THE TEMPERATURE CORRECTION FACTOR FOR ELECTRICAL CONDUCTIVITY OF HONEY

Teresa Szczęsna, Helena Rybak-Chmielewska

Research Institute of Pomology and Floriculture, Apiculture Division,
Department of Bee Products, 24-100 Puławy, Kazimierska 2, Poland.

Received 24 November 2004; accepted 17 December 2004

Summary

The study was aimed at the determination of the temperature correction factor for the electrical conductivity of honey. Material for analyses was provided by samples of honey collected from the experimental apiaries of the Research Institute of Pomology and Floriculture, Apiculture Division in Puławy over the years 2001-2002. The honey samples for routine electrical conductivity assays and samples of commercially available invert syrups were sent to the laboratory by Polish beekeepers and trading firms. In the temperature correction factor study the conductivity determinations were carried out at temperature varying from 15 to 30°C.

The temperature correction factor for electrical conductivity of honey ranged between 2.2 to 3.1 with the mean value of 2.6%/°C. There were no significant differences between conductivity of honey measured at 20°C and at the temperatures varying from 15 to 30°C after applying a temperature correction factor of 2.6%/°C. The lowest values of the electrical conductivity were characteristic for rape, false acacia and multifloral honeys, but they never fell below 0.1 mS/cm. The electrical conductivity for other kinds of nectar honey were: over 0.2 mS/cm for buckwheat, over 0.3 mS/cm for lime, and over 0.4 mS/cm for heather. The value of this parameter for invert syrups ranged between 0.003 and 0.024 mS/cm.

Keywords: honey, electrical conductivity, temperature correction factor, method.

INTRODUCTION

The conductivity of honey is the main quality parameter for this product, which is specified both in Codex Alimentarius Draft revised standard for honey (2001) and EU Directive relating to honey (2002). The Polish Regulation of the Ministry of Agriculture and Rural Development of 3 October 2003 relating to honey (2003) introduced requirements of EU Directive to our country. According to those three documents the values of electrical conductivity for nectar honey and mixtures of blossom and honeydew honeys should be - not more than 0.8 mS/cm, and for honeydew and chestnut honeys - not less than 0.8 mS/cm. There are no requirements for some kinds of honey: strawberry tree (*Arbutus unedo*), bell heather (*Erica*), eucalyptus, lime (*Tilia* spp.), ling heather (*Calluna vulgaris*), manuka or jelly bush (*leptospermum*), tea tree (*Melaleuca* spp.) because of extremely high variation in their conductivity. In Poland we have also another document - Polish standard for honey (1988), which was mandatory until 1st of May 2004. Now in Poland this document can be used only voluntarily by beekeepers and trading firms. Compared to international documents the Polish standard additionally set down minimum requirements for electrical conductivity for some kinds of honey: generally for nectar honey - not less 0.2 mS/cm; for blends of honeydew with blossom honey - not less than 0.6 mS/cm; for deciduous honeydew honey - not less than 0.8 mS/cm and for coniferous honeydew honey - not less than 0.95 mS/cm.

The conductivity of an aqueous solution is the measure of its ability to carry an electrical current by means of ionic motion. It is affected by the type and number of ions in the solution and by the viscosity of the solution itself. Both parameters are temperature dependent. The dependency of conductivity on temperature is expressed as a relative change per degree Celsius (°C) at a particular temperature, commonly as percent °C. Since a small difference in temperature causes a large change in conductivity readings, the conductivity readings for honey are normalized at 20°C and standard requirements for this parameter are defined at 20°C, too. If the determination is carried out at a temperature different from 20°C, the correction factor for temperature should be used for calculation of the conductivity value for honey at exact 20°C. Publications on temperature correction factor for conductivity of honey are lacking and contradictory. For example Vorwohl (1964a) suggested to usea value of 2.61 %/°C. Harmonised Methods of European Honey Commission (*Apidologie*, Extra issue, 1997) proposed value 3.2 %/°C.

The study was aimed at the determination of the temperature correction factor for electrical conductivity of honey in order to verify previously published data.

MATERIAL AND METHODS

MATERIAL

Material for the temperature correction factor study was provided by 50 honey samples collected from the experimental apiaries of the Research Institute of Pomology and Floriculture, Apiculture Division in Puławy over the years 2001-2004.

The honey samples for routine electrical conductivity study were sent to laboratory of Department of Bee Products Apiculture Division in Puławy by Polish beekeepers and trading firms. During the years 2000-2004 we analyzed 127 commercially purchased honey samples, and 5 invert syrups originated from the Polish market.

METHODS

Honey variety of honey samples used for experimental and routine study was determined using the organoleptic test according to the Polish Standard for Honey (1988).

Electrical conductivity was determined according to the Polish Standard for Honey (1988) using HI 9032 Microcomputer Conductivity Meter HANNA.

In the temperature correction factor study the conductivity determinations were carried out using temperature correction factor β=0 at temperatures varying from:

— 18 to 29°C with 2°C decrease (for 20 samples),

— 15 to 30°C, with 5°C decrease (for 30 samples).

The temperature correction factor (β) for conductivity of honey was calculated with the formula:

$$\beta = \frac{C_t - C_{20}}{(t - 20) \quad C_{20}}$$

where,

C_{20} - the conductivity of honey at temperature 20°C,

C_t - the conductivity of honey at temperature different from 20°C,

t - the temperature of conductivity readings.

Results were expressed to the nearest 0.1%/°C.

The data of conductivity for analysed honey samples measured at temperatures different from 20°C were converted to 20°C using mean values of temperature correction factor 2.6%/°C. The results obtained at the temperature of 20°C and after calculation were compared statistically using one-way ANOVA and the t-Student test was used to estimate the significance of differences between the means at a significance level of α=0.05.

RESULTS AND DISCUSSION

Fig. 1 shows the graph of dependency of conductivity on temperature for some kinds of honey (rape, buckwheat, lime and honeydew) with different conductivity values (0.11-1.27 mS/cm). The conductivity of different kind of honey increased with increasing temperature. It was characteristic for honey with low (0.2 mS/cm), medium (0.4-0.6 mS/cm) and high (0.8--1.3 mS/cm) conductivity values. Correlation coefficient between conductivity of honey and temperature ranged from 0.9938 to 1.000, with the mean values of 0.9991.

For 50 analysed honey samples, which conductivity ranged from 0.11 to 1.27 mS/cm, the temperature correction factor received values from 2.2 to 3.1%/°C, 2.6%/°C on average (Table 1, Fig. 2).

Extreme (minimum and maximum) values of this parameter: 2.2; 3.0 and 3.1%/°C

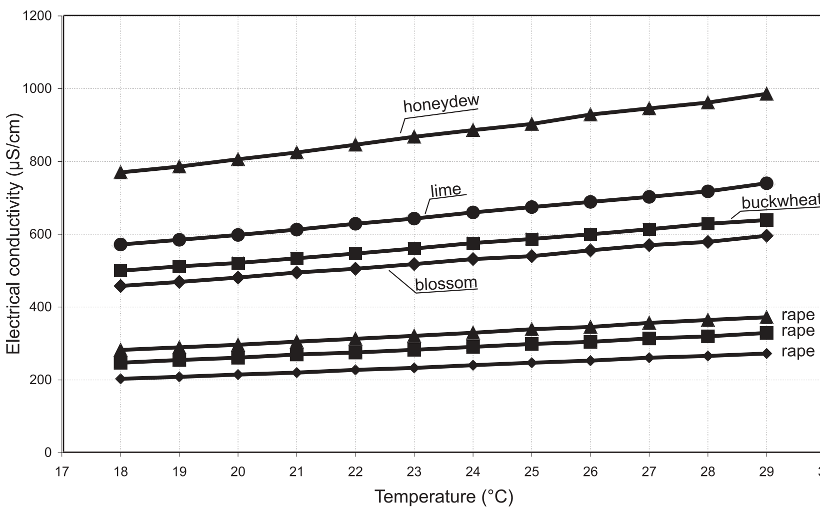

Fig. 1 Dependence of electrical conductivity of honey from temperature (18-29°C)

Table 1

The temperature correction factor for conductivity of honey samples (n=50)

Temperature correction factor (%/°C)	Conductivity (mS/cm)
2.2	0.55
2.3	0.49; 0.50; 0.55; 0.86
2.4	0.45; 0.50; 0.57; 0.61; 0.63; 0.66; 0.74; 0.90; 1.05; 1.15
2.5	0.15; 0.19; 0.48; 0.52; 0.52; 0.60; 0.62; 0.66; 0.69; 0.69; 0.70; 0.71; 0.72; 0.76; 0.81; 0.89; 0.96; 1.18; 1.27
2.6	0.11; 0.13; 0.29; 0.76; 0.89
2.7	0.12; 0.30
2.8	0.11; 0.15; 0.30
2.9	0.15; 0.15; 0.19; 0.26
3.0	0.22
3.1	0.19

Table 2

Electrical conductivity of honey collected during the years 2000-2004 (mS/cm)

Honey type	From - to	Means
Brassica (rape)	0.11 - 0.18	0.14
Robinia (false acacia)	0.13 - 0.16	0.15
Fagopyrum (buckwheat)	0.24 - 0.35	0.29
Tilia (lime)	0.35 - 0.66	0.48
Calluna vulgaris (heather)	0.42 - 0.74	0.63
Multifloral	0.13 - 0.72	0.43
Honeydew	0.71 - 1.70	0.96
Invert syrup	0.003 - 0.024	0.014

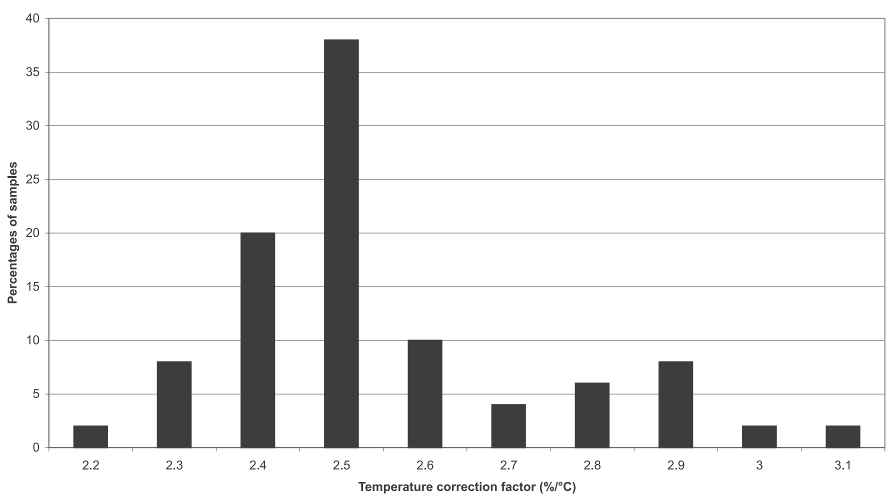

Fig. 2 The temperature correction factor for electrical conductivity of honey samples (%)

were calculated only for single samples with different conductivity values: 0.55; 0.22 and 0.19 mS/cm, respectively. The temperature correction factor values between 2.4 and 2.6%/°C were calculated for honey samples with wide conductivity range from 0.15 to 1.27 mS/cm, with predominance of higher values - over 0.50 mS/cm. Percentage of samples with the temperature correction factor between 2.4 and 2.6 was almost 70%. The results show that there were no significant differences between values at 20°C and at temperatures different from 15 to 30°C after applying the temperature correction factor of 2.6%/°C. Our results according to the temperature correction factor for electrical conductivity for honey are in agreement with those obtained by Vorwohl (1964a).

New conductivity instruments available on the market have possibility to measuring electrical conductivity and temperature and to calculate conductivity at 20°C. For this purpose most of these used standard temperature correction factor 2%/°C. How showed erlier (Vorwohl 1964a) and our study this factor for honey is 2.6%/°C and this value should be used for calculation.

The results for electrical conductivity of different kinds of Polish commercial honey which we obtained over the years 2000--2004 show that the lowest values of this parameter were characteristic for rape, false acacia and multifloral honeys, but they never fell below 0.1 mS/cm (Table 2). The results collected by the International Honey Commission for thousands of commercial honeys (Bogdanov et al. 1999) were only a little lower, mimimum values - 0.09 mS/cm for the same unifloral honeys. The electrical conductivity for other kinds of nectar honey in our study were: over 0.2 mS/cm for buckwheat, over 0.3 mS/cm for lime, and over 0.4 mS/cm for heather. The similar results were obtained by other researchers (Vorwohl 1964b, Rybak 1986, Bogdanov et al. 1999). The electrical conductivity for invert syrup available on the Polish market ranged between 0.003 and 0.024 mS/cm. The electrical conductivity parameter together with other can be used to detect adulteration of honey by inverts but more studies in this area are needed. Lower values of electrical conductivity of honey adulterated with sucrose inverted by bees were obtained earlier by other researchers (Rybak and Achremowicz 1986).

CONCLUSIONS

1. The temperature correction factor for electrical conductivity of honey ranged between 2.2 to 3.1 with the mean value of 2.6%/°C.
2. There were no significant differences between conductivity of honey measured at temperature 20°C and at the temperature varying from 15 to 30°C after applying temperature correction factor of 2.6 %/°C.
3. The temperature correction factor value proposed by the International Honey Commission to be used in the method for determination of electrical conductivity for honey should be corrected by 2.6%/°C rather than by 3.2%/°C.
4. On the basis of the results obtained we propose to complete the International standards about minimum requirements for electrical conductivity for nectar honey, in general - not less than 0.10 mS/cm.

REFERENCES

Bogdanov S., Martin P., Lullman C. (1997)- Determination of electrical conductivity. Harmonised methods of the European Honey Commission. *Apidologie*, Extra Issue, 14-16.

Bogdanov S. and 20 other authors (1999)- Honey Quality and International Regulatory Standards: Review of the Work of the International Honey Commission. *Mitteilungen aus dem Giebiete Lebensmitteluntersuchung und Hyggiene* 90(1): 152-166.

COUNCIL DIRECTIVE 2001/110/EC of 20 December 2001 relating to honey. *Official Journal of European Communities* L. 10, 47-52 (2002).

CODEX ALIMENTARIUS:Draft revised standard for honey (at 10 step of the Codex procedure). *Alinorm* 01/25 19-26 (2001).

Instruction Manual (1996)- HI 9032 Micro-processor Bench Conductivity/TDS/ /NaCl/Fertilizer/°C/°F Meter. Hanna Instruments.

PN-88/A-77626 „Miód Pszczeli” (Polish Standard for Honey).

Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 3 października 2003r. w sprawie szczegółowych wymagań w zakresie jakości handlowej miodu (Regulation of Ministry of Agriculture and Rural Development of 3 October 2003 relating to honey) (Dz.U. Nr 181, poz.1773).

Rybak H. (1986)- Charakterystyka chemiczna krajowych miodów odmianowych (Composition and properties of Polish unifloral honeys). *Pszczeln. Zesz. Nauk*. 30: 3-17.

Rybak H., Achremowicz B. (1986)- Zmiany w składzie chemicznym miodów naturalnych i zafałszowanych zinwertowaną przez pszczoły sacharozą zachodzące podczas przechowywania (Changes in chemical composition of natural and adulterated with inverted by bees sucrose honeys during storage). *Pszczeln. Zesz. Nauk*. 30:19-35.

Vorwohl G. (1964a)- Die Messung der electrischen Leitfahigkeit des Honigs und die Verwendung der Messwerte zur Sortendiagnise und zum Nachweis von Verfalschungen mit Zuckerfutterungshonig. *Z. Bienenforsch.*, 37-47.

Vorwohl G. (1964b)- Die Bieziehungen zwischen der elektrischen Leitfahigkeit der Honig und ihrer trachtmassigen Herkunft. *Ann. Abeille*, 7(4), 301-309.

WSPÓŁCZYNNIK TEMPERATUROWY ZMIAN PRZEWODNOŚCI ELEKTRYCZNEJ MIODU

Szczęsna T., Rybak-Chmielewska H.

Streszczenie

Celem badań było opracowanie współczynnika temperaturowego zmian przewodności miodu. Materiał doświadczalny stanowiły próbki miodu, łącznie 50, pozyskane w pasiekach Oddziału Pszczelnictwa Instytutu Sadownictwa i Kwiaciarstwa w Puławach w latach 2001-2002. Przeprowadzono również badania przewodności miodu w próbkach dostarczonych do laboratorium przez pszczelarzy i firmy zajmujące się obrotem miodu, z terenu całej Polski. Próbki te pochodziły z sezonu 2000-2004. Ponadto oznaczono przewodność kilku próbek inwertów dostępnych na rynku krajowym, produkowanych na potrzeby przemysłu spożywczego. W celu wyznaczenia współczynnika temperaturowego zmian przewodności miodu wykonano pomiary przewodności badanych próbek w temperaturze od 15 do 30°C. W badaniach rutynowych zastosowano opracowany współczynnik temperaturowy zmian przewodności miodu. W ocenie odmian miodu wykorzystano badania organoleptyczne określone w Polskiej Normie (1988).

Uzyskane wyniki wykazały, że współczynnik temperaturowy dla przewodności elektrycznej właściwej miodu wahał się w granicach od 2,2 do 3,1, średnio wynosił 2,6%/°C. Nie stwierdzono istotnych różnic pomiędzy przewodnością miodu mierzoną w temperaturze 20°C, a przewodnością mierzoną w temperaturze różnej od 20°C (15-30°C) przy uwzględnieniu współczynnika temperaturowego - 2,6%/°C. Najniższą wartością przewodności elektrycznej charakteryzowały się miody: rzepakowy, akacjowy i wielokwiatowy, wartości te nie były jednak niższe od 0,1 mS/cm. Przewodność elektryczna dla miodu gryczanego średnio wynosiła 0,30 mS/cm, dla miodu lipowego - 0,48 mS/cm, a dla miodu wrzosowego - 0,63 mS/cm. Przewodność badanych inwertów była bardzo niska i wahała się w zakresie 0,003-0,024 mS/cm, ze średnią wartością 0,014 mS/cm.

Słowa kluczowe: miód, przewodność elektryczne, współczynnik temperaturowy zmian przewodności, metoda.