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Pollen quality and sensory attributes of Algerian jujube (*Ziziphus lotus* (L.) Lam.) honeys

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Pollen quality and sensory attributes of Algerian jujube (*Ziziphus lotus* (L.) Lam.) honeys

Abstract: Honey bees and beekeeping activity are of huge importance for the crop production and biodiversity conservation as well as for the economic impact due to ecosystem services. In the south of Algeria, the jujube blooming is an essential forage source for honey bees. The aim of this study was to determine the melissopalynological and sensory characteristics of Algerian jujube honey. Nineteen samples of jujube honey collected in south Algeria over the period from 2016 to 2018 were analyzed. The unifloral designation attributed to the honey was confirmed by a pollen analysis following the established standard methods. Sensory analysis is carried out testing the color, the odor and aromas. The results showed that *Ziziphus lotus* pollen was predominant in all samples, and in terms of sensory analysis, color ranged from amber yellow to light brown; the determined scent classes were warm, floral and woody with medium intensity; the aroma was represented by medium intensity with the warm caramelized, floral fruity and woody classes. Sweet flavor is perceived at medium intensity, acidic flavor is weak, astringent sensation is average and the piquant note is perceived with a low intensity. This work proves to be important for improving the knowledge in typical honeys.

Key words: jujube; *Ziziphus lotus*; honey; melissopalynology; sensory analysis; pollen

Kakovost peloda in senzorične lastnosti medu iz alžirske vrste čičimaka (*Ziziphus lotus* (L.) Lam.)

Izvleček: Medonosne čebele in njihova reja imajo velik pomen za pridelavo gojenih rastlin in ohranjanje biodiverzitete kot tudi velik ekonomski pomen pri ekosistemskih storitvah. Na jugu Alžirije je cvetenje alžirskega čičimaka (žižole) najpomembnejša paša za medonosne čebele. Namen raziskave je bil določiti sestavo in senzorične lastnosti medu, nabranega na tej rastlini. Analiziranih je bilo 19 vzorcev čičimakovega medu, nabranih na jugu Alžirije v obdobju 2016-2018. Pripadnost medu tej medonosni vrsti je bila potrjena s pelodno analizo in in drugimi uveljavljenimi standardnimi metodami. Pri senzorični analizi so bili preiskušeni barva, vonj in aroma. Rezultati so pokazali, da je v vseh vzorcih medu prevladoval pelod te vrste čičimaka. Barva medu je bila od oranžnorumene do svetlorjave, vonj je bil srednje močan, določen kot topel, cvetlični do lesni. Aroma medu je bila srednje močna, po toplih karamelah, cvetno-sadna z odtenki po lesu.Sladkost je bila srednja, kislost šibka, trpkost srednja, pikantnost je bila zaznana kot šibke jakosti. Raziskava je pomembna, ker prispeva k poznavanju tipičnih medov.

Ključne besede: čičimak; *Ziziphus lotus*; med; melisopalinologija; senzorična analiza; pelod

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1 INTRODUCTION

Bees are the primary animal pollinators in most ecosystems (Neff & Simpson, 1993) and honey bees (*Apis mellifera* L., 1758) in particular play a key role as providers of pollination services essential for agricultural productivity and biodiversity conservation (Potts et al., 2003; Klein et al., 2007; Salami et al., 2016; Ferrazzi et al., 2017). An economic study demonstrated that the total economic value of pollination services globally amounts to approximately €153 billion annually (Gallai et al., 2009), corresponding to about 9 % of the total economic value of agricultural crops grown for human consumption. Moreover, beekeeping supplies market beehive products (honey, pollen, royal jelly, propolis and wax) and livestock (artificial swarms, packed bees, queens). Currently, a total of 92.3 million hives have been recorded around the world and the honey production amounts to around 1.8 million tons (Vercelli et al., 2021).

Mediterranean basin represents an important area for beekeeping activity and honey production characterized by typical unifloral and multifloral honeys (Battesti, 1990). However, in Mediterranean areas, climate change is a severe threat to honey bees (Le Conte &Navajas, 2008; IPBES, 2016; Novelli et al., 2021; Vercelli et al., 2021), influencing significantly other strictly related factors such as diseases, parasites, predators, parasitoids, viruses and pesticide use (Goulson et al., 2015; Zawislak et al. 2019).In arid and semi-arid areas of southern Algeria, the jujube (*Ziziphus lotus* L.) blooming is essential forage sources (nectar and pollen) for honey bees usually between May and June as well as other flowering present during the year (Mekious et al.,2015). Due to this important source, it is possible to produce unifloral honey that is highly sought and appreciated by beekeepers and consumers. As Jujube honey is exposed to a lot of fraud, particularly with regard to its unifloral appellation, the identification and characterization of this honey is essential to preserve the quality as well as geographical and botanical origins. Some studies have been targeted the characterization of this unifloral honey but there is an insufficient knowledge about its sensory properties (Song et al., 2012; Zhou et al., 2013; Mekious et al., 2015; Chakir, et al., 2016; Zerrouk et al., 2017; Mekious et al., 2020; Zerrouk et al., 2021).

Melissopalynological and sensory properties are one of the main ways used to identify unifloral and multifloral honeys (Ferrazzi&Medrzycki, 2002; Piana et al., 2004; Ferrazzi& Vercelli, 2014; Prđun et al., 2020). The aim of this study was to determine pollen characteristics and sensory properties in several of honey samples of the same floral origin. The study of the pollen profile is important to verify the unifloral attributed designation and to know the botanical origin of pollen collected by honey bees. This analysis provides valuable information on the foraging activity of honey bee (Battesti, 1992; Floris et al., 2020). When pollen of one species is highly present in a honey, it is very likely that that species gives an important contribution in terms of nectar in the process of elaboration of this honey except for some honeys derived from plants that do not provide much pollen (pollen under-represented, e.g. lavender honeys) or from plants that produce much more pollen than nectar (pollen over-represented, e.g. eucalyptus honey) (Louveaux et al., 1978; Von Der Ohe et al., 2004).

Furthermore, sensory properties describe the general physical characteristics of honey perceptible by our senses. Taste and aroma vary and depend on the plant origin. Usually, sensory evaluation is commonly used to complete physico-chemical and pollen analyses. It is used to confirm quality, to verify the absence of defects, to establish sensory profiles of unifloral honeys, and also to understand consumer preferences (Piana et al., 2004; Marcazzan, 2018). Organoleptic qualities are also considered as markers of floral origin (Amiot et al., 1989). In the absence of sensory standards specific to jujube honey, this study was based on the evaluation of the intensity of organoleptic attributes in 19 honey samples of the same floral origin in order to define the majority aromatic notes.

2 MATERIALS AND METHODS

2.1 STUDY AREA AND HONEY COLLECTION

During the years 2016-2018, in the regions of Djelfa (34° 40′ 0″ N, 3° 15′ 0″ E) and Laghouat (33° 48′ 23″ N, 2° 52′ 56″ E) located in the south of Algeria, characterized by a hot and dry climate with pastoral vegetation well adapted to pedoclimatic conditions of these regions. According to the information collected by the professional climatological stations of the national metrological office of Djelfa and Laghouat, in the years of our study, the maximum average temperature reached 33.82 °C in Djelfa and 41.09 °C in Laghouat Regarding the precipitation, 275 mmyear^{-1} and163 mmyear^{-1}were registered in Djelfa and in Laghouat, respectively.19 unifloral declared as *Z. lotus* honey samples were collected from hives belonging to professional beekeepers and placed in jujube blossom area.

2.2 QUALITATIVE MELISSOPALYNOLOGICAL ANALYSIS

In order to complete a qualitative melissopalynological analysis, the extraction and analysis of the pollen spectra were carried out using methods established by the International Commission of Apicultural Botany, described by Louveaux et al. (1978), Ferrazzi (1992) and Von der Ohe et al. (2004). Ten grams of honey was dissolved in 20 ml of distilled hot water (20-40 °C). The solution was centrifuged once for 10 min (30,000 rpm), and then another centrifugation was done for 5 min under the same conditions.

The sediment was put on a slide with an area of 24× 24 mm. 500 pollen grains were counted and their relative frequency classes were determined according to the international melissopalynological nomenclature: predominant pollen for pollen occurring for more than 45 % of the total pollen count, accompanying pollen or secondary pollen (16-45 %), important minor pollen (3-15 %) and minor pollen, occurring < 3 %.

The identification of pollen types was carried out by comparing the morphology and dimensions of the pollen grains present in our samples observed under a light microscope with those of microphotographs of reference pollens established by Ricciardelli d'Albore (1998), by our database (Laboratory of aromatic and medicinal plants, University of Blida1) and other pollen atlas. The pollen type includes species and/or genera present in the area, which have the same or similar pollen morphology microscopically.

2.3 SENSORY ANALYSIS

The sensory analysis, visual, olfactory, and gustatory characteristics was performed using the technique described by Piana et al. (2004). The samples were tested by a panel of three assessors from the CARI (Center for Beekeeping Research and Information) trained to identify a sensory stimulus on the basis of odor and aroma wheel developed by CARI laboratory (Bruneau et al., 2000).

The wheel synthesizes a common lexicon of reference and defines a list of descriptors with a precise meaning and the same meaning for all, and on the other hand to approve standardized aromatic references corresponding to each descriptor. Assessors recorded the color using the Pfund method. The intensity of odor and aroma is carried by a system of quantified evaluation on a scale of 1 to 3. 1: low intensity, 2: medium intensity, 3: high intensity.

3 RESULTS AND DISCUSSION

3.1 QUALITATIVE MELISSOPALYNOLOGICAL ANALYSIS

The unifloral declaration attributed to the honey samples was confirmed by a qualitative pollen analysis. The types of pollen present in honey samples divided into four classes of pollen frequencies are illustrated in Table 1.

The pollen grains of nectarless species from the families such as Poaceae, Chenopodiaceae, Pinaceae, Cistaceae, Plantaginaceae and Oleaceae were calculated separately (Louveaux et al., 1978 and Von Der Ohe et al., 2004). The taxa *Ziziphuslotus, Thapsia garganica, Centaurea, Carduus, Euphorbia bupleuroides, Retama retam and Peganum harmala* have a large distribution (>50 %) in the honey samples. Usually, these pollens are markers of the floristic environment, having a high pollen frequency

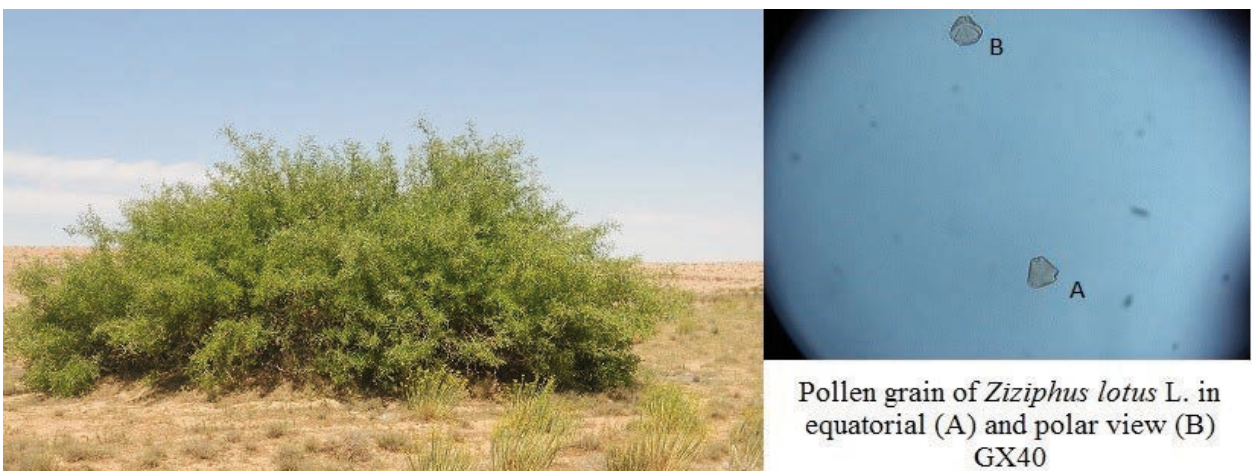

Figure1: The jujube tree in the steppe region of Djelfa and the pollen grain of *Ziziphus lotus* (photo credit: Scherazad Mekious)

Table1: Frequency of distribution of taxa and their frequency classes in honey samples

Family	Taxon (Pollen type)	F (%)	M (<3 %)	I (3-15 %)	S (16-45 %)	P (>45 %)	Max
Anacardiaceae	*Pistacia lentiscus* L.*	10.53	10.53	-	-	-	1.1
Apiaceae	*Thapsia garganica* L.	89.47	42.11	36.84	10.53	-	17.3
Apiaceae A	*Daucus carota* L.	36.84	36.84	-	-	-	7.6
Arecaceae	Arecaceae	21.05	21.05	-	-	-	1.6
Asteraceae	*Echinops*	47.37	47.37	-	-	-	2.5
	Centaurea	68.42	52.63	15.79	-	-	6.1
	Carthamus	10.53	10.53	-	-	-	1.1
Asteraceae S	*Carduus*	57.89	31.58	26.32	-	-	15.2
	Calendula	42.11	42.11	-	-	-	2.7
	Scolymus	15.79	15.79	-	-	-	1.2
Asteraceae T	*Taraxacum*	26.32	26.32	-	-	-	1.2
Boraginaceae	*Echium*	15.79	15.79	-	-	-	2.7
Brassicaceae	*Sinapis* form	21.05	21.05	-	-	-	1.7
Brassicaceae	*Brassica* form	21.05	21.05	-	-	-	1.2
Caprifoliaceae	Caprifoliaceae	31.58	31.58	-	-	-	1.1
Chenopodiaceae	Chenopodiaceae*	15.79	15.79	-	-	-	2.8
Cistaceae	*Cistus**	21.05	21.05	-	-	-	1.4
Ericaceae	*Erica*	10.53	10.53	-	-	-	1.2
Euphorbiaceae	*Euphorbia bupleuroides* (Desf.) Soják,	57.89	42.11	-	15.79	-	23.7
Fabaceae	*Acacia*	10.53	10.53	-	-	-	1.7
	Vicia	21.05	21.05	-	-	-	1.1
	Medicago	10.53	10.53	-	-	-	2.5
	Ononis	31.58	31.58	-	-	-	1.7
	Retama retam (Forssk.) Webb & Berthel.	42.11	31.58	5.26	5.26	-	19.2
Fagaceae	*Quercus**	10.53	10.53	-	-	-	1.1
Lamiaceae	*Thymus*	26.32	26.32	-	-	-	1.7
Liliaceae	*Asphodelus microcarpus* Parl.	10.53	10.53	-	-	-	1.2
Malvaceae	*Malva*	15.79	15.79	-	-	-	2.7
Myrtaceae	*Eucalyptus*	10.53	10.53	-	-	-	1.7
Oleaceae	*Olea**	21.05	21.05	-	-	-	1.4
Papaveraceae	*Papaver rhoeas* L.*	10.53	10.53	-	-	-	2.2
Pinaceae	Pinaceae*	5.26	5.26	-	-	-	1.1
Plantaginaceae	Plantaginaceae*	15.79	15.79	-	-	-	5.2
Poaceae	Poaceae*	31.58	31.58	-	-	-	6.3

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Ranunculaceae	Ranunculaceae	26.32	26.32	-	-	-	1.7
Resedaceae	*Reseda*	10.53	10.53	-	-	-	1.2
Rhamnaceae	*Ziziphus lotus* (L.) Lam.	100.00	-	-	-	100	97.1
Rosaceae	Rosaceae	15.79	15.79	-	-	-	1.2
Tamaricaceae	*Tamarix*	36.84	36.84	-	-	-	7.2
Nitrariaceae	*Peganum harmala* L.	68.42	31.58	26.32	10.53	-	27.6

*: nectarless species. F: Frequency of distribution of taxa in honey samples, M: Minor pollen (< 3 %), I: important minor pollen (3-15 %), A: Secondary pollen (16-45 %), P: Predominant (> 45 %), Max: maximum recorded of pollen frequency

in relation to the widespread distribution in the region (Battesti, 1990). Qualitative pollen analysis highlighted the dominance of *Z. lotus* (Figure 1) in honey samples as predominant with a maximum frequency of 97.1 %. The determination of botanical origin was based on the relative frequencies of the pollen types of nectariferous species. In general, a honey is considered unifloral when the relative pollen frequency of onetaxon exceeds 45 % (Von Der Ohe et al., 2004). *Z. lotus* constitutes an abundant source of nectar frequently collected by honey bees justifying the unifloral designation "Jujube honey" attributed by beekeepers. Jujube is a species also visited for the pollen harvest. Moreover, we noted the secondary presence of pollens from *Thapsia garganica, Euphorbia bupleuroides, Retama retam* and *Peganum harmala*, important sources of nectar and pollen, with respective maximum levels of 17.3 %, 23.7 %, 19.2 % and 27.6 % (Table 1).

3.2 SENSORY ANALYSIS

Regarding visual analysis, slight variations in color, ranging from 61 to 99 mm Pfund, were observed, which corresponds to a color range from amber yellow to light brown. Studies reported that the color interval of Algerian honeys ranged from 18 to 119 mm Pfund corresponding to a color range varying from very light to dark brown. The very light honey samples are dominated by *Citrus* and *Hedysarum* while dark brown honeys are characterized by predominance of*Eucalyptus*, Apiaceae as *Daucus* and *Rubus* (Ouchemoukhet al., 2007; Benaziza et al., 2010).

The profile of the aromas and flavors perceived in the 19 honey samples analyzed were shown in Table 2. The odor classes determined by the tasters were warm, floral and woody, with medium intensity. In terms of the perception of aromas, the general intensity is medium, and the aromatic classes perceived were warm caramelized, floral fruity and woody. The perception of chemical aroma was found only in two samples with low intensity. The sweet flavor was perceived with medium to high intensity.

Z. lotus honey samples are characterized by higher fructose contents than glucose, and pH values between 5.17-5.8 for jujube honey from North Africa (Mekious et al., 2015; Chakir et al., 2016; Zerrouket al., 2017), and an average value of pH equal to 6.71 for jujube honey from China (Zhou et al., 2013). In all samples, the acidic flavor was weak, and the astringent sensation was medium.

The piquant note was perceived in all the samples, but with a lower rate in 84.21 % of honey samples and

Table 2: Sensory characteristics of *Ziziphus lotus* honey samples

Sensory characteristics		
Olfactory assessment	Intensity: medium	Description: warm, floral, woody
	Intensity: low	Description: chemical
Tasting assessment	Intensity	Medium
	Sweetness	Medium to high
	Acidity	Low
Aroma	Intensity: medium	Description: warm caramelised, floral-fruity, woody
	Persistence	Medium
Other sensations	Intensity: low to medium	Description: astringent, piquant
	Crystallization	Absent

with medium rate in the rest of the samples. Pollen analysis of these samples showed the presence of *Euphorbia bupleuroides* pollen, either as an accompaniment with a maximum pollen frequency of 23.7 % or in rare, isolated cases at <3 %(Table 1). The nectar of this species gives a piquant note to honey; this is confirmed by the reference system for unifloral honeys established by the laboratory specifying that the honey samples were obtained from nectars of the Euphorbiaceae family species. Some notes are linked to the flora foraged by bees without exogenous contamination (Guyot-Declerck, 2001).

The unifloral honey samples derived mainly from a single plant species (at least 45 % of pollen grain), may considerably differ in their sensory properties with highly prominent flavor and aroma (Lippolis, 2020).In all honey samples crystallization was absent.

4 CONCLUSION

This study describes the melissopalynological and sensory characteristics of honey from the same floral origin "*Ziziphus lotus*" produced in arid and semi-arid areas in Algeria. Overall, all the honey samples were characterized by the predominance of *Z. lotus* pollen. This type of honey has slight variations in color, ranging from amber yellow to light brown. The perceived odor and aromatic classes were warm caramelized, floral fruity and spicy woody, with medium intensity. Sweet flavor, astringent sensation, acid flavor and spicy notes were also perceived in the honey samples. This work proves to be important for improving the knowledge in typical Algerian honeys and in particular in Jujube honey. In this context, the protection and the promotion of regional honeys will be ensured effectively when the various physicochemical, pollen and aromatic components can be described quite precisely. The definition of floral and regional appellations should be supported, and they are necessary for any quality approach to honey. It is therefore necessary to define a set of pollen and sensory physicochemical standards characteristic of unifloral honey. The acquisition of new data regarding melissopalynological and sensory analysis of honey allows the protection and the promotion of specific regional honeys. In this context, more studies based on the characterization of *Z. lotus* L. are needed to provide a normative framework and to determine future specific standards composition for this type of honey.

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