



Original article

Macro- and trace elements content in honeybee pollen loads in relation to the harvest season

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ABSTRACT

The content of macro-and trace elements in honeybee pollen loads collected from the Al-Ahsa oasis, Saudi Arabia during spring, summer, autumn, and winter in 2018/2019 were determined. After critical screening and observation, we found that the major pollen floral resources were rapeseed, sunflower, summer squash, and date palm. The highest values of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P) and manganese (Mn) were found in pollen loads trapped during spring and winter. The highest levels of copper (Cu) and iron (Fe) were found from pollen loads harvested during autumn, while the highest content of zinc (Zn) was found in pollen loads collected during the summer. Higher concentrations of the essential elements (Na, K, Ca, Mg and P) for human nutrition found in pollen loads collected during the spring and winter seasons, make them valuable food supplements. Finally, the elements contained in pollen loads can be related to the season of pollen load collection.

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1. Introduction

The elements content of collected bee-pollen from Saudi Arabia ranges from 1.88% to 3.88% (Taha, 2015b). The elements content in bee-pollens are affected by several factors; but the botanical origin is the most important (Taha, 2015b; Liolios et al., 2019). Additionally, the geographical origin was recorded as an important factor affected the content of elements (Morgano et al., 2012; Kostić et al., 2015; Taha et al., 2017; ALTunatmaz et al., 2017; Aldgini et al., 2019; Liolios et al., 2019). Other factors, such as collecting season (Harmanescu et al., 2007; Taha and Al-Kahtani, 2019), and the storing of pollen loads (Human and Nicolson, 2006) affected the concentration of the elements.

Tayar and Cibik (2011), and Demirci (2014) reported the daily requirements of the individual elements (mg) in human nutrition

as; P (800–1200), K (800), Ca (800–900), Mg (300–400), Zn (6–22), Fe (10–20), Mn (4–5), and Cu (1–3). The content (mg/kg) of elements in Saudi bee-pollens are reported (Taha, 2015b) Na (6345–8350), K (6232–8258), Ca (2086–5752), Mg (2353–4680), P (234–468), Fe (338–562), Mn (16–38), Zn (31–44), and Cu (4–7).

Bee-pollens have been involved in many supplementary food-stuffs (Degrandi-Hoffman et al., 2010; Li et al., 2012; Farag and El-Rayes, 2016; Haščík et al., 2017; Zeedan et al., 2017; Mortensen et al., 2019). Therefore, we investigated the relationship between the harvest season and the content of the essential elements [sodium (Na), calcium (Ca), phosphorus (P), potassium (K), zinc (Zn), Iron (Fe), magnesium (Mg), copper (Cu) and manganese (Mn)] for human nutrition in bee-pollen, and then we can determine the optimal season for harvesting bee-pollen.

2. Materials and methods

2.1. Sampling of the pollen loads

The pollen loads were collected from five divergent apiaries in the Al-Ahsa oasis (25°25'46"N, 49°37'19"E; 121 m above sea level) eastern of Saudi Arabia. Five colonies of 7 combs of hybrid Carniolan honeybees were equalized to be in the same strength for pollen trapping in each apiary. Pollen traps of 25% efficient at removing pollen loads from workers' corbicula were fitted on the colonies' entrances. Pollen traps were harvested twice a week from 21

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March in 2018 until 20 March in 2019. The collected pollen loads were classified according to the time of collection into four seasons: spring, summer, autumn, and winter. The tested samples were collected at the peaks of gathering pollen in each season.

2.2. Elements extraction and analysis

One-gram sample of pollen loads was digested with nitric acid (AOAC, 2000). The concentrations of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) were determined by using an atomic absorption spectrophotometer (GBC Avanta E, Ser. No. A5616). The UV-VIS spectrophotometer (UV-2550 Shimadzu, Ser. No. A108447) was used for the detection of phosphorus (P).

2.3. Statistical analysis

Data were analyzed by one-way ANOVA and Pearson correlation coefficients between the tested elements were determined using the SAS® software computer program (SAS, 2003). Treatments' means were compared by Duncan's Multiple Range Test (Duncan, 1955).

Table 1
Major pollen plants in the Al-Ahsa oasis during 2018/2019.

Botanical origins			Blooming period
Common name	Scientific name	Family	
Rape	<i>Brassica napus</i> L.	Brassicaceae	January-March
Summer squash	<i>Cucurbita pepo</i> Thunb	Cucurbitaceae	January-October
Date palm	<i>Phoenix dactylifera</i> L.	Arecaceae	February-March
Sunflower	<i>Helianthus annuus</i> L.	Asteraceae	February-September
Alfalfa	<i>Medicago sativa</i> L.	Fabaceae	May-June

Table 2
Macro- and trace elements content (mg/kg DM) in pollen loads in relation to the collecting season.

Mineral (mg/kg)	Season				Sig.
	Spring	Summer	Autumn	Winter	
Na	8350.27 ± 3.70 ^a	6769.63 ± 3.36 ^c	6553.55 ± 3.06 ^d	7778.44 ± 3.14 ^b	**
K	8258.52 ± 4.03 ^a	6662.25 ± 2.26 ^c	6342.20 ± 3.52 ^d	7693.23 ± 2.10 ^b	**
Ca	5752.25 ± 3.70 ^a	5252.19 ± 1.53 ^c	2454.44 ± 2.64 ^d	5298.66 ± 3.83 ^b	**
Mg	3917.52 ± 3.04 ^a	2704.62 ± 2.94 ^c	2493.45 ± 4.61 ^d	3862.33 ± 1.30 ^b	**
P	459.82 ± 2.92 ^a	345.06 ± 1.52 ^c	235.67 ± 2.69 ^d	354.66 ± 3.02 ^b	**
Fe	441.79 ± 2.52 ^c	463.34 ± 2.70 ^b	473.54 ± 2.54 ^a	392.50 ± 2.06 ^d	**
Zn	38.61 ± 0.37 ^b	44.10 ± 1.02 ^a	32.80 ± 0.32 ^c	36.27 ± 0.14 ^b	**
Mn	44.18 ± 0.41 ^a	22.76 ± 0.52 ^c	17.36 ± 0.18 ^d	27.32 ± 0.12 ^b	**
Cu	5.77 ± 0.04 ^c	6.37 ± 0.01 ^b	6.80 ± 0.12 ^a	6.29 ± 0.03 ^b	**

Values are the mean ± S.D. Means of each row followed by a different letter are significantly different.

** Indicate p < 0.01.

Table 3
Pearson correlation coefficients for elements in bee-pollens harvested during different seasons.

	Na	K	Ca	Mg	P	Fe	Zn	Mn
Na								
K	0.99**							
Ca	0.72**	0.75**						
Mg	0.97**	0.97**	0.73**					
P	0.88**	0.90**	0.90**	0.80**				
Fe	-0.61**	-0.62**	-0.57**	-0.78**	-0.39			
Zn	0.04	0.08	0.68*	-0.01	0.47*	0.05		
Mn	0.92**	0.93**	0.72**	0.92**	0.95**	-0.30	0.21	
Cu	-0.90**	-0.90**	-0.85**	-0.81**	-0.98**	0.39	-0.39	-0.95**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

3. Results

The major pollen floral resources in Al-Ahsa oasis were rape-seed (*Brassica napus* L.), sunflower (*Helianthus annuus* L.), summer squash (*Cucurbita pepo* Thunb), alfalfa (*Medicago sativa* L.), and date palm (*Phoenix dactylifera* L.). These five major pollen resources bloomed during spring. Except for alfalfa, all the major pollen resources bloomed during winter (Table 1).

The amount of elements contained in pollen loads significantly ($P < 0.01$) influenced by the collecting season. The highest amount (mg/kg) of Na (8350.27), K (8258.52), Ca (5752.25), Mg (3917.52), P (459.82) and Mn (44.18) were obtained from pollen loads trapped during spring (Table 2). The largest amount (mg/kg) of Fe (473.54) and Cu (6.80) were gotten from pollen loads trapping during autumn. Pollen loads trapping during the summer season showed the highest value of Zn (44.18 mg/kg).

The data shown in Table 3 indicate that sodium was significantly ($P < 0.01$) positively correlated with K ($r = 0.99$), Mg ($r = 0.97$), Mn ($r = 0.92$), P ($r = 0.88$) and Ca ($r = 0.72$), while it was significantly ($P < 0.01$) negatively correlated with Fe ($r = -0.61$) and Cu ($r = -0.90$). Similarly, K was significantly ($P < 0.01$) positively correlated with Mg ($r = 0.97$), P ($r = 0.90$), Mn ($r = 0.90$) and Ca ($r = 0.75$), but significantly ($P < 0.01$) negatively correlated with Fe ($r = -0.62$), and Cu ($r = -0.90$). Additionally, Ca was significantly ($P < 0.01$) positively correlated with P ($r = 0.90$), Mg ($r = 0.73$), Mn ($r = 0.72$) and Zn ($r = 0.68$), while it was significantly ($P < 0.01$) negatively correlated with Fe ($r = -0.57$), and Cu ($r = -0.85$).

4. Discussion

About 70 pollen floral resources bloomed during spring in Al-Ahsa oasis (Taha, 2015a); here all of the major pollen resources (sunflower, rapeseed, summer squash alfalfa, and date palm)

bloomed during spring. Summer squash, alfalfa, and sunflower bloomed throughout the summer season. Sunflower and summer squash bloomed during autumn. Meanwhile, rapeseed, sunflower, summer squash and date palm, bloomed during the winter season. Similarly, Taha (2015a,b) and Taha et al. (2019) reported these botanical origin as the major floral resources during these periods in Al-Ahsa oasis.

The mean contents (mg/kg) of Na (6553.55–8350.27), K (6342.20–8258.52), Ca (2454.44–5752.25), Mg (2493.45–3917.52), P (235.67–459.82), Fe (392.50–473.54), Zn (32.80–44.10), Mn (17.36–44.18), and Cu (5.77–6.80) in pollen loads significantly ($P < 0.01$) depended on the collecting season. Similarly, Negrão and Oorsi (2018) found a significant correlation between harvest season and the nutritional components of bee-pollen. Our ranges are relatively similar to the ranges of Taha (2015b) for most elements of Saudi bee-pollens, the ranges of K, Zn, Cu and Mn of Romanian pollen loads (Stanciu et al., 2012), and the ranges of Taha et al. (2017) for Fe, Zn, Mn, and Cu of Saudi bee-pollen. Meanwhile, the ranges of Na, Ca, Mg, and Fe were higher than the ranges of pollen loads from Brazil (Morgano et al., 2012). The environmental conditions, plant growth conditions and subspecies of honeybees collected the pollens were the same, so the seasonal variation of elements mainly depended on the botanical origin (Taha, 2015b; Spulber et al., 2018).

The concentrations of Na, K, Ca, Mg, and P in pollen loads could be arranged as follow: spring > winter > summer > autumn. The high contents of these elements in pollen loads trapped during the spring were related to the high amount of pollen collected from alfalfa and date palm which characterized by high contents of these elements (Taha, 2015b). Contrastingly, pollen loads harvested during autumn were characterized by insufficient content of Na, K, Ca, Mg and P. It located at the bottom of the range of the four seasons; this due to the large amounts of pollen collected from summer squash and sunflower, which have characterized by lower contents of these elements (Taha, 2015b). This may explain the variations of the elements contained in pollen loads harvested during the different seasons.

The amount of elements content in the examined pollen loads showed an abundance of Na (30.62, 30.39, 35.22 and 30.68% of the total elements quantified), K (30.29, 29.92, 34.08 and 30.35%), Ca (21.09, 23.59, 13.19 and 20.51%) and Mg (14.37, 12.15, 13.40 and 15.24%) for pollen loads collected during spring, summer, autumn, and winter, respectively. Taha (2015b) recorded relatively similar values. Potassium, Ca and P were the most abundant elements in bee-pollen collected from Spain (Serra Bonvehi and Escolà Jordà, 1997), K and Ca in Romanian pollen loads (Stanciu et al., 2012), K, Ca and P in Brazilian pollen loads (Carpes et al., 2009). The differences in the amounts of the major elements among bee-pollens from different regions might be correlated to the environmental conditions included irrigation water and soil in which the plants were grown. The irrigation of the crops in the Al-Ahsa oasis depends on groundwater of high EC with Na and Ca cations (Al-Zarah, 2008). Besides, Hussain and Sadiq (1991) arranged the most abundant cations in water samples of the Al-Ahsa oasis in a descending order: Na > Ca > Mg > K.

Copper contributed by 0.02, 0.03, 0.04 and 0.03% of the total estimated elements in pollen loads, during spring, summer, autumn, and winter, respectively. Relatively similar concentrations were recorded for pollen loads from Romania (Harmanescu et al., 2007), and Saudi Arabia (Taha, 2015b; Taha et al., 2017).

Pollen loads collected during the spring and winter were characterized by high concentrations of Na, K, Ca, Mg, and P, which are considered essential elements for the nutrition of honeybees and humans.

5. Conclusion

The concentration of elements in pollen loads was depended on the harvest season. Pollen loads collected during the spring and winter were characterized by high contents of Na, Ca, Mg, K, and P. We recommend collecting pollen loads during spring and winter for feeding honeybee colonies during the dearth periods. Also, it can be supplemented as healthy nutritive food for human nutrition.

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