INTRODUCTION

Calluna vulgaris L. is widely present in Poland: in light, dry pine forests, pastures and meadows adjacent to forests and, quite frequently, in high peat bogs. Nevertheless, it is only in some areas which are mainly sandy and limestone deficient, where extensive moorlands exist, that beekeepers are able to collect up to twenty kilograms of honey per bee colony (Jabłoński, 1988).

Heather honey, due to the geographical limitations of its production, is a relatively rare honey variety in Poland. It is harvested at the end of September and beginning of October, chiefly in Dolny Śląsk, but also in Podkarpackie and Zachodniopomorskie Voivodships. The unique qualities of honey from Bory Dolnośląskie allowed it to be entered onto the 2005 "Traditional Product List" of the Ministry of Agriculture and Rural Development. In 2008, the honey was registered by the European Commission as a Regional Product, which enabled its producers to adopt the EU symbol “Protected Geographical Indication” (http://www.minrol.gov.pl).

According to the analysis of the Polish apiculture sector, as mapped out for the National Beekeeping Support Program in 2010-2013, favourable climatic conditions in 2007-2009 meant that the heather honey harvest was larger than ever before. The same analysis demonstrates that heather honey is characterised by high water content, an elevated fructose to glucose ratio, electrical conductivity which is relatively high for a nectar honey variety, high proline content and activity of α-amylase enzyme.

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

CHARACTERISTICS OF POLISH UNIFLORAL HONEYS.
III. HEATHER HONEY (CALLUNA VULGARIS L.)

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Summary

The aim of the study was to characterise Polish heather 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, the water content, sugars, 5-hydroxymethylfurfural and proline). The research material consisted of 26 samples of heather honey, collected from selected apiaries over the years 2008-2010.

The organoleptic traits, typical for heather honey, were determined: strong aroma, approaching the aroma of the heather flower, and flavour - not overly sweet, spicy and slightly bitter. A feature typical only for this honey variety, is its gelatinous consistency. Moreover, the examination of physicochemical parameters demonstrated that heather honey is characterised by high water content, an elevated fructose to glucose ratio, electrical conductivity which is relatively high for a nectar honey variety, high proline content and activity of α-amylase enzyme.

Keywords: heather honey, honey variety, characteristics, organoleptic traits, pollen analysis, physicochemical parameters, Poland.
a varied proportional content of *Calluna* pollen in honey sediment, and a wide range in the total number of pollen grains in 10 g of honey (PG/10 g). This is caused by the frequent secondary addition of pollen from beebread during honey extraction. The pollen analysis of Polish heather honeys was carried out by Serwatka (1958), Woźni (1966) and Posziński and Warakomska (1969). Results of European heather honeys pollen analyses, obtained with the cooperation of several European laboratories, were published by Persano Oddo and Piro (2004).


Heather honey harvested under Polish climatic and forage conditions is characterised by amber or tea colour with lighter or darker shades; it has a strong, pleasant aroma approaching that of the aroma of heather flowers. Its flavour is distinctive, sweet and slightly bitter (Rybak, 1986). Similar organoleptic properties were presented by Persano Oddo and Piro (2004) for heather honey originating from the countries of Northern and Western Europe. Moreover, the same study noticed that gelatinous consistency, found only in heather honey varieties, impedes the extraction of honey. The phenomenon is a result of thixotropy (the ability to form colloidal solutions and change from sol to gel form). The gel form is made possible by elevated protein content, higher than in other honey varieties.

Heather honey is also characterised by a higher, in comparison with other varieties, water content (Rybak, 1986; Persano Oddo and Piro, 2004; Semkiw et al., 2008a). According to Persano Oddo and Piro (2004), elevated water content and a faster increase of 5-hydroxymethylfurfural (HMF) content caused by a higher incidence of free acidity (HMF content grows markedly in acidic environments) is responsible for the rapid fall of heather honey quality parameters. Moreover, a relatively high activity level of α-amylase enzyme was found (Rybak, 1986; Semkiw et al., 2010) as well as a high amino acids content, which, according to Serra Bonvehi and Grandos Tarres (1993), may be a distinctive trait of this honey variety. Another significant feature is its electrical conductivity which is the highest of all nectar honeys, except chestnut honey (Rybak, 1986; Persano Oddo and Piro, 2004).

Apart from the works mentioned above (Rybak, 1986; Semkiw et al., 2008a, 2008b, 2009, 2010), elements of the characteristics of Polish heather honey are also presented in the following publications: Curylo and Rybak (1973); Piekt and Borawska (2000); Rybak-Chmielewska and Szczesn (2000). However, none of the previously published works includes a full compilation of all the physicochemical characteristics of this honey variety.

The aim of the study was to characterise Polish heather honey harvested under the 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, the water content, sugars, 5-hydroxymethylfurfural and proline).

**MATERIALS AND METHODS**

Twenty six samples of heather honey were analysed; the samples came from selected apiaries and were collected in the years 2008-2010. Test samples were initially qualified for the research purposes by organoleptic appraisal. 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 in mm Pfund scale by the colorimetric method and using Lovibond PFX 195 colorimeter. The methods compiled by the International Honey Commission (Bogdanov et al., 1997) were used for testing of the physicochemical parameters. Some of the methods, such as chromatographic sugars content and HMF determination or testing for electrical conductivity, were modified according to the conditions 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 for the methods of analyses used in honey assessment (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 14.01.2009).

RESULTS AND DISCUSSION

According to the sensory analysis, heather honey is characterised by strong aroma, resembling the aroma of heather flowers; its flavour is spicy, slightly bitter and not overly sweet. The colour is amber with reddish tone. The distinguishing feature, present only in this honey variety, is its gelatinous consistency. A similar organoleptic assessment of honey was presented by Rybak (1986). The results of the sensory analysis are concurrent with the requirement for this honey variety as defined in the Polish Standard (PN-88/A-77626, 1998).

Physicochemical parameters and pollen analysis results are presented in Tab. 1.

The minimum value determined for colour in the samples tested was 69 in mm Pfund scale. For some samples, exact colour determination (above 114) was not possible due to a limited range of the equipment in high registers. Measurements were also impeded by the gelatinous consistency of honey, preventing total clarification of the samples. Slightly lower colour values (from 63.8 to 90.0; average 76.9 in mm Pfund scale) were obtained by Persano Oddo and Piro (2004) for heather honey from Northern and Western Europe.

Calluna pollen content in the 26 samples tested was 45.4 - 82.3%; average 56.7%. The total number of pollen grains in 10 g of honey (PG/10 g) was between 17 100 - 134 400; average 69 500 (Tab. 1). The results obtained are similar to the ones published elsewhere (Serwatka, 1958; Woźna, 1966; Posziwiński and Warakomska, 1969; Persano Oddo and Piro 2004).

Water content in the samples tested ranged from 15.4 to 21.9%. The average value of the parameter was 19.1% and was much lower than the permitted value for heather honey (23%) as defined by 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). The standard deviation was 1.5 and the variation coefficient was 7.9%. The rather large variability of this factor is caused, as in the case of the problems with colour determination, by the gelatinous consistency preventing total clarification of the samples. The results obtained are congruent with earlier results of other authors: from 17.6 to 24.6%, on average 20.1% (Rybak, 1986); from 19.1 to 21.0%, on average 20.0% (Semkiw et al., 2008a). A slightly lower water content (from 15.6 to 21.4%, on average 18.5%) was found in the heather honey tested by Persano Oddo and Piro (2004). The differences might have resulted from diverse climatic conditions.

Total content of monosaccharides (fructose and glucose) was from 62.4 to 76.1 g/100 g, with the average of 69.3 g/100 g, and with the standard deviation and the variation coefficient 3.3 and 4.8%, accordingly. The results for the monosaccharides correspond to the requirements (Rozporządzenie...
Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003) describing the minimum value for this parameter in nectar honey (60 g/100 g). Similar parameter values (from 69.26 to 70.9%, average 69.96 %) were found by Semkiw et al. (2009). A slightly higher monosaccharides content, on average 73.4 g/100 g, was detected by Persano Oddo and Piro (2004).

In the samples tested, a high ratio of fructose to glucose (F/G) was found; from 1.12 to 1.46, on average 1.32, with the standard deviation of 0.1 and the variation coefficient 7.6%. The much lower glucose content (from 25.9 to 34.3 g/100 g, average 29.9 g/100 g) in comparison with fructose (from 36.5 to 43.3 g/100 g, average 39.3 g/100 g) results in a slow crystallisation process of heather honey and prolonged retention of its gelatinous consistency. Similar results for the sugars content were presented by Rybak-Chmielewska and Szczesna (2000); the range for fructose was from 38.79 to 39.54%, on average 39.17%, and for glucose from 28.49 to 30.13%, on average 29.31%, with the F/G from 1.31 to 1.36, on average 1.34. A slightly lower average value for the F/G (1.25) was found by Semkiw et al. (2009). However, it must be noted that the differences may result from the low number of samples tested by these authors. A high proportion of fructose to glucose content is also confirmed by the results obtained by Persano Oddo and Piro (2004): from 1.15 to 1.40, with the average of 1.26. As was similar in this work, Persano Oddo and Piro found a much lower glucose content (from 29.3 to 35.7 g/100 g, on average 32.5 g/100 g) in comparison with fructose content (from 37.1 to 44.9 g/100 g, on average 40.8 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>69 - higher than 114</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Calaluna pollen</td>
<td>%</td>
<td>45.4 - 82.3</td>
<td>56.7</td>
<td>12.3</td>
<td>21.7</td>
</tr>
<tr>
<td>Pollen absolute number</td>
<td>PG/10 g·103</td>
<td>171 - 134.4</td>
<td>69.5</td>
<td>41.7</td>
<td>60.0</td>
</tr>
<tr>
<td>Water</td>
<td>%</td>
<td>15.4 - 21.9</td>
<td>19.1</td>
<td>1.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Fructose (F)</td>
<td>g/100 g</td>
<td>36.5 - 43.3</td>
<td>39.3</td>
<td>1.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Glucose (G)</td>
<td>g/100 g</td>
<td>25.9 - 34.3</td>
<td>29.9</td>
<td>2.0</td>
<td>6.7</td>
</tr>
<tr>
<td>F+G*</td>
<td>g/100 g</td>
<td>62.4 - 76.1</td>
<td>69.3</td>
<td>3.3</td>
<td>4.8</td>
</tr>
<tr>
<td>F/G**</td>
<td>1.12 - 1.46</td>
<td>1.32</td>
<td>0.1</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>g/100 g</td>
<td>0.5*** - 0.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turanose</td>
<td>g/100 g</td>
<td>0.9 - 2.7</td>
<td>1.4</td>
<td>0.4</td>
<td>28.6</td>
</tr>
<tr>
<td>Maltose</td>
<td>g/100 g</td>
<td>0.8 - 2.8</td>
<td>1.8</td>
<td>0.4</td>
<td>22.2</td>
</tr>
<tr>
<td>Trehalose</td>
<td>g/100 g</td>
<td>0.7 - 2.2</td>
<td>1.3</td>
<td>0.4</td>
<td>30.8</td>
</tr>
<tr>
<td>Isomaltose</td>
<td>g/100 g</td>
<td>0.5*** - 0.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diastase (DN)</td>
<td>Schade****</td>
<td>19.0 - 57.3</td>
<td>32.7</td>
<td>9.4</td>
<td>28.7</td>
</tr>
<tr>
<td>HMF</td>
<td>mg/kg</td>
<td>0.7 - 14.8</td>
<td>4.8</td>
<td>4.1</td>
<td>85.4</td>
</tr>
<tr>
<td>Free Acidity</td>
<td>mval/kg</td>
<td>14.9 - 33.8</td>
<td>22.1</td>
<td>5.4</td>
<td>24.4</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>4.07 - 4.66</td>
<td>4.37</td>
<td>0.17</td>
<td>3.9</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>mS/cm</td>
<td>0.37 - 0.82</td>
<td>0.62</td>
<td>0.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Proline</td>
<td>mg/100 g</td>
<td>33.1 - 92.1</td>
<td>55.3</td>
<td>12.5</td>
<td>22.6</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 the temperature of 40°C
In almost all the samples tested (25), the sucrose content was found below the level of 0.5 g/100 g (the method's determinability limit). In only one sample the sucrose content was established at 0.6 g/100 g. The parameter values in all samples were much lower than the admissible 5 g/100 g (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). A similarly low content (on average 0.85%) was found by Semkiw et al. (2009).

Apart from sucrose, other disaccharides were determined: turanose, maltose, trehalose and isomaltose. The content range for turanose was from 0.9 to 2.7 g/100 g, on average 1.4 g/100 g; for maltose from 0.8 to 2.8 g/100 g, on average 1.8 g/100 g; and for trehalose from 0.7 to 2.2 g/100 g, on average 1.3 g/100 g. In the majority of samples (17), the content of isomaltose was below the level of 0.5 g/100 g; in 5 samples the content was 0.5 g/100 g, in 3 samples it was 0.7 g/100 g and in 1 sample it was 0.6 g/100 g. The standard deviation and the variation coefficient for the content of the disaccharides tested were on similar levels and were accordingly: for turanose - 0.4 and 28.6%; for maltose - 0.4 and 22.2%; for trehalose - 0.4 and 30.8%.

The activity level of \( \alpha \)-amylase determined by the diastase number (DN) for the samples tested, ranged from 19.0 to 57.3 Schade units, on average 32.7 Schade; with the standard deviation of 9.4 and variability coefficient of 28.7%. The values are much higher than the minimum - 8 Schade units (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). The DN results presented here are slightly lower than the results obtained earlier by other authors. The range for \( \alpha \)-amylase activity level in heather honey presented by Rybak (1986) was from 33.7 to 69.7 Schade units, on average 48.4. Those results which were closer to the results from this work were obtained by Semkiw et al. (2010). The range they presented was from 29.82 to 53.76, on average 37.19. A much lower \( \alpha \)-amylase activity (from 12.0 to 36.0; average 23.4) was found in heather honey by Persano Oddo and Piro (2004).

In the samples tested, HMF content was in the range of 0.7 - 14.8 mg/kg. Only in four samples did the parameter value surpass 10 mg/kg; in the majority of samples (21) the levels were much lower. The average content for all the samples tested was 4.8 mg/kg and was much lower than the admissible level of 40 mg/kg (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 03.10.2003). The standard deviation for the value searched was 4.1 and the variation coefficient was 85.4%. A much higher than the average HMF content was observed in the samples with a higher incidence of free acidity.

All the tested samples of heather honey had free acidity in the range of 14.9 to 33.8 mval/kg, on the average, 22.1 mval/kg with the standard deviation of 5.4, and an admittedly high - but lower than in HMF determination, variability coefficient of 24.4%. The range of pH in the samples tested was from 4.07 to 4.66, on average 4.37. The results of pH testing were characterised by much lower variability than the results of testing for free acidity. The standard deviation and coefficient of variation for the pH tests were 0.17 and 3.9%, respectively. A similarly wide range of results in free acidity testing was found by other authors: from 17.9 to 37.6 mval/kg, average 26.5 mval/kg (Rybak, 1986); from 18.9 to 35.0 mval/kg, average 24.55 mval/kg (Semkiw et al., 2010) and from 20.8 to 43.0 mval/kg, average 32.1 mval/kg (Persano Oddo and Piro, 2004). These publications also presented the range and average values of pH results, which were accordingly: from 3.9 to 4.4, average 4.17 (Rybak, 1986); similarly Persano Oddo and Piro (2004) - from 3.9 to 4.7, average 4.2. Unfortunately, the works mentioned do not present data concerning HMF content in heather honey samples. Only Persano Oddo and Piro (2004) briefly mention that heather honey is characterised by a higher-than-elsewhere noted content of HMF related to the higher free acidity.
The heather honey samples tested were distinguished by relatively high electrical conductivity in comparison with other nectar honey varieties. The conductivity range was from 0.37 to 0.82 mS/cm, on average 0.60 mS/cm, with the standard deviation and variability coefficient 0.1 and 16.7%, respectively. Requirements concerning the electrical conductivity of particular honey varieties are stated rather ambiguously 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). The parameter is described more precisely in the Polish Standard (PN-88/A-77626, 1998), which states the minimum 2×10^-4 S/cm for nectar honey; 6×10^-4 S/cm for nectar-honeydew honey, 8×10^-4 S/cm for deciduous honeydew varieties and 9.5×10^-4 S/cm for coniferous honeydew honey varieties. Similarly high values of electrical conductivity in Polish heather honey samples were found by other researchers: from 4.65 to 11.08×10^-4 S/cm, on average 6.92×10^-4 S/cm (Rybak, 1986); from 4.94 to 8.02×10^-4 S/cm, on average 5.73×10^-4 S/cm (Semkiw et al., 2008b). Even higher values of electrical conductivity (from 0.49 to 0.97, average 0.73 mS/cm) were determined in heather honey samples originating from Northern and Western Europe (Persano Oddo and Piro, 2004).

The range for proline content results was from 33.1 to 92.1 mg/100 g, on average, 55.3 mg/100 g with the standard deviation and variability coefficient 12.8 and 23.1%, accordingly. The parameter value for heather honey was decisively higher in comparison with other nectar honey varieties. The requirements concerning minimum of proline content (25 mg/100 g) are described only in the Polish Standard (PN-88/A-77626, 1998) which currently is not a binding document in regards to commercial honey quality. Proline content in the samples tested was much higher than the minimum required and only slightly lower than the content presented in the results obtained by Persano Oddo and Piro (2004) for the samples they tested (from 309 to 1033 mg/kg, average 646 mg/kg).

**CONCLUSIONS**

1. The results obtained allowed to characterise heather honey harvested in the climatic and apicultural conditions of Poland.

2. Heather honey is characterised by a strong aroma, approaching the one of heather flowers, its flavour is spicy, slightly bitter and not overly sweet. The colour is amber with reddish tone. The distinguishing feature, present only in this honey variety, is its gelatinous consistency.

3. Heather honey is characterised by a varied percentile content of *Calluna* pollen and a wide range of total number of pollen grains in 10 g of honey.

4. Physicochemical parameters typical for heather honey are: high water content, elevated fructose to glucose ratio, relatively high, for a nectar honey variety, electrical conductivity, and also high proline content and activity of $\alpha$-amylase enzyme.

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Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 14 stycznia 2009 w sprawie metod analiz związanych z dokonywaniem oceny miodu (Dz.U. Nr 181, poz.1773 z późn. zm. Dz.U. Nr 40, poz. 370).


CHARAKTERYSTYKA POLSKICH MIODÓW ODMIANOWYCH.
III. MIÓD WRZOSOWY (CALLUNA VULGARIS L.)

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Kachaniuk K., Teper D.

Streszczenie


Miód wrzosowy charakteryzuje się silnym zapachem, zbliżonym do zapachu kwiatów wrzosu oraz mało słodkim, ostrym i gorzkawym smakiem. Cechą właściwą tylko dla tej odmiany miodu jest galaretowata konsystencja. Miód wrzosowy ma barwę bursztynową z rudej wody, wyrażoną w mm Ptunda mieściła się w zakresie od 69 do 114. Dla kilku próbek, niemożliwe było dokładne określenie barwy ze względu na ograniczony zakres górnej skali aparatu (114). Analiza pyłkowa wykazała dużą zmienną pod względem procentowej zawartości pyłku Calluna (od 45,4 do 82,3%; średnio 56,7%) oraz całkowitej liczby ziaren pyłku w 10 g miodu wrzosowego (od 17 100 do 134 400; średnio 69 500). Ponadto, badania właściwości fizykochemicznych wykazały, że miód wrzosowy w porównaniu z innymi odmianami, odznacza się: wysoką zawartością wody (od 15,4 do 21,9%; średnio 19,1%), wysokim stosunkiem fruktozy do glukozy (od 1,12 do 1,46; średnio 1,32), wysoką, jak dla miodu nektarowego przewodnością elektryczną właściwą (od 0,37 do 0,82 mS/cm; średnio 0,62 mS/cm) oraz wysoką zawartością proliny (od 33,1 do 92,1 mg/100 g; średnio 55,3 mg/100 g) i aktywnością enzymu α-amylazy (od 19,0 do 57,3 Shade; średnio 32,7 Shade).

Słowa kluczowe: miód wrzosowy, odmiana miodu, charakterystyka, cechy organoleptyczne, analiza pyłkowa, parametry fizykochemiczne, Polska.