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Original Article

Variations in nutritional profile of honey produced by various species of genus Apis

Variações no perfil nutricional do mel produzido por várias espécies do gênero Apis

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Abstract

The medicinal attributes of honey appears to overshadow its importance as a functional food. Consequently, several literatures are rife with ancient uses of honey as complementary and alternative medicine, with relevance to modern day health care, supported by evidence-based clinical data, with little attention given to honey's nutritional functions. The moisture contents of honey extracted from University of Veterinary and Animal Sciences, Lahore honey bee farm was 12.19% while that of natural source was 9.03 ± 1.63%. Similarly, ash and protein contents of farmed honey recorded were 0.37% and 5.22%, respectively. Whereas ash and protein contents of natural honey were 1.70 ± 1.98% and 6.10 ± 0.79%. Likewise fat, dietary fiber and carbohydrates contents of farmed source documented were 0.14%, 1.99% and 62.26% respectively. Although fat, dietary fiber and carbohydrates contents of honey taken from natural resource were 0.54 ± 0.28%, 2.76 ± 1.07% and 55.32 ± 2.91% respectively. Glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Similarly, sucrose and maltose contents of farmed honey were 2.5% and 12% while in natural honey were 1.35 ± 0.49% and 8.00 ± 1.41% respectively. The present study indicates that such as moisture, carbohydrates, sucrose and maltose contents were higher farmed honey as compared to the natural honey. In our recommendation natural honey is better than farmed honey.

Keywords: fructose, carbohydrates, natural honey, Apis species, sucrose.

Resumo

Os atributos medicinais do mel parecem ofuscar sua importância como alimento funcional. Consequentemente, várias literaturas estão repletas de usos antigos do mel como medicina complementar e alternativa, com relevância para os cuidados de saúde modernos, apoiados por dados clínicos baseados em evidências, com pouca atenção dada às funções nutricionais do mel. O teor de umidade do mel extraído da Universidade de Veterinária e Ciências Animais, fazenda de abelhas de Lahore, foi de 12,19%, enquanto o de fonte natural foi de 9,03 ± 1,63%. Da mesma forma, os teores de cinzas e proteínas do mel cultivado foram de 0,37% e 5,22%, respectivamente. Já os teores de cinzas e proteínas do mel natural foram de 1,70 ± 1,98% e 6,10 ± 0,79%. Da mesma forma, os teores de gordura, fibra dietética e carboidratos de origem cultivada documentados foram de 0,14%, 1,99% e 62,26%, respectivamente. Embora os teores de gordura, fibra alimentar e carboidratos do mel retirado dos recursos naturais fossem de 0,54 ± 0,28%, 2,76 ± 1,07% e 55,32 ± 2,91%, respectivamente. Os conteúdos de glicose e frutose do mel retirado da fazenda de abelhas foram de 27% e 34%, mas a fonte natural foi de 22,50 ± 2,12% e 28,50 ± 3,54%. Os conteúdos de glicose e frutose do mel retirado da fazenda de abelhas foram de 27% e 34%, mas a fonte natural foi de 22,50 ± 2,12% e 28,50 ± 3,54%. Da mesma forma, os teores de sacarose e maltose no mel cultivado foram de 2,5% e 12%, enquanto no mel natural foram de 1,35 ± 0,49% e 8,00 ± 1,41%, respectivamente. O presente estudo indica que os teores de umidade, carboidratos, sacarose e maltose foram maiores no mel cultivado em comparação ao mel natural. Em nossa recomendação, o mel natural é melhor que o mel de cultivo.

Palavras-chave: frutose, carboidratos, mel natural, espécies de Apis, sacarose.

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1. Introduction

Every insect species has its own function into the environment and major groups are Coleoptera (beetles), Lepidoptera (butterflies and moths) and Diptera (flies). Furthermore, the Hymenopterans, specially the bees, are the mainly efficient pollinators of crops (bee keeping for pollination in regarding 70% of the earth's planted crops) and various other flowering plants. The honeybees have the powerful attraction to make honey and the scattering of seeds is also recognized for the purpose of pollination. The highly significant role of honeybee is that they pollinate the plants (Morse and Calderon, 2000; Donkersley et al., 2017). There are three types of honeybee such as *Apis florae*, *Apis dorsata* and *Apis cerana* which play significant role in pollination (Partap, 2011). These are innate and known as the local kinds of Pakistan. Bees are differentiated from wasps by means of the existence of stemmed, frequently plumose hairs, and the posterior basitarsi, which are extensive than the successive tarsal fragments. The proboscis is in wide-ranging elongated than the majority sphecoid wasps. Michener (2007) noted 17,533 species of bees globally, characterized through 443 genera and seven families. Honey is a sugary, thick liquid prepared via honey bees. The smell, color and flavor of honey depend upon the different types of flowers. Chua and Adnan (2014) documented monosaccharide's, disaccharides and 17 amino acids from honey. The fitness promoting traits of honey are mostly because of the existence of numerous metabolites consisting of folic acid, thiamine, biotin, niacin, tocopherol, polyphenols, phytosterols besides enzymes and co-enzymes. The details lying on the anti-oxidant, anti-bacterial, anti- 1 fungal, and hepato-protective characteristics of honey are well filed. In standard, honey is a precious addition for fit people (Denisow and Denisow-Pietrzyk, 2016; Muhammad et al., 2016). Honey cannot be consider a entire food by human being nutritional standards, on the other hand it put forwards strength such as a nutritional addition (Mendes et al., 1998).The usage of honey such as foodstuff and drug from human has been extended times before (Crane, 1983). Honey is made worldwide and its international production is more or less 1.20 million tons per annum (Bogdanov et al., 2008). Carbohydrates are amongst most important honey ingredients and are present in the variety of turanose, sucrose, maltulose, isomaltose, maltose, disaccharides, glucose, fructose, and monosaccharides. It also includes oligosaccharides comprising the anderose and panose and enzymes such as: amylase, oxidase peroxide, catalase and acid phosphorylase.

Numerous explorations have been attained in order to find out associations amongst the carbohydrate sketches and the nectar supplies with the usage of multivariate study (Cotte et al., 2004; Devillers et al., 2004). Moreover, honey includes amino acids, trace vitamin B, Vitamin B6, Vitamin C, niacin, folic acid, minerals, iron, zinc and antioxidants (Ball, 2007; Buba et al., 2013). Natural honey is produced by bees if different Apis species. The prevailing honey producing bees go to the genus Apis, underneath the family Apidae. Apis is symbolized via five species in Indian areas, of which four are local species for example: *A. dorsata* (rock bee or giant bee), *A. cerana* (Indian bee), *A. florae* (little bee) and *A. andreniformis* although *A. mellifera* (European bee) is a pioneered species (Waghchoure-Camphor and Martin, 2008). Though the foremost 22 constituents of honey are nearly alike in every honey samples, the accurate chemical assemblage and physical characteristics of natural honeys dissimilar depending upon the plant kinds wherever the bees feed (James et al., 2009; Omafuvbe and Akanbi, 2009; Ebenezer and Olugbenga, 2010).

Facts show that few types of honey comprise kynurenic acid that is a tryptophan metabolite with neuroactive action that can impart to its antimicrobic qualities (Beretta et al., 2007). Analyses of the physical and chemical properties of honey are important for the official recognition procedure which establishes honey worth (Salim et al., 2011). Present study is therefore planned to find out variations in physico-chemical characteristics and nutritional profile of honey produced by various Apis species.

2. Materials and Methods

A total of 5 honey samples of local honey bee species were collected from natural hives in the vicinity of Pattoki city while that of farmed species from Model Honeybee Farm, Department of Wildlife and Ecology, University of Veterinary and Animal Sciences, Ravi Campus (Figure 1). Physical features of these honey samples viz. taste, smell, color and pH were recorded and the samples were stored in plastic glass bottles at room temperature for further analysis.

2.1. Proximate analysis

The proximate content, i.e. protein, fat, dietary fiber, carbohydrate, water and ash were determined depend on the official analysis methods as of Association of Official Analytical Chemists (AOAC). Every trial was performed in triplicate. Protein content was find out through Kjeldahl method depend upon the overall nitrogen content as of the AOAC Official Method 991.20, 2005. The fat content was find out by means of acid hydrolysis process. The dietary fibers comprised of the total, soluble and insoluble fibers of honey samples. 5 g of honey sample was used to measure and ash contents according to the AOAC Official Method (AOAC, 2005). Carbohydrate value was calculated using following Formula 1 (Charrondiere et al., 2004).

$$\mathbf{Total\ carbohydrate}\left(\mathbf{g/100\,g}\right) = 100 - \left(water + ash + protein + fat + dietary\ fiber\right) \quad (1)$$

The energy values for the honey samples were also calculated following Formula 2 (Charrondiere et al., 2004).

$$\mathbf{Energy}\ \left(\mathbf{kcal/g}\right) = 9\left(fat\right) + 4\left(protein\right) + 4\left(carbohydrate\right) \quad (2)$$

2.2. Glucose oxidase activity with peroxide test

The activity of glucose oxidase in honey samples was monitored for peroxide accumulation using Merckoquant

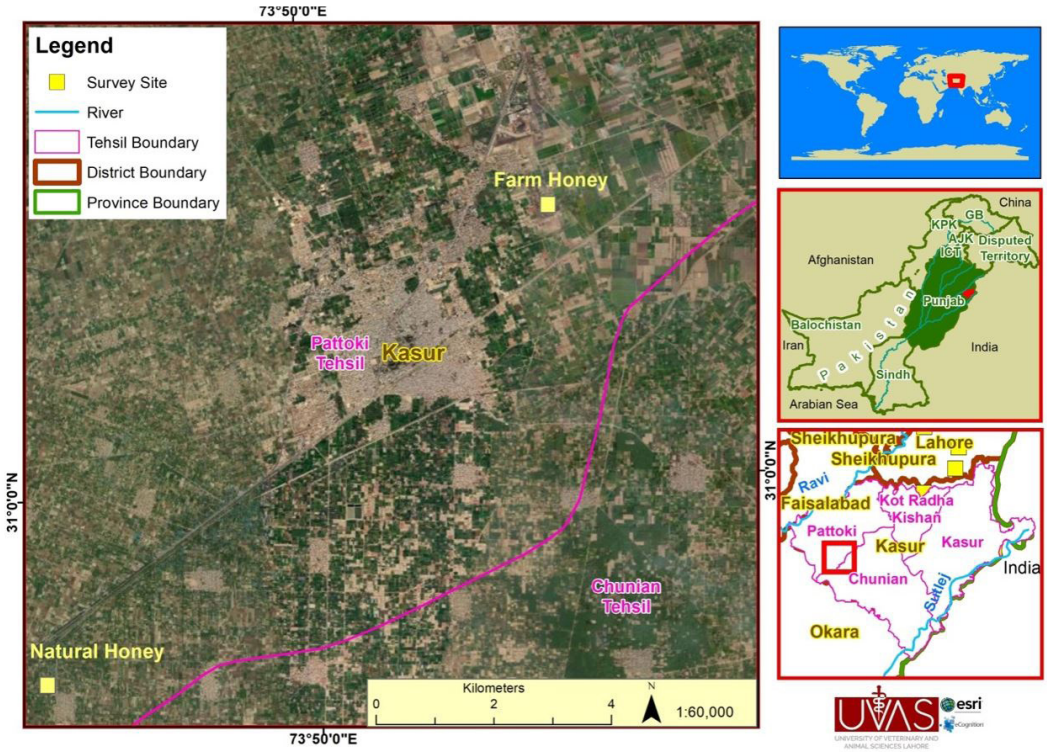

Figure 1. Collection sites of farmed and natural honey.

test strip (no. 10011) from Merck, Germany as illustrated by Kerkvliet (1996) and outcomes were stated in milligram of hydrogen peroxide accumulation in a liter of sample solution for an hour at 20 °C.

2.3. Sugar analysis by HPLC

The major sugar content of honey samples such as fructose, glucose, sucrose and maltose were analyzed using HPLC system coupled to a refractive index detector. Amide column with the dimension of 3.5 µm, 4.6 × 150 mm was applied for the separation. The column was kept at 25 °C all over the analysis. Honey samples (0.5 g) were dissolved in de ionized water and vortexes strongly before sieved used for injection. The injection volume was 20 µl. The average sugar solutions comprised of a combination of fructose, glucose, sucrose and maltose were prepared by diverse concentrations ranging from 5 to 20 g/kg meant for calibration curve construction.

2.4. Statistical analysis

The collected record was focused to statistical software SAS 9.1 and Analysis of Variance (ANOVA) were implemented to note inter specific variations in nutritional profile of honey from various honeybee species.

3. Results

The outcomes of the nutritional profile of honey samples obtained from UVAS Model Honeybee Farm are mentioned in Table 1. Moisture, ash, protein, fat, dietary fiber and carbohydrate values were 12.19%, 0.37%, 5.22%, 0.14%, 1.99% and 62.26%, respectively. Similarly, glucose, fructose, sucrose and maltose were recorded 27%, 34%, 2.5% and 12% respectively. Nutritional profile of honey samples extracted from different sources is mentioned in Table 1. The moisture contents of honey extracted from UVAS honeybee farm was 12.19% while that of natural source was 9.03 ± 1.63%. Similarly, ash and protein contents of farmed honey recorded were 0.37% and 5.22%, respectively. Whereas ash and protein contents of natural honey were 1.70 ± 1.98% and 6.10 ± 0.79%. Likewise fat, dietary fiber and carbohydrates contents of farmed source documented were 0.14%, 1.99% and 62.26%. Although fat,

Table 1. Nutritional profile of honey from honeybee farm and natural source.

Parameters	Farmed Sample	Natural Sample
Moister	12.19%	9.03±1.63%
Ash	0.37%	1.70±1.98%
Protein	5.22%	6.10±0.79%
Fat	0.14%	0.54±0.28%
Dietary Fiber	1.99%	2.76±1.07%
Carbohydrates	62.26%	55.32±2.91%
Glucose	27%	22.50±2.12%
Fructose	34%	28.50±3.54%
Sucrose	2.5%	1.35±0.49%
Maltose	12%	8.00±1.41%

dietary fiber and carbohydrates contents of honey taken from natural resource were 0.54 ± 0.28%, 2.76 ± 1.07% and 55.32 ± 2.91% respectively. In the same way, glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Also, sucrose and maltose contents of farmed honey were recognized 2.5% and 12% though natural honey were 1.35 ± 0.49% and 8.00 ± 1.41%. Nutritional profile of honey samples extracted from various Apis species is mentioned in Table 2. The moisture contents of honey taken from natural honey of *A. dorsata* and *A. florea* were 7.88% and 10.18% respectively while that of moisture contents of farmed honey recorded from *A. mellifera* was 12.19%. Similarly, ash and protein contents of *A. dorsata* and *A. florea* honey (natural sources) were 1.15%, 2.25%, 5.54% and 6.66%. Whereas ash and protein contents of *A. mellifera* honey (farmed source) were 0.37% and 5.22%. In the same way, fat, dietary fiber and Carbohydrates contents of *A. dorsata* and *A. florea* honey were 0.34%, 0.73%, 2.00%, 3.51%, 57.37% and 53.26% but fat, dietary fiber and Carbohydrates contents of honey taken from *A. mellifera* honey were 0.14%, 1.99% and 62.26%. Likewise glucose and fructose contents of *A. dorsata* and *A. florea* honey documented were 24%, 21%, 31% and 26%. Although, the same contents extracted from *A. mellifera* honey were 27% and 34%. Also, sucrose and maltose contents of *A. dorsata* and *A. florea* honey (natural sources) recognized were 1.7%, 1%, 9% 7% and though sucrose and maltose contents of *A. mellifera* honey (farmed source) were 2.5% and 12%.

4. Discussion

The results illustrated no major variations for moisture, ash, protein, fat, carbohydrate, glucose, fructose and sucrose substances in addition to the maltose values of the honey sample when compared with the values of Chua and Adnan (2014); Buba et al. (2013); El Sohaimy et al. (2015); Ibe et al. (2013); Tola et al. (2017); Aljohar et al. (2018) and White and Landis (1980) However, variations in dietary fiber content was examined from the honey sample when compared with the results of Chua and Adnan (2014). Some honey samples were taken from *Koompassia excels*, *Melaleuca cajuputi*, *Acacia mangium* that relate to Chua and Adnan (2014) study. In Ibe et al. (2013) study confered honeys made from diverse tree species for instance *Pentaclethra macrophylla*, *Treculia africana*, *Irvingia gabonensis* and *Trifoliate citrus* while honey sample was taken from Rhamnus sp. (Sidr trees) in El Sohaimy et al. (2015) study. Nutritional profile of honey samples taken from various sources is stated in Table 1. The moisture contents of honey extracted from UVAS honeybee farm was 12.19% while that of natural source was 9.03 ± 1.63%. But same content of honey taken from Chua and Adnan (2014), Buba et al. (2013), El Sohaimy et al. (2015) was 37.31 ± 0.96%, 17.33 ± 2.56 g/100 g, 14.73 ± 0.36%. Similarly, ash and protein contents of farmed honey were recorded 0.37% and 5.22%, respectively. Whereas ash and protein contents of natural honey were 1.70 ± 1.98% and 6.10 ± 0.79%.Also these contents recorded from Chua and Adnan (2014), Buba et al. (2013), El Sohaimy et al. (2015) were 0.19 ± 0.02%, 0.54 ± 0.11 g/100 g, 2.33 ± 0.02%, 0.36 ± 0.05%, 1.04 ± 0.04 g/100 g and 4.67 ± 0.171mg/g respectively. Likewise fat, dietary fiber and carbohydrates contents of farmed source were documented 0.14%, 1.99% and 62.26%. Although fat, dietary fiber and carbohydrates contents of honey taken from natural resource were 0.54 ± 0.28%, 2.76 ± 1.07% and 55.32 ± 2.91% respectively. Whereas fat content of honey extracted from Chua and Adnan (2014), Buba et al. (2013) and Ibe et al. (2013) was 0, 0.20 ± 0.10 g/100 g and 2.97%, dietary fiber content from Chua and Adnan (2014) was 0 and carbohydrates content of honey from Chua and Adnan (2014), Buba et al. (2013) was 61.89% and 83.09 ± 0.54 g/100 g respectively. In the same way, glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Also, sucrose and maltose contents of farmed honey were recognized 2.5% and 12% though natural honey were 1.35 ± 0.49% and 8.00 ± 1.41%. While glucose, fructose, sucrose and maltose contents of honey documented from Chua and Adnan (2014) were 50.447%, 44.908%, 6.090% and 11.693%. These same from Tola et al. (2017) were 31.0%, 38.5%, 1.34% and 7.2% whereas glucose, fructose and sucrose contents from Aljohar et al. (2018) 22-40.7%, 27-44.3% and Not more than 5% respectively. Maltose content of honey recorded from White and Landis (1980) was 2.74-15.98%. Nutritional profile of honey samples taken from various Apis species is stated in Table 2. The moisture contents of honey taken from natural honey of *A. dorsata* and *A. florea* were 7.88% and 10.18% respectively while that of moisture contents of farmed honey recorded from *A. mellifera* was 12.19%. But same content of Apis species honey taken from Qamer et al. (2008), Al-Ghamdi et al. (2019) and Attri (2011) was 20.5-26%, 13.70 ± 0.79%, 18.50 ± 1.53% and 28.8% respectively. Similarly, ash and protein contents of *A. dorsata* and *A. florea* honey (natural sources) were 1.15%, 2.25%, 5.54% and 6.66%. Whereas ash and protein contents of *A. mellifera* honey (farmed source) were 0.37% and 5.22%. Also ash contents recorded from Krishnasree and Ukkuru (2017), Al-Ghamdi et al. (2019) and Attri (2011) was 1.20%,

Table 2. Nutritional profile of honey of various *Apis* species.

Parameters	*A. Dorsata* (Natural Sample)	*A. Florea* (Natural Sample)	*A. mellifera* (Farmed Sample)
Moister	7.88%	10.18%	12.19%
Ash	1.15%	1.15%	0.37%
Protein	5.54%	6.66%	5.22%
Fat	0.34%	0.73%	0.14%
Dietary Fiber	2.00%	3.51%	1.99%
Carbohydrates	57.37%	53.26%	62.26%
Glucose	24%	21%	27%
Fructose	31%	26%	34%
Sucrose	1.7%	1%	2.5%
Maltose	9%	7%	12%

1.16 ± 0.13%, 0.26 ± 0.15% and 0.22% but protein contents of honey noted from Krishnasree and Ukkuru (2018) was 0.22 g 63/100 g, 0.21 g/100 g, 0.22 g/100 g and 0.21 g/100 g. In the same way, fat, dietary fiber and carbohydrates contents of *A. dorsata* and *A. florea* honey were 0.34%, 0.73%, 2.00%, 3.51%, 57.37% and 53.26% but fat, dietary fiber and carbohydrates contents of honey taken from *A. mellifera* honey were 0.14%, 1.99% and 62.26%. Whereas fat content of honey extracted from Ghosh et al. (2016) was 6.91% and Carbohydrates contents of *A. dorsata*, *A. florea*, *A. mellifera* and *A. cerana* honey recorded from Krishnasree and Ukkuru (2018) was 81.12 g/100 g, 81.75 g/100 g, 85.75 39 g/100 g and 80.25 g/100 g respectively. Also glucose and fructose contents of *A. dorsata* and *A. florea* honey documented were 24%, 21%, 31% and 26%. Although, the same contents extracted from *A. mellifera* honey were 27% and 34%. Also, sucrose and maltose contents of *A. dorsata* and *A. florea* honey (natural sources) recognized were 1.7%, 1%, 9%, 7% and though sucrose and maltose contents of *A. mellifera* honey (farmed source) were 2.5% and 12%. While glucose, fructose and sucrose contents of various Apis species honey documented from Qamer et al. (2008), Al-Ghamdi et al. (2019) and Joshi et al. (2000) were 19.61-27.51%, 36.38 ± 2.91%, 35.24 ± 1.06%, 4.54 g/100 g, 36.93-44.61%, 33.82 ± 3.16%, 33.70 ± 1.09%, 1.62 g/100 g, 12.07-20.38%, 2.90 ± 1.85%, 7.32 ± 4.13% and 1.7 g/100 g. But maltose contents of honey taken from Bobis et al. (2017) and Joshi et al. (2000) were 0.50 ± 0.002%, 0.69 ± 0.013% and 0.86 g/100 g.

5. Conclusion and Recommendations

Glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Glucose and fructose contents of honey taken out from honeybee farm were 27% and 34% but natural source were 22.50 ± 2.12% and 28.50 ± 3.54%. Similarly, sucrose and maltose contents of farmed honey were 2.5% and 12% while in natural honey were 1.35 ± 0.49% and 8.00 ± 1.41% respectively. The present study indicates that such as moisture, carbohydrates, sucrose and maltose contents were higher farmed honey as compared to the natural honey. In our recommendation natural honey is better than farmed honey.

References

AL-GHAMDI, A., MOHAMMED, S.E.A., ANSARI, M.J. and ADGABA, N., 2019. Comparison of physicochemical properties and effects of heating regimes on stored *Apis mellifera* and *Apis florea* honey. *Saudi Journal of Biological Sciences*, vol. 26, no. 4, pp. 845-848. http://dx.doi.org/10.1016/j.sjbs.2017.06.002. PMid:31049012.

ALJOHAR, H.I., MAHER, H.M., ALBAQAMI, J., AL-MEHAIZIE, M., ORFALI, R., ORFALI, R. and ALRUBIA, S., 2018. Physical and chemical screening of honey samples available in the Saudi market: an important aspect in the authentication process and quality assessment. *Saudi Pharmaceutical Journal*, vol. 26, no. 7, pp. 932-942. http://dx.doi.org/10.1016/j.jsps.2018.04.013. PMid:30416348.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS – AOAC, 2005. *Official methods of analysis of AOAC International*. 18th ed. Gaithersberg: AOAC International.

ATTRI, P.K., 2011. Physico-chemical investigation of honey samples of *Apis cerana incica* F. (Traditional Beekeeping) and *Apis mellifera* (Morden Apiculture) from Chamba District, Himachal Pradesh. *Biological Forum*, vol. 3, no. 1, pp. 67-73.

BALL, D.W, 2007. The chemical composition of honey. *Journal of Chemical Education*, vol. 84, no. 10, pp. 1647. http://dx.doi.org/10.1021/ed084p1647.

BERETTA, G., CANEVA, E. and FACINO, R.M., 2007. Kynurenic acid in honey from arboreal plants: MS and NMR evidence. *Planta Medica*, vol. 73, no. 15, pp. 1592-1595. http://dx.doi.org/10.1055/s-2007-993740. PMid:17999354.

BOBIS, O., DEZMIREAN, D.S., MARGHITAS, L.A., BONTA, V., MARGAOAN, R., PASCA, C., URCAN, A. and BANDHARI, P.S., 2017. Bee bread from *Apis mellifera* and *Apis dorsata*: comparative chemical composition and bioactivity. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies*, vol. 74, no. 1, pp. 43-50. http://dx.doi.org/10.15835/buasvmcn-asb:12620.

BOGDANOV, S., JURENDIC, T., SIEBER, R. and GALLMANN, P., 2008. Honey for nutrition and health: a review. *Journal of the American College of Nutrition*, vol. 27, no. 6, pp. 677-689. http://dx.doi.org/10.1080/07315724.2008.10719745. PMid:19155427.

BUBA, F., GIDADO, A. and SHUGABA, A., 2013. Analysis of biochemical composition of honey samples from North-East Nigeria. *Analytical Biochemistry*, vol. 2, no. 3, pp. 139-145.

CHARRONDIERE, U.R., CHEVASSUS-AGNES, S., MARRONI, S. and BURLINGAME, B., 2004. Impact of different macronutrient definitions and energy conversion factors on energy supply estimations. *Journal of Food Composition and Analysis*, vol. 17, no. 3-4, pp. 339-360. http://dx.doi.org/10.1016/j.jfca.2004.03.011.

CHUA, L.S. and ADNAN, N.A., 2014. Biochemical and nutritional components of selected honey samples. *Acta Scientiarum Polonorum. Technologia Alimentaria*, vol. 13, no. 2, pp. 169-179. http://dx.doi.org/10.17306/J.AFS.2014.2.6. PMid:24876312.

COTTE, J.F., CASABIANCA, H., CHARDON, S., LHERITIER, J.L. and GRENIER-LOUSTALOT, M.F., 2004. Chromatographic analysis of sugars applied to the characterisation of monofloral honey. *Analytical and Bioanalytical Chemistry*, vol. 380, no. 4, pp. 698-705. http://dx.doi.org/10.1007/s00216-004-2764-1. PMid:15448965.

CRANE, E., 1983. History of honey. In: E. BYCRANE, ed. *Honey: a comprehensive survey*. London: William Heinemann, pp. 439-488.

DENISOW, B. and DENISOW-PIETRZYK, M., 2016. Biological and therapeutic properties of bee pollen. *Journal of the Science of Food and Agriculture*, vol. 96, no. 13, pp. 4303-4309. http://dx.doi.org/10.1002/jsfa.7729. PMid:27013064.

DEVILLERS, J., MORLOT, M., PHAM-DELEGUE, M.H. and DORE, J.C., 2004. Classification of monofloral honeys based on their quality control data. *Food Chemistry*, vol. 86, no. 2, pp. 305-312. http://dx.doi.org/10.1016/j.foodchem.2003.09.029.

DONKERSLEY, P., RHODES, G., PICKUP, R.W., JONES, K.C., POWER, E.F., WRIGHT, G.A. and WILSON, K., 2017. Nutritional composition of honey bee food stores vary with floral composition. *Oecologia*, vol. 185, no. 4, pp. 749-761. http://dx.doi.org/10.1007/s00442-017-3968-3. PMid:29032464.

EBENEZER, I.O. and OLUGBENGA, M.T., 2010. Pollen characterization of honey samples from North Central Nigeria. *The Journal of Biological Sciences*, vol. 10, no. 1, pp. 43-47. http://dx.doi.org/10.3923/jbs.2010.43.47.

EL SOHAIMY, S.A., MASRY, S.H.D. and SHEHATA, M.G., 2015. Physicochemical characteristics of honey from different origins. *Annals of Agricultural Science*, vol. 60, no. 2, pp. 279-287. http://dx.doi.org/10.1016/j.aoas.2015.10.015.

GHOSH, S., JUNG, C. and MEYER-ROCHOW, V.B., 2016. Nutritional value and chemical composition of larvae, pupae, and adults of worker honey bee, *Apis mellifera* ligustica as a sustainable food source. *Journal of Asia-Pacific Entomology*, vol. 19, no. 2, pp. 487-495. http://dx.doi.org/10.1016/j.aspen.2016.03.008.

IBE, A.E., ONUOHA, G.N., ADEYEMI, A.A., MADUKWE, D.K. and UDOBI, J.O., 2013. Quantitative analyses of honey samples from four different sources in abia state, Nigeria. *International Journal of Natural and Applied Sciences*, vol. 9, no. 2, pp. 107-116.

JAMES, O.O., MESUBI, M.A., USMAN, L.A., YEYE, S.O., AJANAKU, K.O., OGUNNIRAN, K.O., AJANI, O.O. and SIYANBOLA, T.O., 2009. Physical characterization of some honey samples from North-Central Nigeria. *International Journal of Physical Sciences*, vol. 4, no. 9, pp. 464-470.

JOSHI, S.R., PECHHACKER, H., WILLAM, A. and VON DER OHE, W., 2000. Physico-chemical characteristics of *A. dorsata, A. cerana* and *A. mellifera* honey from Chitwan district, central Nepal. *Apidologie*, vol. 31, no. 3, pp. 367-375. http://dx.doi.org/10.1051/apido:2000128.

KERKVLIET, E., 1996. Screening method for the determination of peroxide accumulation in honey and relation with HMF content. *Journal of Apicultural Research*, vol. 35, no. 3-4, pp. 110-117. http://dx.doi.org/10.1080/00218839.1996.11100920.

KRISHNASREE, V. and UKKURU, P.M., 2017. Quality analysis of bee honeys. *International Journal of Current Microbiology and Applied Sciences*, vol. 6, no. 2, pp. 626-636. http://dx.doi.org/10.20546/ijcmas.2017.602.071.

KRISHNASREE, V. and UKKURU, P.M., 2018. Nutrient and antioxidant profile of bee honey from Kerala. *Indian Journal of Entomology*, vol. 80, no. 3, pp. 879-884. http://dx.doi.org/10.5958/0974-8172.2018.00134.7.

MENDES, E., BROJO-PROENCA, E., FERREIRA, I.M. and FERREIRA, M.A., 1998. Quality evaluation of Portuguese honey. *Carbohydrate Polymers*, vol. 37, no. 3, pp. 219-223. http://dx.doi.org/10.1016/S0144-8617(98)00063-0.

MICHENER, C.D., 2007. *The bees of the World*. Baltimore: Johns Hopkins University Press.

MORSE, R.A. and CALDERON, N.W., 2000. The value of honeybees as pollinators of US crops. *Bee Culture*, vol. 128, no. 3, pp. 1-15.

MUHAMMAD, A., ODUNOLA, O.A., IBRAHIM, M.A., SALLAU, A.B., ERUKAINURE, O.L., AIMOLA, I.A. and MALAMI, I., 2016. Potential biological activity of acacia honey. *Frontiers in Bioscience*, vol. 8, no. 2, pp. 351-357. http://dx.doi.org/10.2741/e771. PMid:26709666.

OMAFUVBE, B.O. and AKANBI, O.O., 2009. Microbiological and physico-chemical properties of some commercial Nigerian honey. *African Journal of Microbiological Research*, vol. 3, no. 12, pp. 891-896.

PARTAP, U., 2011. The pollination role of honeybees. In: H. R. HEPBURN and S. E. RADLOFF, eds. *Honeybees of Asia*. Berlin: Springer, pp. 227-255.

QAMER, S., AHMAD, F., LATIF, F., ALI, S.S. and SHAKOORI, A.R., 2008. Physicochemical analysis of *Apis dorsata* honey from Terai Forests, Nepal. *Pakistan Journal of Zoology*, vol. 40, no. 1, pp. 53-58.

SALIM, H., ZERROUK, I., BIAGIO, G., ELENA, N., GABRIELE, F. and LARBI, A., 2011. Quality evaluation of some honey from the central region of Algeria. *Jordan Journal of Biological Sciences*, vol. 4, no. 4, pp. 243-248.

TOLA, N., HAILE, G., MEKONNEN, N. and FURGASSA, W., 2017. Review on medicinal and nutritional value of bee's honey: senior seminar on animal health. *Biomedicine and Nursing*, vol. 3, no. 1, pp. 58-67.

WAGHCHOURE-CAMPHOR, E.S. and MARTIN, S.J., 2008. Bee keeping in Pakistan: a bright future in a troubled land. *American Bee Journal*, vol. 14, no. 8, pp. 726-728.

WHITE, J.W. and LANDIS, W., 1980. *Honey composition and properties*. Washington: Agricultural Research Service, United States Department of Agriculture, pp. 82-91.