

## CHANGES OCCURRING IN HONEY DURING RIPENING UNDER CONTROLLED CONDITIONS BASED ON POLLEN ANALYSIS AND ELECTRICAL CONDUCTIVITY

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### S u m m a r y

The objective of the study was to determine the effect of honey ripening under controlled conditions on selected quality parameters. Those selected quality parameters were: the percentage of dominant pollen and specific electrical conductivity. The experiment took place over the course of 3 years. 79 samples of unripe honey were collected. This unripe honey was to be subsequently dehydrated in a specially designed chamber. 74 samples of in-hive ripe honey were also collected. Palynological analysis showed the average content of dominant pollen in unripe honey samples was 63.8%. In honey allowed to remain in the hive until fully ripe the content of dominant pollen dropped to 46.4%. Average differences in the values of electrical conductivity between dehydrated honey and conventionally (in-hive ripened) harvested honey usually did not exceed  $0.5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ .

**Keywords:** honey, ripening honey, dominant pollen, palynological analysis of honey, electrical conductivity of honey.

### INTRODUCTION

The climate in Poland is the reason for the overlap in blooming dates of forage plants. As the honey undergoes ripening there is a flow of nectar from other plants as well. The result is that once the ripening process is completed the honey becomes multifloral rather than unifloral. In order to collect honey that is unifloral, it is best to collect it as soon as blooming of the principal forage plant is terminated. Usually, honey collected in such a manner is not sufficiently ripe yet and must be ripened outside the hive (Semkiw et al. 2008).

The identification of honey origin is usually based on organoleptic analysis which consists of determining colour,

aroma and flavour. This method is not accurate enough and, at present, measurements of specific electric conductivity and palynological analysis are used to check honey variety and type.

The Polish Standard for Honey distinguishes three types of honey: nectar, honeydew, and nectar-honeydew honey. From among nectar honeys, 5 honey varieties are further distinguished: for oilseed rape (*Brassica napus*), buckwheat (*Fagopyrum esculentum*) and heather (*Calluna vulgaris*) honeys the minimum percentage of the dominant pollen was set at 45% whereas for robinia (*Robinia pseudoacacia*) at 30%, for linden (*Tilia* sp.) at 20% (PN – 88/A–77626).

Numerous palynological analysis show

the variety of Polish honeys. These palynological analysis often are in disagreement with the variety of honey claimed by the producer. According to studies performed in other countries unifloral honeys were likewise found to vary for the content of dominant pollen (Persano Oddo and Piro 2004). Palynological analyses showed the content of dominant pollen to vary in heather honey from 10.3 to 76.5% (average of 37%), in robinia honey from 7.0 to 59.5% (average of 28.1%), in linden honey from 1.0 to 55.9% (average of 22.9%).

In honeys recognized as unifloral the percentage of oilseed rape pollen ranged from 62 to 93%, whereas the content of heather pollen came within 42 to 79% (Poszwiński and Warakomska 1969). In oilseed rape honey from the regions of Żuławy and Mazovia from 30 to 92% of oilseed rape pollen was found (Demianowicz et al. 1981). The minimum content of *Borago* pollen in the honey originating from the borage plant was established at 10% (Van der Ham et al. 1999).

Measurements of electrical conductivity in honey are widely used to make the distinction between honeydew vs. nectar honeys as well as to characterize honey varieties (Bogdanov et al. 1999). According to the Council Directive 2001/110/EC2002, the standard Codex Alimentarius Commission (2001) and the Ruling by the Minister of Agriculture and Rural Development of Oct. 3, 2003 (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 3 października 2003 r.), the electrical conductivity of nectar honeys must not be higher than  $8.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . The electrical conductivity of honeydew honey and of sweet chestnut honey (*Castanea sativa*) must not be lower than  $8.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . Because of an excessive variation in measurement results electrical conductivity

values were not established for strawberry tree (*Arbustus unedo*), heath (*Erica*), eucalyptus (*Eucalyptus*), linden (*Tilia*), manuka (*Leptospermum*) and heather (*Calluna vulgaris*). The Polish Standard for Honey (Miód Pszczeli PN – 88/A–77626) specifies the minimum electrical conductivity of honeys: nectar honeys -  $2.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ , nectar-honeydew honeys - not less than  $6.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ , deciduous honeydew honey - not less than  $8.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ , conifer honeydew honey - over  $9.5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ .

The value of that parameter varied for 40 different unifloral honeys harvested under net cage. In oilseed rape honey it averaged  $1.37 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  and in borage honey it was  $1.98 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . A little higher electrical conductivity was found for raspberry honey (*Rubus idaeus*) ( $2.09 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ ) and for linden honey ( $2.89 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ ), and the highest value was measured in buckwheat honey ( $2.98 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ ) (Vorwohl 1964).

Substantial variation in electrical conductivity was also found for Polish honeys. In oilseed rape honey electrical conductivity was found to vary from 1.1 to  $4.03 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  (Demianowicz et al. 1981, Rybak 1986, Szczęsna and Rybak-Chmielewska 2004). Honey from orchards was characterized by electrical conductivity from 1.66 to  $3.92 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ , and robinia honey showed electrical conductivity from 0.9 to  $4.42 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . Electrical conductivity in linden honey ranged from 3.14 to  $11.5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . Heather honey had an electrical conductivity of 4.2 to  $14.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . In nectar-honeydew honey, electrical conductivity ranged from  $5.02$  to  $11.9 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  and in honeydew honeys it was from 6.15 to  $17.0 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . The electrical conductivity of buckwheat honey was found to vary from 2.4 to  $3.5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$

(Rybak 1986, Szczęsna and Rybak-Chmielewska 2004).

The objective of the study was to determine the effect of the ripening of honey under controlled conditions on selected quality parameters. Those selected quality parameters were percentage of dominant pollen and specific electrical conductivity.

### MATERIAL AND METHODS

The study was conducted in 2004-2006 at the Apiculture Division; the Department of Apiary Technologies of The Research Institute of Pomology and Floriculture in Puławy, Poland. The honey samples for the study were collected at apiaries run by the Institute and at commercial apiaries localized across the country. Detailed data concerning the honey varieties sampled,

sampling dates, apiary sites and number of samples are presented in Table 1.

From each honeybee colony stationed at a defined forage site, two honey samples were collected. One sample was from unripe and another from ripe honey. Each sample was ca. 200 ml in volume. A sample of unripe honey was harvested by removing one comb with uncapped honey from the colony while nectar flow from the principal forage source was still in progress. The comb was centrifuged in a special cassette protected with a polyethylene bag so that only honey from one frame could be harvested during centrifuging. The collected sample was dehydrated. A sample of ripe honey was collected from the same colony, as well. The sample was collected from a capped comb in the same manner as the unripe honey was collected.

Table 1

Type of forage source, apiary location and sampling dates of honey to be studied.

Forage source	Location of apiary	Date apiary moved to forage site or date of mounting supers	Unripe honey samples		Ripe honey samples	
			Collection date	Number of samples	Collection date	Number of samples
Multifloral	Celejów	12. V. 2004	03. VI.2004	8	10. VI. 2004	8
Deciduous honeydew	Puławy	25. V. 2004	07.VI.2004	5	12.VI. 2004	5
Mixed nectar and honeydew	Końskowola	04.V.2005	18.V.2005	10	25.V.2005	5
Oilseed rape	Puławy	05.V. 2005	20.V.2005	5	27.V.2005	5
	Osiny	04.V. 2006	22.V.2006	5	29.V.2006	5
Robinia	Sadłowice	02.VI.2006	12.VI.2006	5	16.VI.2006	5
Raspberry	Karczmiska	06.VI.2005	24.VI.2005	5	01.VII.2005	5
		09.VI.2006	19.VI.2006	5	28.VI. 2006	5
Linden	Sadłowice	22. VI.2005	07.VII.2005	5	15.07. 2005	5
		23.VI.2006	10.VII.2006	5	18.07.2006	5
Buckwheat	Lipsko	27.VI.2005	18.VII.2005	5	29.VII.2005	5
		30.VI.2006	21.VII.2006	5	01.VIII.2006	5
Borage	Bydgoszcz	27.VI.2006	20.VII.2006	5	27.VII.2006	5
Heather	Bory Dolnośląskie	18.VIII.2006	31.VIII.2006	6	04. IX.2006	6

Over the three years of the experiment 79 samples of unripe honey, 79 samples of dehydrated honey and 74 samples of in-hive-ripped honey were collected.

Honey samples were classified as nectar, nectar-honeydew, or deciduous honeydew based on measurements of electrical conductivity using the conductometric method as described in the Polish standard for honey PN – 88/A–77626 „Miód Pszczeli”. The varieties of nectar honey (oilseed rape, linden, buckwheat, heather and multifloral) were classified using pollen analysis as described in the standard PN – 88/A–77626 „Miód Pszczeli”. For honey varieties not included in the standard (borage and raspberry honey) the percentage of the respective dominant pollen was assumed as 10 and 45%.

The results on the percentage of the dominant pollen in unripe vs. in-hive ripened honeys and on the specific electrical conductivity values for unripe vs. in-hive ripened honeys were tested for the significance of differences using Student t test at a significance level of  $\alpha = 0.05$

## RESULTS

### The percentage of dominant pollen in sampled honey varieties

Palynological analysis showed the average content of the dominant pollen in honey sampled before reaching ripening to be 63.8% (Table 2). In honey allowed to ripen in the hive, the percentage of dominant pollen dropped to an average of 46.4%. From among the unripe honeys, the highest content of dominant pollen was shown by honeys collected from the sites with oilseed rape, heather and raspberry as the forage source. The lowest percentage of the dominant pollen was recorded for honeys harvested at sites where borage and robinia were in bloom. For conventionally (in-hive ripened) honeys the highest counts of the dominant pollen were found for honey harvested by bees from heather and oilseed rape forage sites. The lowest average percentage of dominant pollen was found for robinia and linden when used as principal forage sources.

The highest drop in the percentage of the dominant pollen during ripening under natural conditions (of more than 20%), was found for linden, raspberry and oilseed rape

Table 2.

Percentage of the dominant pollen in unripe vs. in-hive ripened honeys depending on principal forage source (%).

Forage source	Unripe honeys			In-hive ripened honeys		
	Number of samples (n)	Range min – max	Mean ( $\bar{x}$ )	Number of samples (n)	Range min – max	Mean ( $\bar{x}$ )
Oilseed rape	10	54.8 – 88.9	<b>78.9 B</b>	10	13.9 – 74.0	<b>55.3 A</b>
Robinia	5	31.5 – 81.1	<b>48.1 b</b>	5	20.7 – 57.5	<b>37.0 a</b>
Raspberry	10	45.5 – 93.1	<b>72.6 B</b>	10	23.3 – 66.7	<b>47.9 A</b>
Linden	10	39.4 – 85.2	<b>63.4 B</b>	10	11.7 – 67.9	<b>37.7 A</b>
Buckwheat	10	37.5 – 85.8	<b>52.4 a</b>	10	15.9 – 86.0	<b>46.3 a</b>
Borage	5	30.0 – 50.0	<b>41.9 a</b>	5	33.7 – 42.6	<b>38.7 a</b>
Heather	6	52.5 – 98.4	<b>75.4 b</b>	6	31.7 – 70.9	<b>57.4 a</b>

Values in lines followed by small letters are significantly different at  $p \leq 0,05$  whereas those followed by capital letters are significantly different at  $p \leq 0,01$ .

Table 3.

Classification of unifloral honeys, unripe and in-hive ripened, based on pollen analysis.

Forage source	Required pollen count (%)	Unripe honeys			In-hive ripened honeys		
		Number of samples (n)	Classified as unifloral		Number of samples (n)	Classified as unifloral	
			number of samples (n)	%		Number of samples (n)	%
Oilseed rape	≥ 45	10	10	100	10	9	90
Robinia	≥30	5	5	100	5	4	80
Raspberry	≥45	10	10	100	10	8	80
Linden	≥20	10	10	100	10	8	80
Buckwheat	≥45	10	10	80	10	6	60
Borage	≥10	5	5	100	5	5	100
Heather	≥45	6	6	100	6	4	71

honeys. An average decrease of the dominant pollen of ca. 17% was recorded for heather honey and of 11% for robinia honey. In buckwheat honey the decrease was ca. 9%. The smallest decrease in the percentage of the dominant pollen during ripening of honey in the hive was found for borage honey.

The statistical analysis of the data showed that as the honey undergoes ripening under natural conditions a decrease in the percentage of the dominant pollen occurs. The decrease that occurs in the honeys made from linden, raspberry and oilseed rape is highly significant. The decrease that occurs in the honeys made from robinia and heather is significant. No such differences were found for buckwheat and borage honey.

The honeys were classified based on the principal percentage data in all honey samples. Honeys were classified as belonging to particular varieties, taking into account the required percentage value for each variety (Table 3). From among all honeys harvested at different forage sites, only two samples of unripe buckwheat honey did not contain the minimum amount of the dominant pollen to be

labelled as unifloral.

Among the honeys that were allowed to remain in the hive until ripe only in the case of borage honey all samples could be recognized as unifloral. In honeys harvested at the oilseed rape site, one of 10 samples was classified as multifloral. It was found to contain a substantial percentage of *Salix*, *Acer* and *Prunus* pollen. Out of five samples of honey from the robinia site one was labelled as multifloral because of the prevalence of pollen of the Brassicaceae. Other types of pollen occurring in those samples came from *Trifolium pratense*, *Anthriscus* type and single pollen grains from *Salix* and *Vicia*. In honeys harvested at the raspberry and linden forage sites two samples from each of those sites also were not unifloral honeys. In the raspberry honey numerous Brassicaceae and *Trifolium* pollen grains were found. In two honey samples from the linden site the presence of pollen from *Anthriscus* type, *Malus* type and *Trifolium* was found. In those samples there was also a high percentage of *Phacelia*, *Fagopyrum* and *Centaurea cyanus* pollen.

Four conventional honey samples obtained from buckwheat were labelled as

multifloral due to a high combined percentage of pollen of the *Rubus* type, Brassicaceae, *Trifolium* and *Centaurea cyanus* type. In hive-ripe honey obtained from heather, two cases were labelled as multifloral due to numerous pollen grains coming from other nectar-secreting plants. Among those, pollen from Brassicaceae, *Solidago* and *Rubus* type was found and the presence of single pollen grains from *Fagopyrum*, *Centaurea cyanus* and *Vicia* was also recorded.

#### Specific electrical conductivity of honeys

Among the dehydrated honeys the values of specific electrical conductivity ranged from  $1.25 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  in borage honey to  $9.43 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  in deciduous honeydew

characteristic of oilseed rape honeys, and honeys from raspberry and borage.

The mean values of electrical conductivity were similar for dehydrated and conventionally harvested honey varieties. Some greater differences, but not statistically validated, were found for robinia honey. In dehydrated honey the electrical conductivity value was by ca.  $0.83 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  higher than in fully-hive ripened honey and in multifloral honey, where it was lower by  $0.65 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ . In the remaining honey varieties the differences in electrical conductivity between dehydrated and conventionally harvested honeys ranged from 0 to  $0.24 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ .

Table 4.

Electrical conductivity of dehydrated vs. conventionally (in-hive ripened) harvested honeys ( $10^{-4} \text{ S} \cdot \text{cm}^{-1}$ ).

Honey variety	Dehydrated honeys			Conventional honeys		
	Number of samples (n)	Range min – max	Mean ( $\bar{x}$ )	Number of samples (n)	Range min – max	Mean ( $\bar{x}$ )
Mixed nectar-honeydew	10	6.10 – 7.83	<b>6.90 a</b>	10	6.20 – 7.84	<b>6.86 a</b>
Deciduous honeydew	5	8.75 – 9.43	<b>9.05 a</b>	5	8.65 – 9.40	<b>8.99 a</b>
Oilseed rape	10	1.44 – 3.80	<b>2.25 a</b>	9	1.91 – 2.56	<b>2.34 a</b>
Robinia	5	2.40 – 4.77	<b>3.15 a</b>	4	1.61 – 2.85	<b>2.32 a</b>
Raspberry	10	1.50 – 4.14	<b>2.38 a</b>	8	1.77 – 2.68	<b>2.14 a</b>
Linden	10	6.06 – 7.86	<b>6.90 a</b>	8	6.46 – 7.75	<b>6.89 a</b>
Buckwheat	8	3.90 – 5.07	<b>4.46 a</b>	6	3.97 – 5.29	<b>4.50 a</b>
Borage	5	1.25 – 1.57	<b>1.38 a</b>	5	1.23 – 1.59	<b>1.38 a</b>
Heather	6	2.91 – 8.05	<b>5.68 a</b>	4	4.94 – 8.02	<b>5.73 a</b>
Multifloral	10	2.95 – 5.42	<b>4.44 a</b>	10	2.59 – 5.93	<b>5.09 a</b>

Values in lines followed by the letters a and/or b are significantly different.

honey. In the honeys which were harvested from capped combs, extreme values of that parameter were also found within the same honey variety (Table 4). Out of the nectar honeys, high electrical conductivity was found in linden honey and heather honey. Low electrical conductivity was

## DISCUSSION

Honeys listed in the Polish Standard for Honey i.e. honey from oilseed rape, robinia, linden, buckwheat, and heather, multifloral honey, mixed nectar and honeydew honey and deciduous honeydew honey were examined in this study.

Additionally, the study included two honey varieties which are not in the Standard: raspberry honey and borage honey. The study was extended to include those varieties mainly because of a steady increase in the production of those honeys.

From among 56 unripe honey samples harvested at different forage sites only two samples failed to meet the requirement for the minimum content of the dominant pollen. In 56 conventional honey samples 12 samples failed to meet the minimum pollen count criterion. These facts indicate that the harvest of honey before the principal forage flow is terminated makes the production of a unifloral honey more feasible. The problem was indirectly brought up by Serwatka (1959) and Woźna (1966). The authors demonstrated that the labelling of honey done by the beekeeper does not always reflect the forage source utilized by the bees.

Unripe honeys were characterized by a very high content of dominant pollen. More than once, dominant pollen counts exceeded the minimum thresholds as stipulated by the Polish Standard. By way of example linden honey can be cited. The Polish Standard sets the minimum dominant pollen count at 20% and the samples which were collected in this study had from 39.4 to 85.2, averaging 63.4% of linden pollen. Those counts are also much higher than those determined in linden honey by Persano Oddo and Piro (2004). Likewise, in the unripe honey from robinia and from heather, dominant pollen counts were higher than those reported by the aforementioned researchers. The content of dominant pollen in unripe oilseed rape honeys ranged from 54.8 to 88.9%. This was comparable to the results reported for those honeys by Poszwiński and Warakomska (1969) and slightly higher than those reported by Demianowicz et al. (1981). In this study, borage pollen counts in both unripe and

in-hive ripened honeys averaged 40%. Van der Ham et al. (1999) stated that the minimum borage pollen count in the honey from borage should be higher than 10%. In-hive ripened honeys from robinia, linden and heather, dominant pollen counts were higher than those reported by Persano Oddo and Piro (2004). In conventionally ripened honeys made by bees during the blooming of oilseed rape, the percentage of dominant pollen was lower compared to the counts obtained by Poszwiński and Warakomska (1969).

Electrical conductivity values obtained for nectar-honeydew honey and deciduous honeydew honey meet the requirements laid down in the Polish Standard and are close to those reported by Rybak (1986). Electrical conductivity values of nectar honeys obtained in this study were often higher, thus, not always in agreement with the values determined by Vorwohl (1964). The results obtained in this study for oilseed rape honey were, however, lower than those determined by Rybak (1986) being comparable to those obtained by Demianowicz et al. (1981). Borage honey examined in this study was characterized by electrical conductivity values lower than the data presented by Vorwohl (1964). Average values determined for raspberry honey were slightly higher. Much higher electrical conductivity values were found in linden and buckwheat honey. Electrical conductivity for linden honey averaged ca.  $6.9 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  (6.06 to  $7.86 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ ). However, the results fall within the range of 3.14 to  $11.5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  reported for honeys by Rybak (1986) and Szczęsna and Rybak-Chmielewska (2004). The electrical conductivity found in buckwheat honey averaged ca.  $4.50 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$  and was similar to the values obtained by Rybak (1986). Values close to those reported in the paper cited above, were obtained also for robinia honey. The

electrical conductivity for heather honey found in this study was from 2.91 to  $8.05 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ , the values obtained being lower than those obtained by Rybak (1986) and Szczęśna and Rybak-Chmielewska (2004).

Higher specific electrical conductivity values can be accounted for by a smaller or larger mixture of honeydew in the honey. Honeydew-occurrence coincides very often with the period of nectar secretion by linden trees, buckwheat or heather. In the years 2005 and 2006 honeydew occurred on plants as early as the end of blooming of oilseed rape and lasted practically until the end of the season.

### CONCLUSIONS

- Ripening of honey under controlled conditions increases the chances of obtaining pure unifloral honey from any source of forage.
- In incompletely ripe honeys the content of dominant pollen is significantly higher than that in in-hive ripened honey.
- As compared to honeys harvested by conventional methods honeys dehydrated under controlled conditions are characterized by similar electrical conductivity values.

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**ZMIANY ZACHODZĄCE W MIODZIE PODCZAS  
DOJRZEWANIA W KONTROLOWANYCH WARUNKACH  
NA PODSTAWIE UDZIAŁU PYŁKU PRZEWODNIEGO  
I PRZEWODNOŚCI ELEKTRYCZNEJ WŁAŚCIWEJ**

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Teper D., Skubida P.**

S t r e s z c z e n i e

Celem badań było określenie wpływu dojrzewania miodu w kontrolowanych warunkach na wybrane parametry jakościowe – udział pyłku przewodniego i przewodność elektryczną właściwą. Materiał do badań stanowiły próbki miodów odmianowych pozyskanych z różnych pasiek. W trakcie 3 lat trwania doświadczenia pozyskano do badań 79 próbek miodów niedojrzałych, które poddano odwadnianiu w przygotowanej do tego celu komorze oraz 74 próbki miodów z tych samych pasiek, a dojrzewających w ulach. Analizy palinologiczne wykazały, że średnia zawartość pyłku przewodniego w miodach pozyskanych przed osiągnięciem jego dojrzałości wynosiła 63,8%. W miodzie pozostawionym w ulu do osiągnięcia pełnej dojrzałości, udział pyłku przewodniego spadał średnio do 46,4%. Średnie różnice w wartościach przewodności elektrycznej pomiędzy odmianami miodu odwadnianego i pozyskanego w sposób konwencjonalny nie przekraczały najczęściej  $0,5 \cdot 10^{-4} \text{ S} \cdot \text{cm}^{-1}$ .

**Słowa kluczowe:** miód, dojrzewanie, pyłek przewodni, analiza pyłkowa miodu, przewodność elektryczna właściwa miodu.