THE ANTIMICROBIAL ACTIVITY OF POLYFLORAL HONEY AND ITS AWARENESS AMONG URBAN CONSUMERS IN SLOVAKIA

Peter Šedík, Kristína Predanócyová, Elena Horská, Miroslava Kačániová

ABSTRACT
The current interdisciplinary research studies the antimicrobial activity of selected polyfloral kinds of honey (n = 30) against three microorganisms (gram-positive bacteria Enterococcus faecalis, gram-negative bacteria Salmonella enterica, and one yeast Candida krusei) as well as investigates consumer behavior and awareness towards honey healing properties. Consumer research involved 617 honey consumers living in urban areas. T-test for Equality of means, non-parametric tests, and descriptive statistics were applied. Results showed that antimicrobial activity was found in all honey samples with a concentration of 50%. Nevertheless, better activity was obtained in honey samples from urban beekeepers compared to samples from retail stores. Results of consumer research showed that honey is mostly used as food (sweetener in beverages, ingredient in the recipe, or direct consumption) and as medicine mainly during the winter period. The consumer awareness towards honey healing effects was very high (97%), however, 1/3 of respondents were not able to list any specific examples, and only 11% mentioned antibacterial activity. Furthermore, more than 70% of respondents did not know to explain the term “medical honey” and more than 50% of respondents are not aware of the maximum temperature used for heating honey without decreasing its biologically active compounds.

Keywords: consumer research; consumer perception; honey consumer; antimicrobial activity; Slovak honey

INTRODUCTION
In modern nutrition, honey has an irreplaceable place, as it is considered a valuable dietary food, sweetener, or medicine (Ahlujwalia et al., 2020; Meo et al., 2017; Samarghadian, Farkhondeh and Samini, 2017; Kumar et al., 2010). Selmi, Irnad and Sistanto (2020) emphasize that honey is used for nutritional and medicinal purposes, as well as honey is required by industries, especially by pharmaceutical and cosmetic companies. In recent years, honey has been considered an important commodity in the international market (Buba, Gidado, and Shugaba, 2013). In the context of the above mentioned it could be stated that the popularity of honey is increasing, and natural honey is becoming a sought-after product among consumers. The increased demand can be justified by the awareness of consumers towards the unique properties of honey, which are attributed to the influence of the various groups of substances it contains (Puscion-Jakubik, Borawaska and Socha, 2020; Yew et al., 2013).

Escuredo et al. (2013) focus on the fact that honey is a food that contains about 200 substances. Honey contains a mixture of two monosaccharides (glucose and fructose) and is a source of proteins, minerals, vitamins, organic acids, flavonoids, phenolic acids, and enzymes (Keskin and Keskin, 2021; Gündoğdu, Cakmakteş and Şat, 2019). The composition of honey is not uniform and it has a very complex composition, which depends on the different factors. The most important determinants influencing the composition of honey are, in particular, the botanical and geographical origin, climatic conditions, and weather during harvest. Another important determinant is also beekeeping management, which is associated with the collection and storage of honey, as well as its conditions (Escuredo and Seijo, 2019; Da Silva et al., 2016; Escuredo et al., 2014; Karabagias et al., 2018; Otero and Bernolo, 2020). Ranneh et al. (2021) add that honey contains macro and micronutrients which depend on bee type, floral source, but also on environmental and processing factors.

Honey can be classified as a superfood thanks to its unique natural composition, and its consumption has a positive effect on the health of consumers. Honey can boost the immune system to fight infection (Seepankova, Saraiva and Estevinho, 2017); honey has proven antiviral effects (Kala et al., 2020), honey is also beneficial for sore throats, coughs, and colds (Kumar et al., 2010) and honey is a valuable cure against pathogenic respiratory agents, including viruses that cause cough (Al-Hatamleh et al., 2020). Abbas et al. (2019) showed that honey in a combination with other substances has also a relatively high
efficiency in patients with asthma. According to Idrus et al. (2020), honey can even act as a protective agent in cardiovascular disease. Khalil and Sulaiman (2010) add that honey has anxiolytic, antidepressant, anticonvulsant, and antiinociceptive effects and ameliorates the oxidative content of the central nervous system. Moreover, Güney and Rn (2007) indicate that honey has beneficial effects in the treatment of diabetes. In addition, Samarghandian, Farkhondeh and Samini (2017) stated that honey could be able to act preventively against cancer, for example, breast cancer, carcinoma, melanoma, colon carcinoma, hepatic cancer, and bladder cancer. However, they also add that there are necessary more studies to improve understanding of the positive effect of honey and cancer.

In the context of the above, it could be concluded that honey is one of the most complete foods for humans, due to its therapeutic, antioxidant, antimicrobial, antitumoral, anti-inflammatory, antiviral, and activities (Bueno-Costa et al., 2015). Nowadays, however, the antibacterial effects of honey are also highlighted. Antibacterial activity is considered the most investigated biological property of honey (Bucekova et al., 2019). Natural unheated honey has broad-spectrum antibacterial activity honey is specific for its antibacterial activity, which it also shows by tests against pathogenic bacteria, oral bacteria as well as food spoilage bacteria (Lusby, Coombes and Wilkinson, 2005; Mundo, Padilla-Zakour and Worobo, 2004). The antibacterial activity of honey is not derived from one mechanism, resp. the action of one chemical, but is based on multifactorial action. The factors responsible for the antibacterial activity of honey are the high sugar concentration, which participates at osmotic pressure, low pH value, and water activity, as well as the 1,2-dicarbonyl compound methylglyoxal (MGO) and the cationic antimicrobial peptide bee defensin-1 (Kwakman et al., 2010; Bucekova et al., 2020). Mandal and Mandal (2011) emphasize that identification of the antibacterial purpose of honey can be beneficial and can provide relevant information related to honey quality as well as therapeutic potentials against health diseases of people.

Scientific Hypothesis

Assumption No. 1: We assume that there exist significant differences in antimicrobial activity between honey samples from urban beekeepers and those purchase from retail stores.

Assumption No 2: We assume that there exists a statistically significant dependence between annual honey consumption and respondent’s age.

Assumption No. 3: We assume that there exists statistically significant dependence between honey usage and respondent’s age.

Assumption No. 4: We assume that urban consumers evaluate the factors affecting the purchase of honey differently.

Assumption No. 5: We assume that more than 40% of respondents are not aware of the max. temperature for heating honey without decreasing biological active compounds.

MATERIAL AND METHODOLOGY

Samples

30 samples of polyfloral honey (15 samples were directly from urban beekeepers and 15 samples were purchased from retail stores).

Chemical

Muller Hinton broth, Mueller Hinton agar, Sabouraud dextrose broth, Sabouraud dextrose agar, blank discs, antibiotics: tigecycline (30 μg per disc), chloramphenicol (30 μg per disc), fluconazole (30 μg per disc) (Oxoid, Basingstoke, UK).

Animals and Biological Material

One species of Gram-positive bacteria Enterococcus faecalis CCM 4224, one subspecies of Gram-negative bacteria Salmonella enterica subsp. enterica CCM 4420, and one species of yeast Candida krusei CCM 8271. All tested microorganisms were collected from the Czech Collection of microorganisms (Brno, Czech Republic).

Instrument

Densitometer (Biosan DEN-1, Riga, Latvia).

Laboratory Methods

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method according to CLSI criteria. The inoculums of bacteria were prepared in sterile Muller Hinton broth and yeast in Sabouraud dextrose broth. The optical density of microorganisms to 0.5 McFarland turbidity with a densitometer (Biosan DEN-1, Riga, Latvia) was used. The test microorganisms were uniformly seeded over the Mueller Hinton agar (Oxoid, Basingstoke, UK) resp. Sabouraud dextrose agar (Oxoid, Basingstoke, UK). Diameters of the zone of inhibition around the discs were measured using a ruler in mm. The antibiotics tested were for Gram-positive bacteria tigecycline (30 μg per disc), for Gram-negative bacteria chloramphenicol (30 μg per disc), and yeasts fluconazole (30 μg per disc) as a positive control.

Antimicrobial activity of honey

Susceptibility testing was performed by Kirby–Bauer disk diffusion method according to criteria by CLSI, 2016. The inoculums of each microorganism were prepared with a sterile loop and suspended in sterile Mueller-Hinton broth resp. Sabouraud dextrose broth. The optical density of microorganism suspension were determined with densitometer on McFarland turbidity 0.5. The test microorganism was uniformly seeded over the Mueller–Hinton agar resp. Sabouraud dextrose agar on the surface. Using a sterile cork borer (6 mm diameter, 4 mm deep, and about 2 cm apart), wells were made in the agar medium. Using a micropipette, 50 μL of honey with a concentration of 50%, 25%, 12.50%, and 6.25% was added to the wells in the plate. The plates with bacterial strains were incubated at 37°C for 24 h and with yeasts at 25 °C for 24 h. The mean diameters of inhibition zones were measured in mm, and the results were recorded. Sterile distilled water is used as negative control and antibiotics as a positive control. The experiment was repeated triplicate for each strain.

Description of the Experiment

Sample preparation:

Thirty honey samples were used for antimicrobial testing. Hundred percent pure honey (100% v/v) was obtained after filtered using sterile gauze. To get 50% honey solutions (v/v), 0.50 mL of honey was diluted in 0.50 mL sterilized Muller Hinton broth (Oxoid, Basingstoke, UK) and yeast in

Volume 15  468  2021
Sabouraud dextrose broth (Oxoid, Basingstoke, UK). Further serial dilutions of 0.25 mL of each, 0.125 mL and 0.0625 mL of honey, and 0.50 mL of sterile Muller Hinton broth and yeast in Sabouraud dextrose broth were added to obtain 50%, 25%, 12.5%, and 6.25% honey solutions (v/v), respectively.

Number of samples analyzed: 30
Number of repeated analyses: 3
Number of experiment replication: 3

Consumer research

The second part of the research was based on a questionnaire survey conducted in 2020. The survey was carried out online in Google forms and was disseminated via emails and social media (mostly Facebook groups) by applying a snowball sampling strategy. The research sample comprised 617 honey consumers living in urban areas. The socio-demographic profile is described in Table 1. The questionnaire involved both close-ended questions and open-ended questions regarding consumption patterns, purchasing behavior, and consumer’s awareness of the healing properties of honey.

Table 1 Socio-demographic profile of research sample. (%)

| Demographic variable | (%)     |
|----------------------|---------|
| Gender               |         |
| male                 | 36.63   |
| female               | 63.37   |
| Age                  |         |
| 18 – 30 years        | 47.81   |
| 31 – 50 years        | 36.95   |
| >50 years            | 15.24   |
| Education            |         |
| secondary            | 51.70   |
| university           | 48.30   |
| Economic status      |         |
| employed             | 66.29   |
| unemployed           | 1.13    |
| student              | 22.37   |
| pensioner            | 5.51    |
| maternity leave      | 4.70    |
| Individual income per month (Netto) |         |
| up to 400 €          | 21.39   |
| 401 – 600 €          | 13.13   |
| 601 – 800 €          | 20.42   |
| 801 – 1,000 €        | 19.12   |
| >1,000 €             | 25.93   |

Statistical Analysis

The antimicrobial activity of honey samples was conducted in triplicate and recorded with standard deviations. T-test for Equality of means was used for testing differences between honey samples from stores and urban beekeepers. In consumer research, there were applied non-parametric tests such as the Chi-square test of Independence, Friedman test, and multiple pairwise comparisons using Nemenyi’s procedure. The significance level was set to 0.05. All statistical analysis was carried out in statistical software SPSS Statistics v.25, IBM.

RESULTS AND DISCUSSION

Antimicrobial activity of honey samples

Results showed that antimicrobial activity was found in all tested kinds of honey (50% concentration). The highest antimicrobial activity in commercial kinds of honey was found against E. faecalis followed by S. enteritidis and C. kruase, while in kinds of honey from urban beekeepers was the order as follows: E. faecalis > C. kruase > S. enteritidis (see Table 2). In addition, we formulated the first hypothesis, which assumes that there exist significant differences in antimicrobial activity between honey samples from urban beekeepers and those purchase from retail stores. T-test for Equality of Means confirmed statistically significant differences in all three types of microorganisms (p ≤0.001).

Table 2 Antimicrobial activity of analyzed honey samples at concentration 50% (mm).

| Microorganisms   | S. enteritidis | E. faecalis | C. kruase |
|------------------|----------------|-------------|-----------|
| Beekeeper’s kinds of honey 50% | 5.13 ±0.81     | 9.78 ±0.72  | 5.49 ±0.89 |
| Commercial kinds of honey 50% | 3.89 ±0.73     | 4.62 ±0.78  | 3.69 ±0.78 |

Note: mean (n = 15) ±standard deviation.

Moreover, the antibacterial activity of kinds of honey with a concentration of 25% was found only in one type of examined microorganism and only of few honey samples. Eight honey samples from urban beekeepers inhibited E. faecalis (10.75 ±0.43) while only two honey samples from stores inhibited S. enteritidis (4.5 ±0.23). Antibacterial activity of honey with a concentration of 12.5% was found only in the case of 5 samples from urban beekeepers and it was against E. faecalis (6.9 ±0.97). Antibacterial activity is the most evaluated and investigated biological activity of honey and its presence has been proven in several tested samples of honey from the different botanical and geographical origin that were the object of examination of numerous studies which were orientated on the antibacterial activity (Al-Jabri et al., 2003; Al-Waili, 2004; Bucekova et al., 2019; Bucekova et al., 2018; Cilia et al., 2020). The mentioned statement confirms our achieved results related to antimicrobial activity. The similar results with samples of Slovak honey were obtained by Šedik et al. (2018) and by Kačaniová et al. (2012).

Results of consumer research

The questionnaire survey showed that Slovak consumers living in urban areas have the following annual consumption patterns: 39.7% consume only up to 1 kg and honey is mostly consumed occasionally or only during illness; 32.4% consume 1 or 2 kg in certain frequencies (few times per month or week). The rest 27.8% consume ≥3 kg mostly every day or few times per week. Based on the realized survey in Romania Pocol (2011) identify that 11.0% of consumers do not consume honey, while consumption of honey at the level of a maximum of 750 g per year is recorded in a group of approximately 35% of the population. Pocol (2011) also added that the average consumption, between 750 g and 2 kg per year, has a rate of approximately 27%, while 20% of the population consumes over 2 kg of honey per year. Furthermore, by applying the Chi-square test of independence we confirmed (p-value =<0.0001) the statistically significant differences in honey consumption per year among different age segments (H2). Lower honey consumption (only up to 1 kg) is more
frequent for younger consumers (18 – 30 years). The highest annual consumption has consumers older than 50 years (see Figure 1). Kopala, Balerak and Kuznica (2019) also found that elder respondents declared honey consumption more often than young people. Moreover, Žak (2017) realized the survey in Poland and reports that 83% of Poles over 65 years consume 500 g of honey in a month. In the context of the above Pocol and Moldovan-Teselios (2012) stated that young people up to 30 years consume rather small quantities of honey, consumers in the age category 32 – 45 years present a “normal” consumption behavior which is similar that the entire population, consumers between 46 – 60 years prefer consumption of average and large quantities of honey, being under-represented among non-consumers and the last category of consumers, consumers older than 61 years, consume medium quantities of honey.

Figure 1 Annual honey consumption based on respondent’s age.

Honey is mostly consumed as follows: sweetener in beverages > ingredient in the recipe > directly from a jar. Around 1/2 of respondents consume this product all over the year and around 43% only during the winter period to support their health. Moreover, 31% use honey regularly as a healthier alternative to sugar, and approximately 60% only sometimes.

Distribution of honey takes place primarily through producer-consumer or manufacturer-retailer-consumer channels (Borowska, 2011; Kumar, Sharma and Singh, 2012). Results of our study showed that the honey is mostly purchased as follows: directly from beekeeper > shops and retail stores > farmer markets > specialty shops. The least frequent place of purchase was e-shops. These results are also confirmed by Roman, Popiela-Pleban and Kozak (2013) who found that more than 60.0% of respondents prefer to buy honey from beekeepers, and by Cirić, Ignatijević and Cvijanovic (2015) who identified more than 40% of consumers has a habit of purchasing honey directly from the manufacturer of honey. Pocol and Bolboaca (2013) concluded, that local producers were preferred to purchase honey, but on the other hand, respondents also purchase honey and bee products in regional markets, hypermarkets or supermarkets, fairs and exhibitions, specialized shops for organic products, and other places. Marzec (2003) in her research showed that 84% of consumers purchase honey at the store and only 21% directly from the beekeeper. Krystallis, Petrovici and Arvanitoyannis (2007) state that the most usual channel for frequent food purchases for more than half of the sample is small local stores and open markets, while supermarkets are preferred for occasional food purchases. The optimal price per 1 kg of honey was considered 7 € (22%), 8 € (20%), or 6 € (17%). In comparison with other studies, we could state that consumers from other countries also most prefer honey up to 10 € per 900 g (Kos Skubic, Erjavec and Klopcič, 2018). In addition, respondents evaluated the importance of selected factors during honey purchase using 7 points scale, where 1 = the most important and 7 = the least important. Based on the Friedman test (p-value = <0.0001) it can be stated that there exist statistically significant differences in the evaluation of selected factors (H4). These differences were identified by Nemenyi’s procedure and are illustrated in Table 3. The most important factors are the following: honey quality > honey taste > honey origin > hone type > consistency. The least important were honey packaging and price.

In the context of quality as the most important factor during honey purchase is important to emphasize that honey quality is connected with food safety, creedence dimension, quality mark, honey taste, as well as nutritional value (Borodin, Arion and Muresan, 2013; Röhr et al., 2005).

According to Ványi, Csapo and Karpati (2010), the most important properties in the process of honey purchasing are the taste, quality, and color of honey.
Table 3 Results of Nemenyi’s procedure applied to selected purchasing factors.

| Sample       | Mean of ranks | Groups |
|--------------|---------------|--------|
| quality      | 2.74          | A      |
| taste        | 3.07          | A      |
| origin       | 3.26          | B      |
| type         | 4.22          | C      |
| consistency  | 4.29          | C      |
| price        | 4.78          | C      |
| packaging    | 5.64          | D      |

Note: questionnaire research, 2021.

Oravecz et al. (2020) found that consumers consider honey as a trusted product, which is confirmed by the fact that the source and the quality are the most important factors that influence the purchase of honey. The results of a study conducted by Wu et al. (2015) emphasize that the origin of honey is a very important attribute when choosing purchased honey and that even consumers are willing to pay a higher price for local honey, which also confirms our result that price is not a decisive factor in the process of honey purchase. On the one hand, Gyau et al. (2014) realized the descriptive analysis of the main attributes of honey and they showed that price, packaging, and color are the three key attributes that strongly influence a consumer’s choice of honey. On the other hand, they emphasized that quantity, taste, and the origin of the honey have a moderate influence on the choice, whereas the production process does not influence consumer preferences.

In addition, the survey focused also on consumer awareness and perception towards honey and its biological properties. Approximately 97% of respondents think that honey has healing properties, however, 1/3 of them were not able to answer the specific ones. The interesting result is that more than 40% of them were younger than 30 years. The rest of the respondents listed various properties and effects.

The most frequent were the following ones: immunity booster (22.7%), healing properties in case of cold, flu, or sore throat (12.5%), antibacterial activity (11.2%), anti-inflammatory (8.4%), and others. Based on the results, it can be concluded that the consumer’s awareness about the antibacterial activity is very low. A similar situation is with medical honey which is unknown for 72% of urban consumers. The rest of them perceived it as honeydew honey, honey used in hospitals, in medicine, or as clean, pure honey used for healing wounds.

In general, consumers are interested in the liquid consistency of honey, which was proved by Cosmina et al. (2016). Due to this fact, crystallized honey is usually liquefied by applying thermal treatment. Increasing temperature of honey can decrease its antibacterial activity (Pimentel-González et al., 2015). The last hypothesis (H5) assumes that more than 50% of respondents are not aware of the maximum temperature for heating honey without decreasing biological active compounds. The survey showed that only 18% knows the correct answer – 42 degree. The rest of them either do not know (48%) or has incorrect information (34%).

CONCLUSION

Slovak multi floral kinds of honey with a concentration of 50% were able to inhibit the growth of all three microorganisms (S. enteritidis, E. faecalis, C. krusei). A better antimicrobial activity was found in honey samples from urban beekeepers. Consumer research showed that consumers in Slovakia use honey as food (sweetener in beverages or ingredients in the recipe) and as medicine mostly during the winter to support their health. Approximately 97% think that honey has healing effects, however, only 11% are aware of its antibacterial activity and 1/3 was not able to identify specific effects. The rest of them mostly listed immunity booster, healing properties in terms of cold or sore throat.

REFERENCES

Abbas, A. S., Ghozy, S., Minh, L. H. N., Hashan, M., Soliman, A., Van, N., Hirayama, K., Nguyen, H. 2019. Honey in Bronchial Asthma: From Folk Tales to Scientific Facts. Journal of Medicinal Food, vol. 22, no. 6, p. 543-550. https://doi.org/10.1089/jmf.2018.4303

Ahluwalia, M., Ahluwalia, P., Dhandapani, K. M., Vaibhav, K. 2020. Honey: A Sweet Way to Health. In Rehman, M. U., Majid, S. Therapeutic Applications of Honey and its Phytochemicals. Singapore : Springer, p. 53-80. ISBN 978-981-15-6799-5. https://doi.org/10.1007/978-981-15-6799-5_4

Al-Hatamleh, M., Hatmal, M., Sattar, K., Ahmad, S., Mustafa, M., Bittencourt, M., Mohamud, R. 2020. Antiviral and Immunomodulatory Effects of Phytochemicals from Honey against COVID-19: Potential Mechanisms of Action and Future Directions. Molecules, vol. 25, no. 21, p. 1-23. https://doi.org/10.3390/molecules25215017

Al-Jabr, A., Nzeako, B., Mahroori, Z., Naqdy, A., Nsanze, H. 2003. In vitro antibacterial activity of Omani and African honey. British Journal of Biomedical Science, vol. 60, no. 1, p. 1-4. https://doi.org/10.1080/09674845.2003.11783668

Al-Waili, N. 2004. Investigating the Antimicrobial Activity of Natural Honey and Its Effects on the Pathogenic Bacterial Infections of Surgical Wounds and Conjunctiva. Journal of Medicinal Food, vol. 7, no. 2, p. 210-222. https://doi.org/10.1089/109662041324139

Borodin, T., Arion, F., Muresan, I. 2013. Romanian premium honey consumer’s perceptions about traceability. Agricultura – Știință și practică, vol. 85, no. 1-2, p. 104-111.

Borowska, A. 2011. Stan i perspektywy rozwoju pszczelarstwa w Polsce ze szczególnym uwzględnieniem miódów regionalnych Zeszyty Naukowe SGGW w Warszawie (The state and prospects for the development of beekeeping in Poland, with particular emphasis on regional honeys. Scientific Papers of the Warsaw University of Life Sciences.) Problemy Rolnictwa Światowego, vol. 11, no. 4, p. 37-47. (in Polish)

Buba, F., Gidado, A., Shugaba, A. 2013. Analysis of Biochemical Composition of Honey Samples from North-East Nigeria. Biochemistry & Analytical Biochemistry, vol. 2, no. 3, p. 1-7. https://doi.org/10.4172/2161-1009.1000139

Bucekova, M., Bugárová, V., Godocikova, J., Majtan, J. 2020. Demanding New Honey Qualitative Standard Based on Antibacterial Activity. Foods, vol. 9, no. 9, p. 1-12. https://doi.org/10.3390/foods9091263

Bucekova, M., Jardekova, L., Juricova, V., Bugárová, V., Marco, G., Gismondi, A., Leonardi, D., Farkasovska, J., Godocikova, J., Laho, M., Klaudiny, J., Majtan, V., Canini, A., Majtan, J. 2019. Antibacterial Activity of Different Blossom Hones: New Findings. Molecules, vol. 24, no. 8, p. 1-20. https://doi.org/10.3390/molecules24081573
Bucekova, M., Jurcova, V., Di Marco, G., Gismond, A., Leonard, D., Canini, A., Majtan, J. 2018. Effect of thermal liquefying of crystallised honeys on their antibacterial activities. Food Chemistry, vol. 269, p. 335-341. https://doi.org/10.1016/j.foodchem.2018.07.012

Bueno-Costa, F., Zambrini, R., Bohmer, B., Chaves, F., Silva, W., Zanusso, J., Dutra, I. 2015. Antibacterial and antioxidant activity of honeys from the state of Rio Grande do Sul, Brazil. LWT - Food Science and Technology, vol. 65, p. 333-340. https://doi.org/10.1016/j.lwt.2015.08.018

Cilia, G., Fratini, F., Marchi, M., Sagona, S., Turchi, B., Adamchuk, L., Felicioli, A., Kacanikova, M. 2020. Antibacterial Activity of Honey Samples from Ukraine. Veterinary Sciences, vol. 7, no. 4, p. 181. https://doi.org/10.3390/ves7040181

Ciric, M., Ignjatijevic, S., Cvijanovic, D. 2015. Research of honey consumers’ behavior in province of Vojvodina. Ekonomika poljoprivrede, vol. 62, no. 3, p. 627-644. https://doi.org/10.5937/ekopolj30627C

Cosmina, M., Gallenti, G., Marafon, F., Troiano, S. 2016. Attitudes towards honey among Italian consumers: A choice experimental approach. Appetite, vol. 99, no. 1, p. 52-58 https://doi.org/10.1016/j.appet.2015.12.018

Da Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C. O. 2016. Honey: Chemical composition, stability and authenticity. Food Chemistry, vol. 196, p. 309-323. https://doi.org/10.1016/j.foodchem.2015.09.051

Escoredo, O., Dobre, I., Fernandez-Gonzalez, M., Seijio, M. C. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. Food Chemistry, vol. 149, p. 84-90. https://doi.org/10.1016/j.foodchem.2013.10.097

Escoredo, O., Miguez, M., Fernandez-Gonzalez, M., Seijo-Coello, M. C. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic area. Food Chemistry, vol. 138, no. 2-3, p. 851-856. https://doi.org/10.1016/j.foodchem.2012.11.015

Escoredo, O., Seijo, M. C. 2019. Honey: Chemical Composition, Stability and Authenticity. Foods, vol. 8, no. 11, p. 1-3. https://doi.org/10.3390/foods8110577

Gündoğdu, E., Cakmakci, S., Şat, İ. 2019. An Overview of Honey: Its Composition, Nutritional and Functional Properties. Journal of Food Science and Engineering, vol. 9, p. 10-14. https://doi.org/10.17265/2159-5828/2019.01.003

Güneş, U., Rn, I. 2007. Effectiveness of a Honey Dressing for Healing Pressure Ulcers. Journal of wound, ostomy, and continence nursing, vol. 34, no. 2, p. 184-190. https://doi.org/10.1097/01.WON.000024833.11108.35

Gyau, A., Mayimba, C., Degrande, A., Biloso, A. 2014. Determinants of Consumer Preferences for Honey in the Democratic Republic of Congo. Journal of Food Products Marketing, vol. 20, no. 5, p. 476-490. https://doi.org/10.1080/10454446.2013.807405

Idrus, R., Sainik, N., Nordin, A., Saim, A., Sulaiman, N. 2020. Cardioprotective Effects of Honey and Its Constituent: An Evidence-Based Review of Laboratory Studies and Clinical Trials. International Journal of Environmental Research and Public Health, vol. 17, no. 10, p. 1-22. https://doi.org/10.3390/ijerph17103613

Ismaiel, S., Khaitani, S., Adgaba, N., Al-Ghamdi, A., Zulail, A. 2014. Factors That Affect Consumption Patterns and Market Demands for Honey in the Kingdom of Saudi Arabia. Food and Nutrition Sciences, vol. 5, no. 17, p. 1725-1737. https://doi.org/10.4236/fn.2014.517186

Kačániová, M., Hleba, L., Dzugan, M., Pasternakiewicz, A., Kozovická, V., Pavelková, A., Felsőcsová, S., Petrová, J., Ročná, K., Kluz, M., Grabek-Lejko, D. 2012. Microbiological properties and antimicrobial effect of slovakian and polish honey having regard to the water activity and water content. Journal of Microbiology, Biotechnology and Food Sciences, vol. 2, no. 1, p. 272-281.

Kala, C., Taleuzzaman, M., Gilani, S., Imam, S., Ali, S. 2020. Positive Influence of Honey on Human Health. In Rehman, M. U., Majid, S. Therapeutic Applications of Honey and its Phytochemicals. Singapore : Springer, p. 237-259. ISBN 978-981-15-6799-5. https://doi.org/10.1007/978-981-15-6799-5_12

Karabagias, I. K., Maia, M., Karabagias, V. K., Gatzias, I., Badeka, A. V. 2018. Characterization of Eucalyptus, Chestnut and Heather honeys from Portugal Using Multi-Parameter Analysis and Chemo-Calculus. Foods, vol. 7, no. 12, p. 1-25. https://doi.org/10.3390/foods7120194

Keskin, M., Keskin, S. 2021. Health-promoting benefits of honey. In Chukwuebuka, E., Abhay, P. M., Megh, R. G. Preparation of Phytopharmaceuticals for the Management of Disorders. Amsterdam, Netherland : Elsevier, p. 303-306. ISBN 9780128202852. https://doi.org/10.1016/B978-0-12-820284-5.00024-1

Khaliil, M., Sulaiman, S. A. 2010. The Potential Role of Honey and its Polyphenols in Preventing Heart Diseases: A Review. AJTCAM, vol. 7, no. 4, p. 315-321. https://doi.org/10.4314/ajtcam.v7i4.56693

Kopala, E., Balcerak, M., Kuźnicka, E. 2019. Survey of consumer preferences on the bee product market. Part 1. Honey. Annals of Warsaw University of Life Sciences - SGGW - Animal Science, vol. 58, no. 2, p. 153-158. https://doi.org/10.22630/AAS.2019.58.2.16

Kos Skubic, M., Erjavec, K., Klopcić, M. 2018. Consumer preferences regarding national and EU quality labels for cheese, ham and honey: The case of Slovenia. British Food Journal, vol. 120, no. 3, p. 650-664. https://doi.org/10.1108/BFJ-04-2017-0236

Krystalis, A., Petrovici, D., Arvanitoyannis, I. 2007. From Commodities to the Consumption of Quality Foods in Eastern European Context. Journal of East-West Business, vol. 14, no. 1, p. 5-37. https://doi.org/10.1300/j097v14n01_02

Kumar, K., Bhowmik, B., Chiranjib, C., Biswajit, B., Chandira, M. R. 2010. Medicinal uses and health benefits of honey: An Overview. Journal of Chemical and Pharmaceutical Research, vol. 2, no. 1, p. 385-395.

Kumar, V., Sharma, U. K., Singh, S. 2012. Marketing pattern of honey in Haryana. Annals of Agri Bio Research, vol. 17, p. 144-148.

Kwakman, P., Te Velde, A., Boer, L., Speijer, D., Vandenbroucke-Grauls, C., Zaat, S. 2010. How honey kills bacteria. The FASEB Journal : The Journal of the Federation of American Societies for Experimental Biology, vol. 24, no. 7, p. 2576-2582. https://doi.org/10.1096/fj.09-150789

Lusby, P. E., Coombes, A. L., Wilkinson, J. M. 2005. Bactericidal activity of different honeys against pathogenic bacteria. Archives of Medical Research, vol. 36, no. 5, p. 464-467. https://doi.org/10.1016/j.arcmed.2005.03.038

Mandal, M. D., Mandal, S. 2011. Honey: its medicinal property and antibacterial activity. Asian Pacific Journal of Tropical Biomedicine, vol. 1, no. 2, p. 154-160. https://doi.org/10.1016/S2221-1691(11)60016-6

Marzec, J. 2003. Wpływ struktury handlu detalicznego na miejsca dokonywania zakupów miód przez mieszkańców Krakowa (The impact of the retail trade structure on the places where honey is purchased by the inhabitants of Krakow). Proceedings of the XI. Naukowej Konferencji Przeczeszarckiej. Puławy, Poland. 11-12 March 2003. p. 55-56. (in Polish)
Meo, S. A., Al-Asiri, S. A., Mahesar, A. L., Ansari, M. J. 2017. Role of honey in modern medicine. *Saudi Journal of Biological Sciences*, vol. 24, no. 5, p 975-978. https://doi.org/10.1016/j.sjbs.2016.12.010

Mundo, M. A., Padilla-Zakour, O. I., Worobo, R. W. 2004. Growth inhibition of foodborne pathogens and food spoilage organisms by select raw honeys. *International Journal of Food Microbiology*, vol. 97, no. 1, p. 1-8. https://doi.org/10.1016/j.ijfoodmicro.2004.03.025

Oavez, T., Mucha, L., Magda, R., Tótth, G., Illés, C. 2020. Consumers’ Preferences for Locally Produced Honey in Hungary. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, vol. 68, no. 2, p. 407-418. https://doi.org/10.1111/aaua.202068020407

Otero, M. C., Bernolo, L. 2020. Honey as Functional Food and Prospects in Natural Honey Production. In Egbuna, C., Dable Tupas, G, Functional Foods and Nutraceuticals, 1st ed. New York, USA : Springer, p. 197-210. ISBN 978-3030423186. https://doi.org/10.1007/978-3-030-42319-3_11

Pimentel-González, D. J., Basilio-Cortes, U. A., Hernández-Fuentes, A. D., Figueira, A. C., Quintero-Lira, A., Campos-Montiel, R. G. 2015. Effect of Thermal Processing on Antibacterial Activity of Multifloral Honeys. *Journal of Food Process Engineering*, vol. 40, no. 1, p. 1-8. https://doi.org/10.1111/jfpe.12279

Pocel, C. B. 2011. Modelling the honey consumption behaviour in Romania by using socio-demographic determinants. *African Journal of Agricultural Research*, vol. 6, p. 4069-4080.

Pocel, C. B., Bolboaça, S. 2013. Perceptions and trends related to the consumption of honey: A case study of North-West Romania. *International Journal of Consumer Studies*, vol. 37, no. 6, p. 642-649. https://doi.org/10.1111/jics.12046

Pocel, C. B., Moldovan-Teslios, C. 2012. Socio-economic determinants of honey consumption in Romania. *Journal of Food, Agriculture and Environment*, vol. 10, no. 2, p. 18-21.

Puscion-Jakubik, A., Borawksa, M., Socha, K. 2020. Modern Methods for Assessing the Quality of Bee Honey and Botanical Origin Identification. *Foods*, vol. 9, no. 8, p. 1-21. https://doi.org/10.3390/foods9081028

Ranneh, Y., Md. Akim, A., Hashia, A., Khazaai, H., Fadel, A., Zakaria, Z., Albujja, M., Abu Bakar, M. F. 2021. Honey and its nutritional and anti-inflammatory value. *BMC Complementary Medicine and Therapies*, vol. 21, no. 30, p. 1-17. https://doi.org/10.1186/s12906-020-03170-5

Röhr, A., Lüddeke, K., Drusch, S., Müller, M. J., Alvensleben, R. V. 2005. Food quality and safety - consumer perception and public health concern. *Food Control*, vol. 16, no. 8, p. 649-655. https://doi.org/10.1016/j.foodcont.2004.06.001

Roman, A., Popiela-Pleban, E., Kozák, M. 2013. Factors influencing consumer behavior relating to the purchasing of honey part 1. The buying process and the level of consumption. *Journal of Apicultural Science*, vol. 57, no. 2, p. 159-172. https://doi.org/10.2478/jas-2013-0026

Samarghadian, S., Farkhondeh, T., Samini, F. 2017. Honey and Health: A Review of Recent Clinical Research. *Pharmacognosy Research*, vol. 9, no. 2, p. 121-127. https://doi.org/10.4103/0974-8490.204647.

Scepankova, H., Saraiva, J. A., Estevinho, L. M. 2017. Honey Health Benefits and Uses in Medicine. In Alvarez-Suarez, J. Bee Products - Chemical and Biological Properties. New York, USA : Springer, p. 83-96. ISBN 9783319596891. https://doi.org/10.1007/978-3-319-59689-1_4

Šedík, P., Zagula, G., Ivaniová, E., Kňazovická, V., Horská, E., Kačániová, M. 2018. Nutrition marketing of honey: chemical, microbiological, antioxidant and antimicrobial profile. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 12, no. 1, p. 767-774. https://doi.org/10.5219/988

Selmi, S., Irand, I., Sistanto, S. 2020. Segmentation of consumers of honey and identification of honey preference in Kota Bengkulu. *AGRITROPICA : Journal of Agricultural Sciences*, vol. 3, no. 2, p. 88-97. https://doi.org/10.31186/AgriJotropica.3.2.88-97

Vanýi, G. V., Csapo, Z., Karpati, L. 2010. Honey consumption in Europe with especial regard to Hungary. In 45th Croatian & 5th International Symposium on Agriculture: Agricultural Economics and Rural Sociology. Opatija, Croatia : Josip Juraj Strossmayer University, p. 200-204. ISBN 978-953-6331-80-2.

Wu, S., Fooks, J., Messer, K., Delaney, D. 2015. Consumer demand for local honey. *Applied Economics*, vol. 47, no. 41, p. 4377-4394. https://doi.org/10.1080/00036846.2015.1030564

Yeow, S. H. C., Chin, T., Yeow, J., Tan, K. 2013. Consumer Purchase intentions and honey related products. *Entrepreneurship Vision 2020: Innovation, Development Sustainability, and Economic Growth - Proceedings of the 20th International Business Information Management Association Conference, IBIMA 2013*, p. 332-345. https://doi.org/10.5171/2013.197440

Zák, N. 2017. Preferencje konsumentów polskich oraz amerykańskich dotyczące spożycia miodów pszczelich (Preferences of Polish and American consumers regarding the consumption of bee honey). *Marketing i Zarządzanie*, vol. 2, no. 48, p. 117-130. https://doi.org/10.18276/miz.2017.48-11 (in Polish)

**Funds:**

This work has been supported by Grant Agency of The Slovak University of Agriculture in Nitra, grant no. 16/2019 with title “Analysis of consumer behaviour in the honey market with emphasis on its quality and nutritional value”, and by the Operational Program Integrated Infrastructure within the project: Demand-driven research for the sustainable and innovative food, Drive4SiFood 313011V336, cofinanced by the European Regional Development Fund.

**Conflict of Interest:**

The authors declare no conflict of interest.

**Ethical Statement:**

This article does not contain any studies that would require an ethical statement.

**Contact Address:**

*Peter Šedík, Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Center for Research and Educational projects, Trieda A. Hlinku 2, 949 76 Nitra, Slovakia, Tel.: +421 37 641 4908, E-mail: peter.sedik@uniag.sk*

**ORCID:** https://orcid.org/0000-0003-2495-5162

Kristina Predanocová, Slovak University of Agriculture in Nitra, AgroBioTech Research Centre, Trieda A. Hlinku 2, 949 76 Nitra, Slovakia, Tel.: +421 37 641 4914, E-mail: kristina.predanocova@uniag.sk

**ORCID:** https://orcid.org/0000-0001-8867-1666
