CHARACTERISTICS OF POLISH UNIFLORAL HONEYS. II. LIME HONEY (TILIA SPP.)

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Summary

The aim of the study was to characterise Polish lime honey harvested under local climatic conditions. The characterisation was based on sensory analysis (evaluation of aroma, flavour, colour, consistency) and analysis of pollen as well as physicochemical parameters (electrical conductivity, activity of α-amylase enzyme, pH and free acidity, water content, sugars, 5-hydroxymethylfurfural, and proline). The research material consisted of 53 samples of lime honey collected from selected apiaries over the years 2007-2010.

The organoleptic traits, typical for lime honey, were determined: a strong aroma which is similar to that of the lime flowers, and a sweet, slightly burning flavour - often with a hint of bitterness. Prior to crystallisation, lime honey has a consistency of thick liquid. The crystallised form is fine-grained.

Some samples of lime honey have a relatively high, for a nectar honey, electrical conductivity and lower monosaccharides content caused by the addition of honeydew. The samples were characterised by high variability of the majority of parameters determined (colour, diastase number, electrical conductivity, free acidity, content of proline and disaccharides: turanose, maltose, and trehalose).

Keywords: lime honey, honey variety, characteristics, organoleptic traits, pollen analysis, physicochemical parameters, Poland.

INTRODUCTION

Lime trees are common in mixed forests. They are also frequently planted in parks and along roadsides. Initially, two species of lime were present in Polish natural habitats: small-leaved (Tilia cordata Mill.) and large-leaved (Tilia platyphyllos Scop.). A number of other lime species and crosses from Europe, Asia and America, may be encountered in parks and gardens where lime trees are used for their ornamental value. Different species of lime have diverse flowering dates which extend their utility for honey production. The large-leaved lime (T. platyphyllos) may begin its flowering season in mid-June with other varieties following: Tilia x Moltkei, T. hybryda and T. x europea. In our climate, the small-leaved lime (T. cordata) is the most important for honey production. It begins flowering in the 3rd decade of June. The flowering season is then concluded by T. tomentosa, T. japonica II and T. insularis. The average length of flowering for each species is about 12-18 days (Szklanowska et al., 1999; Jabłoński and Kołtowski, 1999; Weryszko-Chmielewska and Sadowska, 2010).

Lime trees are generally considered to be among the best nectariferous plant species. Quite often though, despite their numerous presence in a given area, the yield of honey may not be abundant. This is due to a variety of factors determining nectar production, such as temperature, humidity, sunlight exposure, air movement and soil conditions. Low or fluctuating temperatures and intensive precipitation in the flowering season are commonly responsible for the scarcity of lime nectar.
Lime flowers possess exposed nectaries which are easily dried out by wind or washed out by rain (Demianowicz and Hłyn, 1960; Maksymiuk, 1960).

Occurrence of lime nectar often coincides with the production of honeydew secreted by the lime aphid (Eucallipterus tiliae L.). The breeding season of the lime aphid begins in May. The largest amounts of honeydew appear in July, when in favourable weather conditions, the aphids may appear in great numbers and supply honeybees with forage more abundant than the lime nectar (Haragsim, 1970; Persano Oddo and Piro, 2004).

According to the data presented in the Polish apiculture sector analysis compiled for the National Beekeeping Support Program in 2010-2013, in the last few years, the harvest of lime honey was satisfactory only in some regions of Poland (Semkiw and Skubida, 2010).

Organoleptic features and pollen content in honey sediment required for lime honey (no less than 20%) are described by the Polish Standard (PN-88/A-77626, 1998). The low (20%) Tilia pollen content limit for lime honey results from the small total number of pollen grains in lime nectar (Demianowicz and Demianowicz, 1957 after Maurizio, 1949). For this reason lime honeys were classified as underrepresented (class I, pollen content below 20 000 PG/10 g). The analysis of Polish lime honey samples was conducted by Woźna (1966) and Semkiw et al. (2008b). Pollen analyses from the samples of European lime honey were obtained with the cooperation of a number of European laboratories. The results were published by Persano Oddo and Piro (2004).

Detailed guidelines referring to physicochemical properties of honey are contained in the Regulation of the Ministry of Agriculture and Rural Development of Oct. 3, 2003 (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003), which is in agreement with the EU Directive (Council Directive, 2002).

Owing to its exceptional organoleptic attributes and high quality parameters, lime honey is highly popular among consumers. The majority of physicochemical parameters describing honey quality show average values for this variety. Occasionally, high level of electrical conductivity, with values exceeding the average for a nectar honey type, and lowered content of monosaccharides result from the presence of honeydew (Persano Oddo and Piro, 2004) are observed.

The characteristics of Polish lime honey were presented in the following publications: Demianowicz and Demianowicz (1957); Fedorowska et al. (1979); Curyło and Rybak (1973), Rybak (1986); Piekut and Borawska (2000); Rybak-Chmielewska and Szczęsna (2000) and Semkiw et al. (2008a, 2008b, 2009, 2010). However, none of the previously published works include a full compilation of all the physicochemical characteristics of this honey variety.

The aim of the study was to characterise Polish lime honey harvested under local climatic conditions. The characterisation was based on sensory analysis (evaluation of aroma, flavour, colour, consistency) and analysis of pollen as well as physicochemical parameters (electrical conductivity, activity of α-amylase enzyme expressed as diastase number, pH and free acidity, water content, sugars, 5-hydroxymethylfurfural and proline).

MATERIALS AND METHODS

Fifty-three samples of lime honey were analysed. The samples came from selected apiaries and were collected over the years 2007-2010. Organoleptic appraisal was used to make sure the test samples initially qualified for the research purposes. The variety of honey was confirmed by pollen analysis; the method used confirmed to the Polish Standard (PN-88/A-77626, 1998 based on Louveaux et al., 1978). Following the standard’s requirements, flavour, aroma and consistency were also determined. The colour of honey was defined using the mm Pfund scale
by the colorimetric method and using the Lovibond PFX 195 colorimeter. In testing of the physicochemical parameters, methods compiled by the International Honey Commission (Bogdanov et al., 1997) were used. Some of the methods, such as chromatographic sugars content and HMF determination or testing for electrical conductivity, were modified in of the Bee Products Quality Testing Laboratory (Rybak-Chmielewska and Szczęsna, 2003; Szczęsna and Rybak-Chmielewska, 1999; 2004).

The methods utilised for determining physicochemical parameters are also detailed in the Regulation of the Ministry of Agriculture and Rural Development of Jan. 14, 2009 (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 14.01.2009).

**RESULTS AND DISCUSSION**

Organoleptic features typical for lime honey are a strong aroma similar to that of lime flowers, and a sweet, slightly burning flavour - often with a hint of bitterness. Prior to crystallisation, the honey has the consistency of thick liquid. The colour is greenish-yellow with diferent yellow tone. The crystallised form is fine-grained, whitish-yellow with diferent intensity of amber tone. A similar organoleptic assessment of honey was presented by Rybak (1986). The results of the sensory analysis are in agreement with the requirement for this honey variety as defined in the Polish Standard (PN-88/A-77626, 1998).

The results of physicochemical parameters and pollen analysis of the lime honey samples are presented in Tab. 1. The colour of the tested honey samples ranged from 19 to 78, on average 47 in mm Pfund scale, with the standard deviation and variation coefficient of 13.0 and 27.7%, accordingly. The parameter’s high variability results from the different amounts of honeydew content in different samples. Persano Oddo and Piro (2004) found lower colour values, which ranged from 11.0 to 55.0, the average being 33.3 using the mm Pfund scale.

In the 53 samples tested, the content of *Tilia* pollen was 20.4 - 41.4%, on average 28.1%, and the total pollen count in 10 g of honey (PG/10 g) ranged from 8 400 to 19 500, on average 13 700 (Tab. 1). The obtained results are close to the results published elsewhere (Demianowicz and Demianowicz, 1957 after Maurizio, 1949; Woźna, 1966; Persano Oddo and Piro, 2004; Semkiw et al., 2008b).

Water content ranged from 15.9 to 19.0%. The average parameter value obtained (17.4%) was much lower than the threshold value (20%), as set by the Regulation of the Ministry of Agriculture and Rural Development (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). The standard deviation was 0.8 and the coefficient of variation - 4.6%. The results obtained here are slightly below those of Rybak (1986), which were from 16.7 to 20.0%, on average 18.0, but are higher when compared with Semkiw et al. (2008a): from 15.9 to 18.2%, the average being 16.8% and Persano Oddo and Piro (2004): from 14.6 to 19.3%, with an average of 16.9%.

The total content of monosaccharides (fructose and glucose) was from 63.3 to 77.4 g/100 g, the average being 68.6 g/100 g; with the standard deviation and variability coefficient equal to 2.9 and 4.2%, respectively. The results for the total content of monosaccharides are concurrent with the standard (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003) which describe the minimum value for this parameter in nectar honey as 60 g/100 g. Slightly lower values (from 59.95 to 67.08%, average 63.17%) were obtained by Semkiw et al. (2009). Persano Oddo and Piro (2004) showed results very close to the ones presented in this work (from 61.5 to 77.4 g/100 g, average 69.5 g/100 g).

The fructose to glucose ratio (F/G) was from 1.01 to 1.33, with the average at 1.19, with the standard deviation and variability coefficient of 0.1 and 8.4% accordingly. The fructose content was in the range of 33.9 to 40.6 g/100 g, on average 37.3 g/100 g. The glucose
The fructose to glucose ratio was lower in the results obtained by Rybak-Chmielewska and Szczęsna (2000). Their ratio was from 1.02 to 1.15, the average was 1.07. The range of the fructose content, as presented by these authors, was from 29.11 to 34.97%, on average 31.82%; and for glucose from 27.31 to 33.61%, on average 29.86%. The results of other authors were similar to the ones presented in this work: Semkiw et al. (2009) showed the average value for F/G ratio as 1.15; Persano Oddo and Piro (2004) found the average value of the parameter to be 1.18 and its range was from 0.94 to 1.43.

In the majority of the samples tested, sucrose content was found to be from 0.5 g/100 g (the method's determinability limit). Only in two samples was the content (5.8 and 5.9 g/100 g) slightly above the admissible value of 5 g/100 g (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). Similarly, a low sucrose content (average 1.2 g/100 g) was found by Persano Oddo and Piro (2004). Higher results for Polish lime honey (average 8.62 g/100 g) were presented by Semkiw et al. (2009).

Apart from sucrose, other disaccharides were determined: turanose, maltose, trehalose and isomaltose. The content range for turanose was from 0.5 to 2.9 g/100 g, with an average of 1.5 g/100 g. The maltose content was from 0.6 to 3.3 g/100 g, with an average of 2.3 g/100 g. Trehalose content ranged from 0.5 to 3.1 g/100 g, with an average of 1.2 g/100 g. Isomaltose was not detected in any of the samples, with the method's determinability limit being 0.5 g/100 g.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Min-Max</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Variation coefficient (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>mm Pfund</td>
<td>19 - 78</td>
<td>47</td>
<td>13.0</td>
<td>27.7</td>
</tr>
<tr>
<td>Tilia pollen</td>
<td>%</td>
<td>20.4 - 41.4</td>
<td>28.1</td>
<td>7.8</td>
<td>28.0</td>
</tr>
<tr>
<td>Pollen absolute number</td>
<td>PG/10 g/103</td>
<td>8.4 - 19.5</td>
<td>13.7</td>
<td>3.8</td>
<td>27.8</td>
</tr>
<tr>
<td>Water</td>
<td>%</td>
<td>15.9 - 19.0</td>
<td>17.4</td>
<td>0.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Fructose (F)</td>
<td>g/100 g</td>
<td>33.9 - 40.6</td>
<td>37.3</td>
<td>1.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Glucose (G)</td>
<td>g/100 g</td>
<td>27.3 - 38.5</td>
<td>31.3</td>
<td>1.9</td>
<td>6.1</td>
</tr>
<tr>
<td>F+G*</td>
<td>g/100 g</td>
<td>63.3 - 77.4</td>
<td>68.6</td>
<td>2.9</td>
<td>4.2</td>
</tr>
<tr>
<td>F/G**</td>
<td></td>
<td>1.01 - 1.33</td>
<td>1.19</td>
<td>0.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Sucrose</td>
<td>g/100 g</td>
<td>0.5 - 5.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turanose</td>
<td>g/100 g</td>
<td>0.5 - 2.9</td>
<td>1.5</td>
<td>0.5</td>
<td>33.3</td>
</tr>
<tr>
<td>Maltose</td>
<td>g/100 g</td>
<td>0.6 - 3.3</td>
<td>2.3</td>
<td>0.7</td>
<td>30.4</td>
</tr>
<tr>
<td>Trehalose</td>
<td>g/100 g</td>
<td>0.5 - 3.1</td>
<td>1.2</td>
<td>0.5</td>
<td>41.7</td>
</tr>
<tr>
<td>Isomaltose</td>
<td>g/100 g</td>
<td>0.5 - 1.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diastase (DN)</td>
<td>Schade****</td>
<td>10.6 - 44.4</td>
<td>21.3</td>
<td>7.6</td>
<td>35.7</td>
</tr>
<tr>
<td>HMF</td>
<td>mg/kg</td>
<td>0.5 - 14.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Free Acidity</td>
<td>mval/kg</td>
<td>12.9 - 45.6</td>
<td>21.6</td>
<td>7.5</td>
<td>34.7</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>3.82 - 4.64</td>
<td>4.17</td>
<td>0.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>mS/cm</td>
<td>0.23 - 8.11</td>
<td>0.54</td>
<td>0.15</td>
<td>27.8</td>
</tr>
<tr>
<td>Proline</td>
<td>mg/100 g</td>
<td>25.6 - 79.4</td>
<td>44.6</td>
<td>12.5</td>
<td>28.0</td>
</tr>
</tbody>
</table>

* total content of monosaccharides (fructose and glucose)  
** fructose to glucose ratio  
*** limit of determination  
**** one diastase unit is equivalent to the activity level of the enzyme contained in 1 g of honey which may hydrolyze 0.01 g of starch within 1 hour at a temperature of 40°C.
2.9 g/100 g, on average 1.5 g/100 g; for maltose from 0.6 to 3.3 g/100 g, on average 2.3 g/100 g, and for trehalose from 0.5 to 3.1 g/100 g, on average 1.2 g/100 g. The content of isomaltose was determined to be on a level of from 0.5 g/100 g to 1.8 g/100 g. The standard deviation and coefficient of variation values for the tested disaccharides were on similar levels: for turanose - 0.5 and 33.3%, for maltose - 0.7 and 30.4% and for trehalose - 0.5 and 41.7%, respectively.

The content of disaccharides in lime honey was presented earlier by Rybak-Chmielewska and Szczęsna (2000). Their results were as follows: the range for maltose was from 1.04 to 2.15%, on average 1.44%; and for turanose from 0.94 to 2.07%, on average 1.43%.

The level of activity of α-amylase, determined by the diastase number (DN) for the tested samples ranged from 10.6 to 44.4 Schade units, on average 21.3 with the standard deviation 7.6 and the variability coefficient 35.7%. The values are much higher than the minimum - 8 Schade units - described in the previously mentioned Regulation concerning detailed requirements for commercial honey quality (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). The own results of diastase number are much lower than the results of Rybak (1986): from 44.7 to 78.9, on average 55.5 Schade units; but decisively higher than the ones of Semkiw et al. (2010) - 20.35 mval/kg and Persano Oddo and Piro (2004) - 20.8 mval/kg. In the works quoted, the range and average values of pH were also determined and were as follows: from 3.9 to 4.2, on average 4.01 (Rybak, 1986) and from 3.9 to 5.0, on average 4.4 (Persano Oddo and Piro, 2004).

The tested samples of lime honey were very varied in regards to electrical conductivity. The range for this parameter was found to be from 0.23 to 0.81 mS/cm, on average 0.54 mS/cm, with the standard deviation and coefficient of variation at 0.15 and 27.8%, respectively. Some samples showed a high parameter value (over 0.6 mS/cm), unquestionably resulting from the honeydew content. In the Regulation of the Ministry of Agriculture and Rural Development (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003) no requirements concerning electrical conductivity of lime honey are specified. This parameter is described more precisely in the Polish Standard (PN-88/A-77626, 1998) which states the minimum $2\times10^{-4}$ S/cm for nectar honey; $6\times10^{-4}$ S/cm for nectar-honeydew honey, $8\times10^{-4}$ S/cm for deciduous honeydew varieties and $9.5\times10^{-4}$ S/cm for coniferous honeydew honey varieties. High results for electrical conductivity in Polish lime honey samples were found by other
researchers: Rybak (1986) - from 3.14 to 7.71×10⁻⁴ S/cm, average 5.32×10⁻⁴ S/cm. Even higher values for the parameter were obtained by Semkiw et al. (2008b) - from 6.46 to 7.75×10⁻⁴ S/cm, average 6.89×10⁻⁴ S/cm. Equally high values of electrical conductivity (from 0.37 to 0.87, average 0.62 mS/cm) were noted by Persano Oddo and Piro (2004).

The range determined for proline content was from 25.6 to 79.4 mg/100 g, on average 44.6 mg/100 g with the standard deviation and variation coefficient equal to 12.5 and 28.0%, accordingly. Requirements concerning the minimum proline content were only described by the Polish Standard (PN-88/A.-77626, 1998), which currently is not a binding document as far as commercial honey quality is concerned. The content of proline in the majority of the samples tested, greatly exceeded the required minimum. The presented results for proline are also higher than the results obtained by Persano Oddo and Piro (2004): from 202 to 554 mg/kg, on average 352 mg/kg.

CONCLUSIONS

1. Lime honey is characterised by a strong aroma which is similar to that of lime flowers, and a sweet, slightly burning flavour - often with a hint of bitterness. Prior to crystallisation, the honey has the consistency of thick liquid. The crystallised form is fine-grained.

2. The content of *Tilia* pollen and the total pollen count in 10 g of honey (PG/10 g) matched the data presented by other authors.

3. The relatively high, for a nectar honey, electrical conductivity and the lower content of monosaccharides found in some samples are caused by the honeydew addition.

4. The samples were characterised by a high variability in the majority of parameters determined (colour, diastase number, electrical conductivity, free acidity, the content of proline and disaccharides: turanose, maltose, and trehalose).

5. The obtained results allowed lime honey harvested in the climatic and apicultural conditions of Poland, to be characterised.

6. The results obtained do not differ significantly from the results published by other authors.

REFERENCES


Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 14 stycznia 2009 w sprawie metod analiz związanych z dokonywaniem oceny miodu (Dz.U. 2009 nr 17 poz. 94).


CHARAKTERYSTYKA POLSKICH MIODÓW ODMIANOWYCH.
II. MIÓD LIPOWY (TILIA SPP)

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Streszczenie

Miód lipowy charakteryzuje się silnym zapachem, zbliżonym do zapachu kwiatów lipy i słodkim smakiem, lekko piekącym z często wyczuwalnym gorzkawym posmakiem. Procentowa zawartość pyłku Tilia oraz całkowita liczba ziaren pyłku w 10 g miodu (PG/10 g) była zgodna z danymi z literatury.

Obserwowana niekiedy wysoka, jak dla miodu nektarowego przewodność elektryczna właściwa (od 0,23 do 0,81 mS/cm; średnio 0,54 mS/cm) oraz niższa zawartość cukrów prostych (od 63,3 do 77,4 g/100 g; średnio 68,6 g/100 g) była spowodowana domieszką spadzi. Próbki charakteryzowały się dużą zmiennością dla większości oznaczanych parametrów: barwa (od 19-78; średnio 47 w mm Płunlla), liczba diastazowa (od 10,6 do 44,4 Schade; średnio 21,3 Schade), wolne kwasy (od 12,9 do 45,6 mval/kg; średnio 21,6 mval/kg), przewodność elektryczna właściwa (od 0,23 do 0,81 mS/cm; średnio 0,54 mS/cm) zawartość proliny (od 25,6 do 79,4 mg/100 g; średnio 44,6 mg/100 g) oraz zawartość dwucukrów (turanozy - od 0,5 do 2,9 g/100 g; średnio 1,5 g/100 g; maltozy - od 0,6 do 3,3 g/100 g; średnio 2,3 g/100 g; trehalozy - od 0,5 do 1,2 g/100 g). Słowa kluczowe: miód lipowy, odmiana miodu, charakterystyka, cechy organoleptyczne, analiza pyłkowa, parametry fizykochemiczne, Polska.