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Quality of Slovene Honey

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Summary

82 honey samples representing various floral and honeydew honeys were obtained from different areas in Slovenia. By means of sensory analysis they were assorted in seven groups: acacia, floral, forest, fir, chestnut, lime and blend honey. The following physico-chemical properties were tested: electrical conductivity, pH value, acidity, diastase number and the content of water, ash, total insoluble solids, hydroxymethylfurfural, fructose, glucose, melizitose and sucrose. Between types of honey there are significant differences ($\alpha \leq 0.001$) in all analysed parameters, except in odour and in the content of water, insoluble solids, and sucrose. It is shown that practically all honeys lie within the limits set by legislation.

Key words: assorted honey, sensory analysis, electrical conductivity, hydroxymethylfurfural, diastase number, sugars

Introduction

Honey is the sweet substance produced by honey bees from the nectar of blossom or from secretions of or on living parts of plants, which they collect, transform and combine with specific substances, and store in honey combs *(1)*. Honey is a highly variable natural product, particularly in its sensory properties (colour, odour), water content, ash content, *pH* value and sugar composition. These attributes depend upon the climate, floral type, and individual beekeeping practices. The consistency of honey can be fluid, viscous or partly to entirely crystallised. Chemically honey comprises carbohydrates (70–80 %), water (17–20 %) and other substances such as organic acids, mineral salts, proteins, enzymes, free amino acids, and vitamins. Variation in the main components of the honey provides a little information useful for classification; minor components, on the other hand, may be more appropriate for differentiating various kinds of honey *(2)*.

Honeys are usually classified by the pollen spectra, which can be appropriate for determination of both the botanical and geographical origin of the product. Sensory properties of honey determine its acceptability by the consumers. Each type of honey has its characteristic colour, odour and taste. On the basis of physical properties and chemical composition the specific characteristics of various types of honey can be determined as well as possible adulterations.

Although Slovenia is a small country there are many regions with different climate conditions and wide variety of plants. These provide a wide range of different types of honey with its specific odour and aroma. It is known that authentical Slovene honey is of good quality, especially the honey purchased from beekeepers.

The aim of this research was to evaluate the main physicochemical properties of assorted honey collected from different regions of Slovenia and to establish its quality according to the regulations.

Materials and Methods

82 samples of honey of known origin from different regions of Slovenia were investigated. The honey was harvested from July to October 1996. Honey was assorted by means of sensory analysis. The sensory analysis was performed by means of scoring (1=very bad, 2=bad, 3=average, 4=good, 5=excellent) recommended by the International Standard *(3)*.

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Among honeys studied there were: 20 samples of acacia, 16 floral, 4 forest, 5 fir, 14 chestnut, 6 lime, and 17 of blend honeys.

The following parameters were determined: mass fraction of water, insoluble solids, ash, *pH*, mass concentration of total acidity, mass fraction of hydroxymethylfurfural (HMF), diastase number (DN), mass fraction of sucrose, fructose, glucose and melizitose and electrical conductivity ($\varkappa$). Methods recommended by Slovenian regulations *(4)* and AOAC *(5)* were used. Two parallel determinations were performed and the results were expressed as a mean of two runs. The results obtained were statistically analysed for the mean value ($\bar{x}$), standard deviation (SD), interval, coefficient of variability (CV) and correlation and regression.

Results

Results of sensory analysis

In Table 1 results of sensory assessment are presented. The panel (five experts for honey evaluation) assessed three sensory attributes: colour, odour and taste. Although all samples were labeled by beekeepers, the final classification was done on the basis of the results of sensory analysis.

As it is generally known all the attributes exhibit a considerable variability for the assorted honeys. It was considered that the differences in colour and taste between the groups of honey are significant at $\alpha \leq 0.001$, while the differences in odour are not statistically significant. Among seven types of honey, higher scores for colour, odour and taste were assigned to forest, fir and acacia honey as compared to lime and chestnut honey. Lower scores assigned for taste were the consequence of nonspecific taste, sweetness or acidity.

Results of physicochemical analysis

Table 2 includes the average standard deviation (SD), coefficient of variability (CV) and interval for 12 chemical and physical parameters determined in honeys. The last column of the table presents the values set by the Slovene standard regulations. Comparing our results with the required values it is obvious that all samples except two lie within the legal requirements.

Between all the parameters correlations were calculated, and some of them were found to be significant:

$\varkappa$ – ash content	r = 0.952 (Fig. 1)
$\varkappa$ – *pH* value	r = 0.827 (Fig. 2)
pH value – ash content	r = 0.754
DN – $\varkappa$	r = 0.742
DN – ash content	r = 0.738
DN – HMF	r= 0.274 (Fig. 3)

The results of physicochemical parameters determined in seven types of honey are presented in Table 3.

Mass fraction of water: In all analysed honeys the average mass fraction of water lies below the limit set by Slovenian regulations (21 %). The averages of different sorts are very close, they range between 15.36 % in chestnut honeys and 16.60 % in fir honeys (Table 3). The differences between the types studied are not significant. The great variability was established for acacia (14.2–19.9 %), fir (14.5–19. 8%) and blend honeys (honeys from nectar and honeydew) (12.6–18.1 %). Comparing our own results with other studies, it can be concluded that Slovene honeys have a lower content of water. Krauze and Zalewski *(6)* reported 17.0 % for acacia, 20.1 % for lime, 19.5 % for flower and 19.7 % for honeydew honeys.

Mass fraction of ash: Standards allow 0.5 % of ash for nectar honey, and 1.0 % for honeydew honey *(1, 4)*. Our samples correspond to these regulations, with the

Table 1. Sensory analysis of 82 samples of honey

Samples	Parameters	Colour scores (1–5)	Odour scores (1–5)	Taste scores (1–5)
Acacia (n=20)	$\bar{x}$	4.1	3.3	3.65
	SD	0.63	0.78	1.12
Floral (n=16)	$\bar{x}$	[a]	3.1	2.94
	SD		1.07	1.10
Forest (n=4)	$\bar{x}$	4.25	3.0	4.25
	SD	0.89	2.00	0.46
Fir (n=5)	$\bar{x}$	4.2	3.0	3.6
	SD	1.03	2.21	1.11
Chestnut (n=14)	$\bar{x}$	3.07	2.8	3.21
	SD	0.90	1.29	1.28
Lime (n=6)	$\bar{x}$	2.5	2.3	1.5
	SD	1.78	1.15	1.67
Blend (n=17)	$\bar{x}$	3.95	3.3	3.56
	SD	1.29	1.34	1.32
Analysis of variance		$F=7.35^{***}$	F=1.23	$F=6.59^{***}$

[a] the colour of floral honey has not been assessed because of the nature of this sort; floral honeys come from polyfloral nectar and have a great spread of colour shades

Table 2. The physicochemical characteristics of honeys

Parameters	n	$\bar{x}$	SD	CV/%	Interval	Slovene legislation *(4)*
w(water)/%	82	16.05	1.235	7.69	12.60–19.90	< 21.0
w(ash)/%	80	0.395	0.252	63.80	0.03–1.30[a]	< 0.5; < 1.0
w(insoluble solids)/%	82	0.0267	0.0185	69.29	0.0005–0.0668[b]	< 0.10
$\varkappa$/(mS/cm)	80	0.843	0.503	59.68	0.175–2.100	
pH	82	4.41	0.651	74.43	3.50–6.50	
γ(acidity)/(mmol/kg)	82	25.46	6.35	24.94	10.16–37.19	< 40.0
w(HMF)/(mg/kg)	82	4.477	4.386	97.83	0.20–21.60	< 40.0
DN	82	14.25	4.741	33.27	5.36[c]–27.30	> 8
w(fructose)/%	82	39.51	3.900	9.87	30.82–47.17	
w(glucose)/%	82	29.35	1.941	6.61	23.60–33.98	
w(sucrose)/%	40	1.861	1.913	102.8	0.385–10.09	< 5; < 5.5; < 8; < 10
w(melizitose)/%	38	6.98	4.595	65.83	1.37–21.46	
w(fructose+glucose)/%	82	68.85	4.756	6.91	56.67–78.79	> 65; > 60
w(fructose)/w(glucose)	82	1.35	0.140	10.37	1.10–1.65	

[a] one sample of blend honey
[b] one sample of floral honey
[c] seven samples of acacia and one sample of blend honey

Table 3. The physico-chemical components of different types of Slovene honey

Samples	w(water) / %	w(ash) / %	w(insoluble solids) / %	$\varkappa$ / mS / cm	*pH*	γ(acidity) / mmol / kg	w(HMF) / mg / kg	DN
Acacia (n=20)								
$\bar{x}$	16.51	0.09	0.025	0.235	3.73	24.45	5.22	9.27
SD	1.241	0.032	0.014	0.035	0.126	2.712	4.001	1.945
interval	14.2–19.9	0.03–0.15	0.003–0.06	0.175–0.286	3.5–4.0	20.15–30.99	0.4–17.1	6.62–12.76
Floral (n=16)								
$\bar{x}$	15.96	0.33	0.019	0.669	4.21	28.86	7.09	13.37
SD	0.856	0.117	0.029	0.181	0.296	3.874	4.844	3.351
interval	14.3–17.4	0.12–0.53	0.0005–0.047	0.33–0.96	3.8–4.6	23.76–37.19	2.5–19.2	8.87–20.76
Forest (n=4)								
$\bar{x}$	15.53	0.50	0.025	1.23	4.73	26.04	2.08	18.59
SD	0.772	0.143	0.018	0.263	0.411	5.299	1.220	4.686
interval	14.8–16.6	0.35–0.63	0.0043–0.0435	0.916–1.46	4.2–5.2	18.8–30.48	1.4–3.9	12.52–22.95
Fir (n=5)								
$\bar{x}$	16.6	0.46	0.037	1.15	4.58	29.77	1.46	16.55
SD	2.058	0.070	0.020	0.146	0.164	6.156	0.439	3.248
interval	14.5–19.8	0.35–0.516	0.0203–0.070	0.968–1.29	4.4–4.8	19.81–36.07	0.9–1.9	12.3–21.14
Chestnut (n=14)								
$\bar{x}$	15.36	0.64	0.034	1.483	5.39	17.45	1.25	17.45
SD	0.694	0.168	0.018	0.345	0.568	4.866	0.854	2.538
interval	14.6–16.9	0.36–0.88	0.0108–0.0668	0.977–2.03	4.6–6.5	10.33–24.79	0.2–3.0	12.72–21.82
Lime (n=6)								
$\bar{x}$	16.58	0.35	0.018	0.815	4.15	24.97	3.63	13.22
SD	1.342	0.059	0.005	0.080	0.351	5.138	3.135	1.937
interval	14.9–18.1	0.28–0.43	0.0125–0.0275	0.701–0.915	3.9–4.8	16.02–29.96	1.0–9.2	10.56–15.44
Blend (n=17)								
$\bar{x}$	15.85	0.60	0.028	1.045	4.55	28.81	5.55	16.98
SD	1.454	0.247	0.013	0.407	0.419	7.245	5.468	5.502
interval	12.6–18.1	0.32–1.30	0.0095–0.053	0.388–2.1	4.0–5.8	10.16–36.58	0.5–21.6	5.36–27.3
Analysis of variance	F=1.80	F=27.43***	F=1.027	F=39.56***	F=31.13***	F=9.13***	F=3.74**	F=11.83***

exception of one sample of blend honey with 1.3 % (Table 3). The differences in the mass fraction of ash are statistically significant ($\alpha \leq 0.001$). The lowest average mass fraction of ash was determined in nectar honeys: in acacia 0.09 %, in floral 0.33 %, and in lime 0.35 %. The highest average mass fraction of ash was observed in chestnut and blend honey: 0.64 %, and 0.60 %, respectively.

Mass fraction of water insoluble solids: The mass fraction of water insoluble solids of our samples is far below the limit set by legislation. It was found to be between 0.018 % for lime honey and 0.037 % for fir honey (Table 3). The honeys do not differ significantly in the content of insoluble solids.

Electrical conductivity ($\varkappa$): The $\varkappa$ measurement in honey gives an indication regarding its origin (nectar or honeydew) and the source of nectar, and can detect whether bees have been fed with sugar *(7)*. As $\varkappa$ of honey has been used increasingly, the European Honey Commission *(8)* has proposed the standard values for this parameter. The results of our measurements are as follows: the $\varkappa$ of acacia honey does not exceed 0.5 mS/cm, which is the value that Talpay *(9)* recommends for nectar honeys. The situation is different with lime honey (0.815 mS/cm), which might be blend with some honeydew honey. Fir, forest and chestnut honey correspond to the recommended value for the honeydew honeys. They are higher than 0.8 mS/cm and 0.95 mS/cm, respectively. The analysis of variance among the types of honey has proved to be significant at $\alpha \leq 0.001$. The relation between the $\varkappa$ and the ash content is shown in Fig. 1.

***pH* and acidity:** Standard specifications set a limit on the free acids mass concentration of honey with maximum permitted level of 40 mmol/kg. All honeys studied gave an acidity below this maximum value (Table 3). The differences in the *pH* values and acidity between different types of honey are significant at $\alpha \leq 0.001$. Chestnut honey, in particular, has a very low acid concentration, with a mean value of 17.97 mmol/kg compared to more than 24 mmol/kg in honeys from other sources. The majority of the samples have the *pH* values above 4.0, *i.e.* all samples of forest, fir, chestnut and blend honeys, while in acacia honey the *pH* values are between 3.5 and 4.0, in floral between 3.8 and 4.6 and in lime between 3.9 and 4.8. Wide interval of the *pH* values, from 4.6 to 6.5 was determined in the group of chestnut honeys. The relation between the $\varkappa$ and the *pH* value of seven types of honey is represented in Fig. 2.

Diastase number (DN): In honey specifications DN is used to exclude honeys that have been damaged by overheating during processing or by exceeded storage time at unfavorable temperatures. In our study honey samples show DN ranging from 5.36 to 27.3 (Table 3). Average DN for all sorts of honey is above 8 as it is required by Slovenian legislation, except for the seven samples of acacia and one blend honey which are below this value. It has to be mentioned that at the moment of analysis these samples were 8 months old, and that some honeys (for instance acacia) have naturally low diastase number *(10)*. Statistical treatment showed that the differences between different types of honey are stasictically significant at $\alpha \leq 0.001$. The lowest DN was determined in acacia honey (average 9.27), followed by lime (13.22), floral (13.37), fir, blend, chestnut and forest, the last having DN 18.59.

Mass fraction of hydroxymethylfurfural, w(HMF): Like diastase number the mass fraction of HMF is widely used parameter in evaluating the freshness of honey *(10)*. Heat and prolonged storage initiate discoloration reactions involving sugars and aminoacids by promoting the formation of HMF. Slovenian legal regulations *(8)* establish the maximum HMF content at 40 mg/kg. As it is evident from the Table 3, all the samples correspond to this criteria. It is interesting to note that only 10 samples have HMF contents higher than 10 mg/kg. Among six lime honeys one sample contains w(HMF) = 9.2 mg/kg, while HMF mass fraction in other five samples is below 5.2 mg/kg. Comparing this result with the results of sensory analysis, it can be seen that the colour and odour of this particular sample were not characteristic for lime honey as the total sum of all scores assigned to this sample was only 4. The average w(HMF) for acacia is 5.22 mg/kg because of the two samples with 10.9 and 17.1 mg/kg. However, without these two samples the average w(HMF) of acacia would be 4.2 mg/kg. Among floral honey two samples were high in the w(HMF) (18.1 and 19.2 mg/kg), and among the blend honey one having 21.6 mg/kg. The last is the highest HMF content among 82 samples analysed. In other types of honey the average HMF content ranges

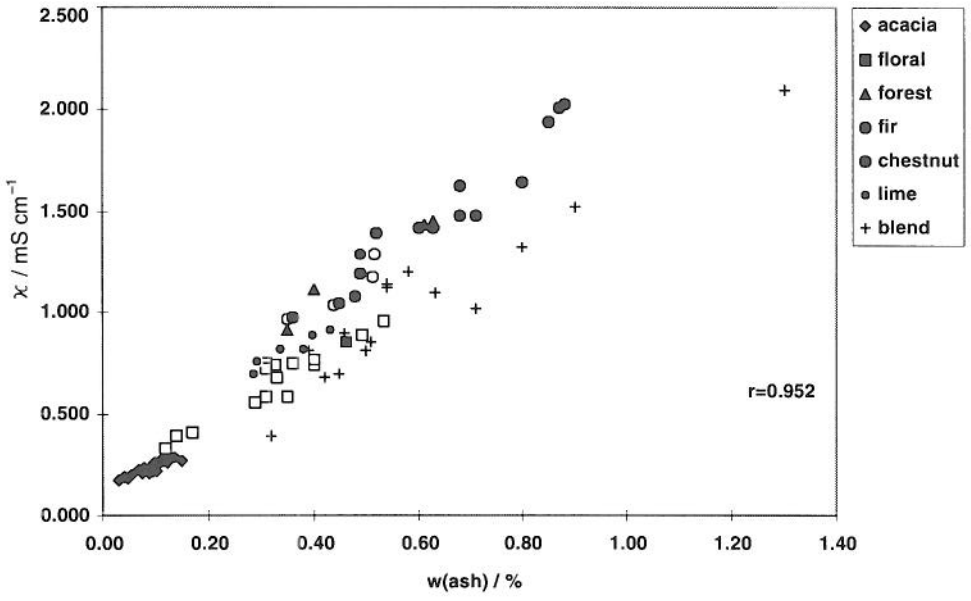

Fig. 1. Relation between the electrical conductivity and mass fraction of ash in different types of honey

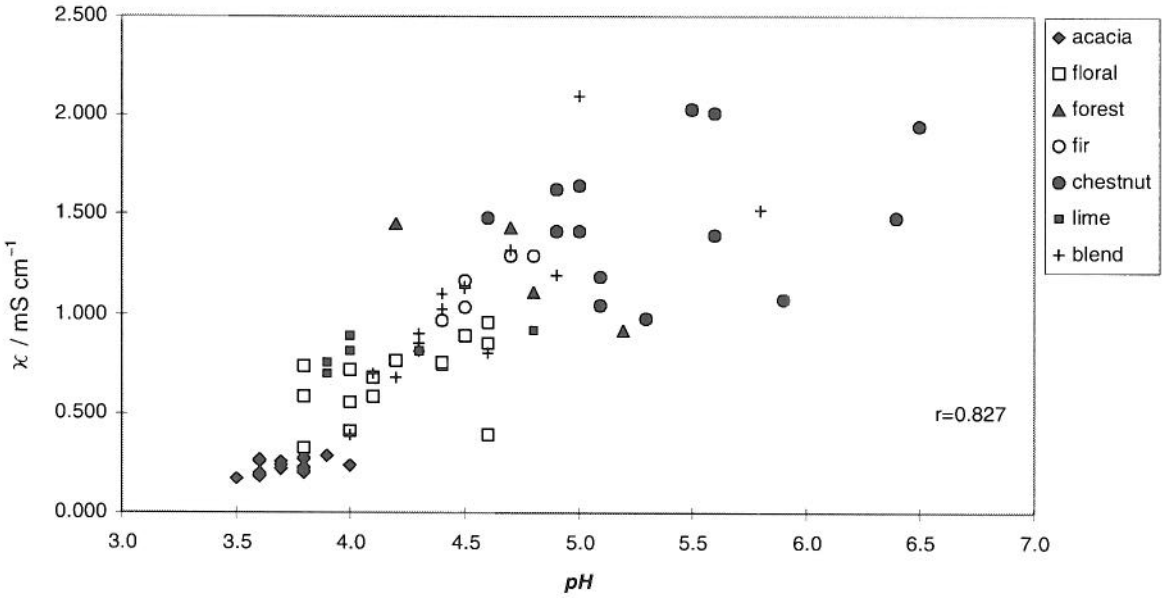

Fig. 2. Relation between the electrical conductivity and the *pH* value in different types of honey

Table 4. The sugars in Slovene assorted honeys

Samples	w(fructose) %	w(glucose) %	w(sucrose) %	w(melizitose) %	w(fructose + glucose) %	w(fructose) / w(glucose)
Acacia						
n	20	20	18	1	20	20
average	43.74	29.16	2.34	1.89	72.90	1.5
SD	1.642	1.097	1.627		2.190	0.069
interval	39.04–47.17	26.92–31.62	0.92–6.40		67.52–78.79	1.35–1.65
Floral						
n	16	16	7	8	16	16
average	38.60	30.27	1.59	5.84	68.86	1.29
SD	2.382	1.615	1.193	2.693	2.727	0.106
interval	35.34–43.26	28.45–33.92	0.38–3.76	2.64–11.75	64.03–72.79	1.10–1.47
Forest						
n	4	4	1	3	4	4
average	35.42	27.04	0.88	7.54	62.45	1.31
SD	3.197	1.125		2.249	3.160	0.142
interval	30.99–38.42	26.07–28.65		8.21–12.18	57.88–64.96	1.15–1.45
Fir						
n	5	5	1	5	5	5
average	34.20	27.71	0.73	15.08	61.92	1.24
SD	2.867	2.560		6.978	4.809	0.089
interval	30.82–37.65	24.22–31.21		5.15–21.46	56.67–67.32	1.12–1.33
Chestnut						
n	14	14	6	5	14	14
average	41.50	29.36	0.77	1.39	70.85	1.42
SD	2.351	2.147	0.232	1.125	3.943	0.096
interval	37.65–46.03	23.60–32.38	0.470–1.175	3.02–5.73	61.9–78.41	1.32–1.62
Lime						
n	6	6	2	2	6	6
average	39.94	31.62	0.57	1.19	70.56	1.24
SD	2.893	1.398	0.212	0.216	2.140	0.141
interval	35.72–42.98	29.02–33.12	0.42–0.72	3.48–3.78	6.61–73.03	1.10–1.48
Blend						
n	17	17	5	14	17	17
average	36.43	28.89	2.77	4.89	65.34	1.26
SD	2.689	1.953	4.104	3.687	4.007	0.087
interval	32.38–42.92	25.31–31.98	0.41–10.09	1.37–13.65	58.81–70.85	1.14–1.45
Analysis of variance	F=23.28***	F=4.621***	F=0.972	F=4.06**	F=15.74***	F=15.93***

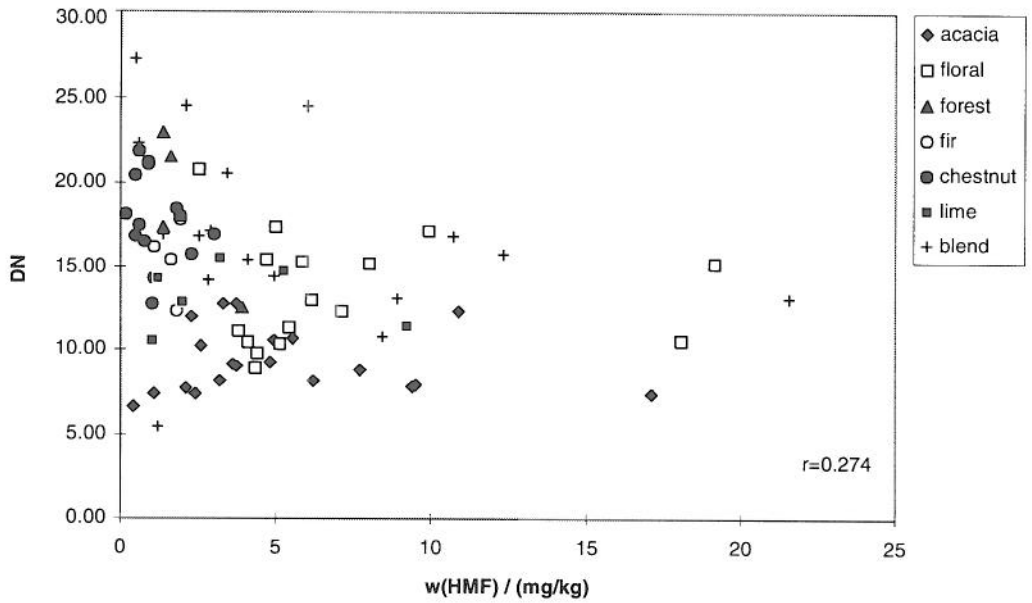

Fig. 3. Relation between diastase number and mass fraction of hydroxymethylfurfural in different types of honey

from 1.25 mg/kg in chestnut to 1.46 mg/kg in fir, and 2.08 mg/kg in forest honey. The differences in the HMF content between various types of honey are statistically significant ($\alpha \leq 0.001$). The relation between DN and the w(HMF) for our samples is presented in Fig. 3.

Reducing sugars and sucrose: Data in Table 4 indicate that the mass fraction of total reducing sugars range from 56.67 % in fir honey to 78.79 % in one sample of acacia honey. The highest average (72.90 %) was determined in the acacia samples. According to the contents of sucrose all the assorted honeys correspond to the requirements set by Slovenian legislation. Only one sample of blend honey has 10.09 % of sucrose which is above the limit set by regulations for this sort of honey.

Sugar profiles are given in Table 4. The differences in the fructose and glucose mass fraction among different types of honey are significant at $\alpha \leq 0.001$, and in melizitose at $\alpha \leq 0.01$.

Mass fraction of fructose: Acacia honey has the highest mass fraction of fructose, with the average of 43.74 %, followed by chestnut honey with 41.50 %, while the other types of honey have less than 40.00 % of fructose. The lowest average (34.20 %), minimal and maximal values (30.82 and 37.65 %, respectively) were indicated in fir honey.

Mass fraction of glucose: The highest average mass fraction of glucose was determined in lime honey (31.62 %), and in floral honey (30.27 %). Other types have the w(glucose) below 30 %.

Mass fraction of melizitose: Comparing our results with Földhazi *(11)* it can be concluded that the mass fraction of melizitose in acacia, forest, fir, chestnut and blend honeys are in accordance with the Hungarian honeys, however Slovenian floral and lime honeys have higher content of melizitose.

Each type of honey has different mass fraction of invert sugar (fructose and glucose), and its characteristic ratio of w(fructose)/w(glucose), which is evident from the Table 4. Calculated ratios w(fructose)/w(glucose) significantly differ ($\alpha \leq 0.001$) between the types of honey. The highest values are calculated for acacia w(fructose)/w(glucose) = 1.5, and chestnut honey w(fructose)/w(glucose) = 1.42. Other types of honey have significantly ($\alpha \leq 0.001$) lower w(fructose)/w(glucose) ratio, ranging from 1.24 to 1.31. High value of w(fructose)/w(glucose) indicates a slow rate of crystallization of honey. The w(fructose)/w(glucose) values for Slovenian acacia honey (1.35–1.65) are comparable with the respective values for French (1.32–1.56), Romanian, Hungarian and Chinese (1.4–1.7), and for Polish (1.51–1.60) acacia honey. In our study honeydew honeys contained less fructose than nectar honeys and their w(fructose)/w(glucose) values were around 1.2, slightly higher than the value 1.0, reported by Krauze *(12)* for honeydew honeys.

The sum of fructose and glucose mass fraction shows, that acacia honey has the highest mass fraction of inverted sugar, 72.90 %, while that in the honeydew honeys is significantly ($\alpha \leq 0.001$) lower (61.92 % in fir honey, and 62.45 % in forest honey).

Conclusions

With the sensory analysis of seven groups of Slovenian honeys significant differences ($\alpha \leq 0.001$) were found for colour and taste, while the differences in odour were not significant.

The results of physicochemical analysis show that all the parameters lie within the limits set by the Slovenian legislation. Between various types of honey there are significant differences ($\alpha \leq 0.001$) in all of the analysed parameters, except in the content of water, insoluble solids, sucrose, and melizitose.

Electrical conductivity of all honeys was in accordance with the proposal of the European Honey Com-

mission (1997). $\varkappa$ was found to be significant ($\alpha \leq 0.001$) parameter for differentiating between types of honey.

Between some parameters high correlations were established. Electrical conductivity was in high correlation with the ash mass fraction, *pH* value and diastase number; while the w(ash) well correlated with the *pH* value and diastase number.

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Kakvoća slovenskog meda

Sažetak

Iz raznih područja Slovenije skupljena su 82 uzorka meda od cvjetova i slatkog soka biljaka. Senzorskom analizom uzorci meda razvrstani su u sedam skupina: akacija, cvjetni, šumski, kestenov, lipov i miješani med. Ispitana su ova fizičko-kemijska svojstva: električna vodljivost, pH-vrijednost, kiselost, dijastazni broj te udjeli vode, pepela, ukupnih netopljivih tvari, hidroksimetilfurfurala, fruktoze, glukoze, melicitoze i saharoze. Između raznih vrsta meda postoji značajna razlika ($\alpha \leq 0.001$) između nekih parametara, osim po mirisu te udjelu vode, netopljivih tvari i saharoze. Pokazalo se da svi ispitani uzorci udovoljavaju zahtjevima Pravilnika o kakvoći meda.