondary pollen grains were also found in 12 sunflower honey samples: buckwheat (*Fragopyrum esculentum*) – 5.4–14.3%. In 8 samples of studied honey there were pollen grains of willow (*Salix spp.*) – 12.4–21.3%, amorphia bush (*Amorpha fruticose L.*) – 5.6–8.9% and white acacia (*Robinia pseudoacacia L.*) – 4.4–7.3%. In 23 samples of honey, 17.4–29.9% of creeping clover (*Trifolium repens L.*) pollen grains, 7.8–11.8% of white burkun (*Melilotus albus*), 7.8–11.8% of white clover (*Lamium album L.*) were found. During the study of 11 samples of sunflower honey, pollen grains of field mustard (*Sinapis arvensis L.*) – 8.3–10.7%, linden (*Tilia cordata Mill.*) – 5.8–7.8%, meadow plantain (*Lathyrus sylvestris L.*) – 4.3–6.7%, asparagus (*Onobrychis arenaria*) – 6.7–16.8% were found. At the second stage of the research, the physico-chemical parameters were studied only for monofloral sunflower honey.

The results of research (table 1) showed that the mass fraction of water in sunflower honey samples ranged from 16.6 to 20.0%, which on average is  $17.8 \pm 0.58$ , which corresponds to the national standard of Ukraine and the Codex Alimentarius for honey (Codex Alimentarius).

Enzyme activity, which is estimated by the diastase number of honey, is an important indicator of its maturity and origin. It was found that in 86 samples of sunflower honey, the diastase number ranged from 13.4 to 23.6 units Goethe, with an average value of  $18.55 \pm 2.97$  units Goethe.

The content of reducing sugars and sucrose in the studied samples ranged from 82.8 to 91.2% and 0.6–4.2%, respectively. On average, the content of reducing sugars was  $87.72 \pm 1.96\%$ , and sucrose was  $2.91 \pm 0.81\%$ .

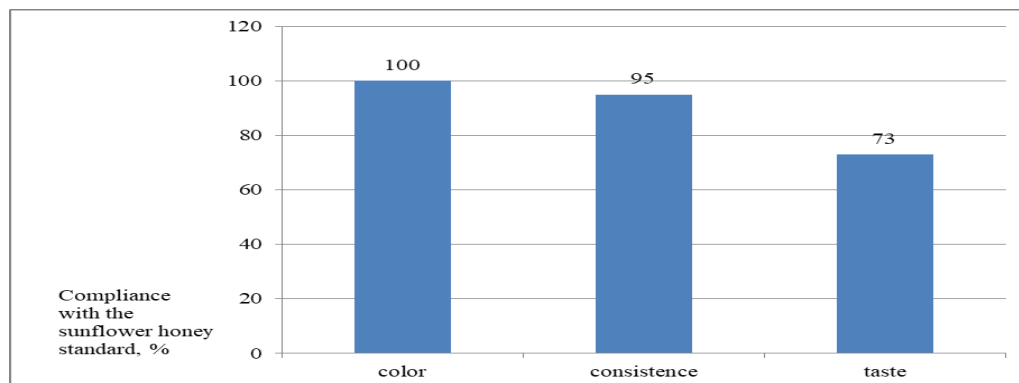


Fig. 1. Organoleptic evaluation of sunflower honey



For most flower honey, the acidity (pH) value ranges from 30.0 to 40.0 ml/kg. During the study of 86 samples of sunflower honey, the acidity value ranged from 9.4 to 36.7 ml/kg, which averaged  $20.33 \pm 3.6$  ml/kg. During the study of 86 samples of sunflower honey, acidity values ranged from 9.4 to 36.7 mEq/kg, which averaged  $20.33 \pm 3.60$  mEq/kg.

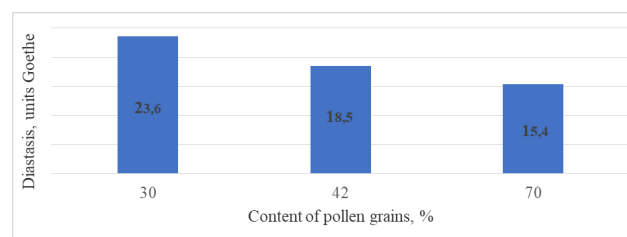
The obtained data showed that the proline content ranged from 98.0 mg/kg to 445.0 mg/kg, which averaged  $233.38 \pm 53.76$  mg/kg. The ratio of fructose to glucose ranged from 0.9 to 1.24 with a mean value of  $1.12 \pm 0.07$ .

According to the results of research, it was found that monofloral sunflower honey differed slightly from the standard indicators according to SSU in terms of physical and chemical parameters. In particular, the average values of the mass fraction of water, sucrose, acidity and proline content were lower, compared to honey of the highest grade according to SSU by 3.4%, 16.8%, 49.1%, 22.2% respectively, while such indicators as diastase number, reducing sugars and electrical conductivity, on the other hand, are higher by 28.9%, 9.6% and 75% respectively.

It is important to note, in addition to the quality indicators of honey, its safety. For example research results (table 2) showed that monofloral sunflower honey produced by bees in the conditions of the forest-steppe of Ukraine contains both radioactive substances and heavy metals, however, their concentration does not exceed the maximum permissible levels (MPL). Thus, the specific activity of Cesium-137 and Strontium-90 was lower than PL-2006 by 22.9 times and 238 times,

respectively. The concentration of lead and cadmium in monofloral sunflower honey was also lower than the MPL by 4.7 times and 3.6 times, respectively.

According to the results of our research, a certain dependence was established between the diastase number and the content of pollen grains in honey, in particular, among the analyzed samples of sunflower honey (fig. 2), the diastase number decreases with an increase in the presence of pollen grains in honey.



**Fig. 2. Honey diastase activity depending on the proportion of pollen grains in sunflower honey**

It was proved that with a content of pollen grains from 25 to 30%, the diastase number of honey was within 19.5 units Goethe up to 23.6 units Goethe, and with a content from 42% to 70% in the range from 15.4 to 18.5 units Goethe. That is, with an increase in the level of pollen grains in honey, the activity of diastase decreased.

Changes in the content of proline in honey were also detected depending on the content of pollen grains in it (fig. 3). In particular, it should be noted that during the study of sunflower honey samples, where the content

Table 1

### Physicochemical parameters of monofloral sunflower honey

Investigated indicators	Units of measurement	Measurement results	Normative value according to SSU
Mass fraction of wster	%	$17.8 \pm 0.58$	$18.8^*/21.0^{**}$
Diastase number	Units Goethe	$18.55 \pm 2.97$	$15.0^*/10.0^{**}$
Reducing sugars	%	$87.72 \pm 1.96$	$80.0^*/70.0^{**}$
Sucrose	%	$2.91 \pm 0.81$	$3.5^*/6.0^{**}$
Acidity	mEq/kg	$20.33 \pm 3.6$	$40.0^*/50.0^{**}$
Proline	mg/kg	$233.38 \pm 53.76$	$300.0^*/300.0^{**}$
Correlation	F/G	$1.12 \pm 0.07$	--
Electrical conductivity		$0.35 \pm 0.04$	$0.2-1.0^*/0.2-1.5^{**}$

Note: \* – honey of the highest grade, \*\* – honey of the first grade.

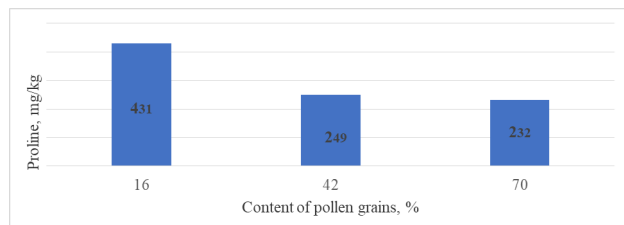
Table 2

### Content of harmful substances in monofloral sunflower honey

Studied substances	Units of measurement	Actual content	Norm according to TPL-2006 and MPL
Cesium-137	Bq/kg	$8.7 \pm 0.32$	200
Strontium-90	Bq/kg	$0.21 \pm 0.012$	50
Lead	mg/kg	$0.21 \pm 0.0031$	1.0
Cadmium	mg/kg	$0.014 \pm 0.005$	0.05

\*Note: TPL-2006 – on radionuclides, MPL on heavy metals.

of pollen grains was 42%, the proline content was 249 mg/kg, when the honey contained more than 70% sunflower pollen grains, the proline content decreased and amounted to 232 mg/kg, and in the presence of 16% pollen grains, the proline content increased to 431 mg/kg.



**Fig. 3. Dependence of proline content on the proportion of pollen grains in sunflower honey**

The obtained data show that the value of proline content in sunflower honey is less than that specified in the national standard, but at the same time, this indicator meets the existing EU requirements (proline content is not less than 180 mg/kg).

**Conclusion.** As a result of the conducted research, it was established that monofloral sunflower honey produced in the conditions of the forest-steppe of Ukraine contains from 45% to 89% of pollen grains of this crop. According to the organoleptic assessment, monofloral sunflower honey, in particular, color, consistency and taste, meets the standard by 100%, 95% and 73%, respectively. According to the physical and chemical parameters, monofloral sunflower honey is characterized by the content of reducing sugars  $87.72 \pm 1.96\%$ , sucrose –  $2.91 \pm 0.81\%$ , electrical conductivity  $0.35 \pm 0.04$  ms/cm, proline  $233.38 \pm 53.76$  mg/kg, with a diastase number of  $18.55 \pm 2.97$  units Goethe. However, it should be noted that with an increase in the content of pollen grains in honey, a decrease in the activity of diastase and proline was observed.

The content of monofloral sunflower honey was lower than PL-2006 in terms of Cesium-137 by 22.9 times and Strontium-90 by 238 times, the concentration of lead and cadmium by 4.7 times and 3.6 times, respectively, compared to the MPL.

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