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DETERMINATION OF HONEY QUALITY IN RELATION TO ITS PHYSICOCHEMICAL PROPERTIES – A BIBLIOGRAPHIC REVIEW

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ABSTRACT

Honey quality is one of the aspects associated with the productive chain of honey that has little been researched in the beekeeping industry in Colombia. Herein, a bibliographic review is displayed in order to determine in what way the physicochemical characteristics of honey are used to establish its quality for human consumption. It has been found that acidity parameters, ph, Hidroximetilfurfural (HMF), ashes, electrical conductivity, sugars, humidity, among others are the characteristics used in the setting of honey quality. The method of bibliographic review was used. Using such a method, more than 150 articles published in indexed journals were initially collected. From those 150, 60 were selected by means of such criteria as geographical provenance, the effect of no more than 7 years, and topic relevance in research fields. Some possible non- traditional applications of honey are stated at the end of the paper.

Keywords: Acidity parameters, electrical conductivity, glucose, honey quality, metals, phenol.

INTRODUCTION

The following paper mainly presents the outcome of bibliographic review carried out in the research "Expert system for determining the quality of honey in bees based on physical-chemical properties, applied in honeys traded in Santander State (Colombia)" funded by UNAD university. Such review is intended to recognize research works related to the honey quality in the context associated to the honey trade that, according to Feás, Pires, Iglesias, & Estevinho (2010), can be determined from the compositions of physical-chemical data of the product. Such data should be available for the authorities, distributors and consumers.

The research prospective agenda in the agro industrial productive chain of the bees and apiculture in Colombia states that the mega-tendency of natural, environmentally-sustainable foods is worldwide accepted, which locates the apiculture products and services on a growing market dynamic Laverde, Egea, Rodríguez, & Peña (2010). According to the Institute of business promotion (IFE for its Spanish acronym), the international demand increases but the production of some countries decreases, either for diseases or lack of resources, Haberle & Zarratea (2014). In Colombia, such tendency is maintained; that means that there is a lack of

stimuli in internal consumption as, according to Sánchez, Castañeda, Muños, & Tellez (2013) the offer of quality honey according to the international standards is guaranteed.

A first approximation to the study of honey quality is focused in assessing the difference in botanic origin, the classification by floral and geographic origin, in both uni-flower and multi-flower honeys, by means of the physical-chemical and biochemical characterization to identify the discriminant parameters using the multivariate methods, among others, Resende, et al, (2014); Corbella & Cozzolino (2006); Kus, Jerkovic, & Giov, (2014); Cimpoiu, Hosu, & Miclaus (2013); Nikolova, Tsankova, & Evtimov (2016); Domínguez, Gonçalves, Di Nezio, Ugulino, & Centurión (2014); Scandurra, Tripodi, & Verzera (2013) and Yang, et al (2012).

Another approach that authors such as Zakaria, et al (2011); Feás, Pires, Iglesias, & Estevinho (2010); Yücel & Sultanoğlu (2013); Serrano, Villarejoa, Espejo, & Jodral (2004); Özbalci, Hakkı, Topcu, Kadılar, & Tamer (2013) and Lakhanpal & Vaidya, (2015) have used to determine the quality of honey is based in the quantification of the total and reducer sugar content, particularly in monosaccharides and disaccharides, among which sucrose, glucose, fructose, maltose as well as other sugar-related substances as diastase and invertase activity and glucose oxidase can be found.

Literature Review and Methodology

The method of bibliographic review, using as conceptual referents the ones stated by authors such as Barbosa, Barbosa, & Rodríguez (2013); Molina (2005); Jiménez (2007) and Rojas, (2007). There are no rules about the optimal number of bibliographic references that must be included in a review of the state of art, according to López (2006).

The research paper selection for their analysis was carried out taking the system Scopus as reference, considering the following selection criteria:

- Publishing dates: 2010 and after, without leaving classical texts behind.
- That the current paper presents an experience related to the analysis of honey quality.
- Only full-version papers available are to be selected.
- The paper looks into on the determination of the honey quality and/or the use of technologies of Information (TI) in the process.
- Used keywords: Sistemas Expertos, Expert Systems, Quality, Honey, Físico-Químico, Organoléptica, Physical-Chemical, Organoleptic, Calidad de la Miel.

The recovered references are organized by date of publishing in order to develop a process of selection and later by importance. With each reference that met the selection criteria, the next step was to look for the full version of the paper in data bases such as Academic Search Complete (EbscoHost), Journal Storage, Compendex, Elsevier Directory of Open Access Journals and Internet. In case such paper was not found, the reference was excluded. The selected papers were completely reviewed and were summed up in their most relevant aspects by registering such aspects in an analysis matrix that contains the following: Search words, Data base, Keywords. Reference, Types of honey, research problem or question. Material and methods, Parameter of analysis, used statistical analysis, Used Software or technology and conclusions.

The method of determining the mineral content was used by Terrab, Recamales, Hernanz, & Heredia (2004); Conti, et al (2014); Moniruzzaman, Zaman, Rahman, Sulaiman, & Gan (2014); Grembecka & Szefer (2013) and Sarker, et al (2015) in order to establish the quality of honey and bee products by means of the use of multivariate techniques among others. In such studies, the determination of the level of heavy metals such as cadmium (Cd), chrome (Cr), lead (Pb), cooper (Cu), iron (Fe), zinc (Zn) and manganese (Mn), by means of the plasma spectrophotometry by inductive coupling and atomic absorption spectrophotometry. Other related physical-chemical parameters such as pH, acidity (free, lactonic and total), ashes and electric conductivity.

Honey characterization is a very important issue in food industry and of very high interest for the consumers. This approach was undertaken by researchers such as Cruz, et al (2014); Moniruzzaman, Sulaiman, Khalil, & Gan (2013); Saxena, Gautam, & Sharma (2010; Dardón & Enríquez (2008); Montenegro, et al (2003); Zamora & Aria (2011) and Shafieea, Minaeia, Moghaddam, Ghasemi, & Barzegar (2013) which focused on determining its anti-inflammatory, anti-bacterial, anti-oxidant and biochemical properties. Such studies were mainly focused on determining the use of honey, taking into account its therapeutic properties, its nutritional value and taste. Thus, honey can be used to replace other sweeteners. Authors also state that, facing the growing appearance of antibiotic-resistant bacterial strains, honey arises as an appropriate alternative to conduct treatments on ulcers, burns and wounds, due to its protective effect against the oxidative stress.

One of the most frequently found analysis in literature is based on the analysis of the most common physical-chemical parameters such as humidity, electric conductivity, free acidity, carbohydrates, HMF, color, optic rotation and pH, Popek (2002); Bettar, et al (2015); Lazarevic´, Andric´, Trifkovic´, Tešic´, & Milojkovic´(2012); Soria, Gonzalez, de Lorenzo, Martınez Castro, & Sanz (2004); Missio, Gauche, Gonzaga, Oliveira, & Fett (2016); Finola, Lasagno, & Mariol (2007) and Moguel, Echazarreta, & Mora (2005), for which the Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) and the Stepwise Discriminant Analysis (SDA) are used. Such models allow to assess the existence of data patterns and allow to find relationships between physical-chemical parameters and the botanic origin of honey. Likewise, this type of analysis permits to describe the chemical characteristics of the components present in honey, its stability when heated or stored during long periods of time, and the identity and quality parameters. The results obtained with this kind of analysis are contrasted, among others, to the requirements of physical-chemical quality established by the European Commission of Honey (CEM for its Spanish acronym).
Finally, it was found that some authors such as Anupama, Bhat, & Sapna (2003); Durrani, Verma, & Srivastava (2011); Ulloa, Mondragón, Rodríguez, Reséndiz, & Rosas (2010) and Avilés & Matos (2009) use the sensory analysis for the indexes generation in honey quality, that can be carried out by means quantitative descriptive analysis, and by means of the evaluation of sensory panels according to the hedonic scale.

RESULTS

Methods of determining honey quality: In general terms, in order to determine the quality of honey, according to Missio, Gauche, Gonzaga, Oliveira, & Fett (2016) the sensory and physical-chemical properties have to be had mind, establishing the color and minimal or maximal quantity related to the maturity, purity and deterioration of honeys. Regarding maturity, the sugar content, the HMF content, acidity, the diastatic activity and humidity is assessed. In order to determine the purity, the content of ashes, the electric conductivity and

water-insoluble solids are then analyzed. The content of humidity is one of the most important characteristics that influences in the physical properties of honey, (such as viscosity and crystallization) and other parameters such as color, taste, specific gravity, solubility and conservation.

Tests to determine the quantity of ashes allow to estimate the mineral content present in the honey that can be an indication that environmental contamination happens. On the other hand, the electrical conductivity of honey is related to the ashes content and acidity. Such facts reveal the presence of ions, organic acids and proteins. Both the color, taste and geographic origin depend on the type of soil in which flowers grow, from which the nectar is collected. A dark color in honey can develop during the storage and can also be related with the temperature of storage and honey composition.

Another method used to estimate the quality of honey is the sensory analysis. Researches as Avilés & Matos (2009; Anupama, Bhat, & Sapna (2003) and Terrab, Recamales, Hernanz, & Heredia (2004) propose the usage of trained staff for sensorial assessment, which perform such assessment according to hedonic scales of 9 points, among others.

Mechanisms and/or devices: Starting from the review, some mechanisms for determining the quality of honey were found. Among such mechanisms the use of a technique of sensor fusion, the e-nose and e-tongue have allowed to establish, for the honey, its floral origin, the sugar content and the recognition of tainted samples (Zakaria, et al, 2011). Another device that has been identified is the Machine vision, that along with the e-tongue and e-nose provide an innovative and robust means for the characterization of honey (Shafieea, Minaeia, Moghaddam, Ghasemi, & Barzegar, 2013). A contribution, from Artificial Intelligence, is the use of the neural networks, as proposed in Nikolova, Tsankova, & Evtimov (2016) that is based on grouping allow an improvement in the prediction of the floral origin of honey.
Other mechanisms, more in the conceptual order, correspond for instance to the Raman spectroscopy (Özbalci, Hakkı, Topcu, Kadılar, & Tamer, 2013), that, combined to other multivariate methods, can be adopted successfully to determine quantitatively the content of glucose, fructose, sucrose and maltose in samples of honey with no treatment or chromatic methods. The viability of using the impedance spectroscopy as a quick method for determining the floral origin of different honeys is proposed by Scandurra, Tripodi, & Verzera (2013). Finally, the most used scheme is the evaluation of physical-chemical profile that, along chemometrics, represent a method to assess the origin of honey. (Fechner, Moresi, Ruiz, Pellerano, & Vázquez, 2016).

Physical-chemical parameters: The most used parameters when comes to qualify any given honey are the following: determination of conductivity, the acidity, the ashes content, the sucrose content, and the content of reducer sugars (Popek, 2002); other parameters such as electric conductivity, the pH and the HMF were, according to Corbella & Cozzolino (2006) the ones that best predict the floral origin of the honey samples. The electric conductivity, along with the basic physical –chemical parameters, can be used as fast and reliable tools to estimate the botanic origin of the honeys (Serrano, Villarejoa, Espejo, & Jodral, 2004).
Another important fact is the physical-chemical and biologically-active properties of honey can be affected by the flora and geographical variations (Can, et al, 2015) and according to Cimpoiu, Hosu, & Miclaus (2013) the determined parameters can provide enough information for the classification and distinction of the botanic source of honeys. Although the physical-chemical parameters researched reflect the chemical composition of the honey in

its whole, if researched isolated, they do not contain enough information to define the geographic origin of honey (Lazarevic´, Andric´, Trifkovic´, Tešic´, & Milojkovic´ Opsenica, 2012). It was also possible to find that in almost all kinds of honey, fructose is predominant, being glucose the second sugar in importance (Finola, Lasagno, & Mariol, 2007).

DISCUSSION

Alternative uses of honey: It was possible to find from the review that there are certain uses of the honey that go beyond its mere usage as sweetener, energy source and food. This is due to the fact that honey is rich in minerals such as Mg, K, Ca, Zn, Cu, Fe y Mn. Also, its contribution constitutes in important source for human diet, growth and health, Moniruzzaman, Sulaiman, Khalil, & Gan (2013); Grembecka & Szefer (2013) and Sarker, et al (2015).

Added to its traditional use, honey can be utilized as alternative supplement in disease therapy because of its inhibitory effect on the growth of several microorganisms, which means that honey might be traded as an alternative treatment for infections healing (Lakhanpal & Vaidya, 2015). Another potential use is stablished by Zamora & Arias (2011), as the contents of phenols, flavonoids, ascorbic and proline in honey may be used as a therapeutic method as those contents have the capacity of eliminating free radicals (Moniruzzaman, Sulaiman, Khalil, & Gan, 2013). That effect was observed in treatment of diseases such as Parkinson and diabetes (Cruz, and others, 2014), where it seems that this antioxidant activity has its effect due to the contents of proline and phenol (Saxena, Gautam, & Sharma, 2010). Finally, the treatment of diverse affections such as respiratory, dermatologic and gastrointestinal have been reported by Dardón & Enríquez (2008).
In the ecological field, the study of Conti, et al (2014), confirms that the honey can be used as bio monitor of the environmental contamination, although it may not be reliable for places with low contamination levels.

New areas of research: Some knowledge gaps that were identified and that may constitute in research opportunities are: the assessment in the use of therapeutic properties for the management of chronic diseases associated to stress (Cruz, et al, 2014); the study of the stability of chemical component present in honey during the storage from the dynamic of crystallization and its dependence of the content of water and temperature (Missio, Gauche, Gonzaga, Oliveira, & Fett, 2016) and (Venir, Spaziani, & Maltini, 2010); chemical transformations produced in the process of honey harvesting and during the conservation of honey inside the beehives (Yang, et al, 2012); the classification of honeys of diverse botanic origin serving its mineral content (Fernández , et al, 2005); the establishment of therapeutic properties (antioxidant y antimicrobial) of honeys (Ouchemoukh, Louaileche, & Schweitzer, 2007) and the normalization of fabrication and storage procedures (Kahraman, Kemal, Vural, & Sandikci, 2010).

CONCLUSIONS

It can be found that the different categories of honey quality obey to diverse factors such as seasons, packaging conditions, processing, floral source, geographical origin and storage period. Similarly, it was possible to state that the dielectric properties are directly related to the water and ash contents: the acidity is the one that indicates the honey´s degree of freshness as being related to the fermentation by microorganisms.

The machine vision can also provide a proper approach to the characterization of floral origin of honey, as well as the prediction of some chemical parameters. This fast and economic approach does not require any sample preparation or addition of reagents. The machine vision, along with the e-tongue and e-nose can provide a robust novel technological means for the characterization of the honey.

Raman´s spectroscopy, along with the multi-variable methods, can be adopted successfully to determine quantitatively the content of glucose, fructose, sucrose and maltose in samples of honey with no treatment or chromatographic methods. Almost every type of honey contains fructose, being glucose the second main sugar. Furthermore, it can be concluded that multivariable techniques are efficient tools for the quality and authenticity assessment of food.

To the honey, quality is a multifactorial parameter linked to the botanic and geographic origin that has an effect on its commercial value and it is very relevant when it comes to determine the register of origin denomination.

Both electric conductivity as pH and HMF are the chemical parameters that are used the most in order to predict the floral origin of honey samples. Also, it can be found that it is viable to use the impedance spectroscopy as a quick method for determining floral origin of honey. Such fact can provide enough information for the classification and distinction of the botanic source of honeys. Moreover, these properties, along with other tests, can be used for detecting tainted honey.

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