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Review paper

Honeybee pollen as a bioindicator of contamination: an overview

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ABSTRACT

Honeybees and honeybee products (honey, bee wax, bee pollen and bee bread) are potential bioindicators of contaminants (pesticides, mycotoxins, pyrrolizidine alkaloids, toxic elements, radionuclides etc.) in the environment. In this study, recent results on the food safety risks of bee pollen and data about the concentration of toxic substances detected in bee pollen are summarized. Based on different studies, a risk assessment was conducted for the most common pesticide active substances (chlorpyrifos, fluvalinate, carbendazim, thiacloprid), heavy metals (arsenic, cadmium, mercury, lead) and common mycotoxins (aflatoxin-B1, ochratoxin-A, fumonisins, zearalenone, deoxynivalenol, T-2 toxin).

1. Introduction

Bee pollen contains essential nutrients. According to *Campos et al*., (2008), carbohydrates (13–55%), proteins (10–40%), lipids (1–13%) and fibre (0.3–20%) all contribute to the composition of bee pollen. In addition, bee pollens are rich in biologically active micronutrients like minerals, polyphenols and vitamins. Based on a report by *Habryka et al*., (2016), the product is used in apitherapy mainly for its antioxidant, anti-inflammatory, antibiotic and antiallergic effects. Bee pollen improves blood supply to the nerve tissue, thereby increasing mental performance and eliminating the state of fatigue. Research works have also shown a positive effect of bee pollen on some diseases of the liver, heart and prostate. The main consumers of bee pollen are the followers of health- and environmentally-conscious lifestyles, as well as the elderly, who use it due to its antioxidant and other therapeutic effects (*Végh et al*., 2021).

Besides all of these positive effects and high biological and nutritive value, bee pollen can contain hazardous trace elements, pesticide residues (*Ambrus et al*., 2020; *Bostan et al*., 2019; *Toselli and Sgolastra*, 2020), toxic metals and metalloids (*Spirić et al*., 2019; *Ćirić et al*., 2021; *Murashova et al*., 2020; *Roman*, 2009), moulds and mycotoxins (*Alarcón et al*., 2019), pyrrolizidine alkaloids (*Botías et al*., 2015), allergens (*Pitsios et al*., 2006; *Nonotte-Varly*, 2016) and GM (genetically modified) foods (*Malone*, 2002). To ensure the safety and quality of bee pollen, some counties issued national legislations, decisions and guidelines which correlate with European and International standards. In Serbia for instance, honeybee

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Table 1. Pesticide residue contents of bee pollen from different studies

Pesticide Concentration Mean value	Active ingredients	Country of origin	Reference
30 µg/kg 61 µg/kg 16 µg/kg	Tebuconazole Thiacloprid Chlorpyrifos	Poland	*Roszko et al*. (2016)
470 µg/kg 79 µg/kg	Thiacloprid Prothioconazol-desthio	Germany	*Böhme et al*. (2018)
133 µg/kg 40 µg/kg	Thiacloprid Permethrin-cis	Luxembourg	*Beyer et al*. (2018)
24 µg/kg 7 µg/kg	Carbendazim Amitraz II	France	*Lambert et al*. (2013)
915 µg/kg 128 µg/kg 83 µg/kg	Fluvalinate Chlorpyrifos Carbaryl	Taiwan	*Nai et al*. (2017)
6 µg/kg 28 µg/kg 227 µg/kg 50 µg/kg 3 µg/kg	Coumaphos Carbaryl Phosmet Carbendazim Atrazine	USA	*Stoner and Eitzer* (2013)
1 µg/kg 3 µg/kg <1 µg/kg	Azoxystrobin Carbendazim Carbaryl	Uruguay	*Niell et al*. (2015)

products must meet legal criteria (*Republic of Serbia*, 2015). Maximum Residue Level (MRL) values for honey vary between 0.01 and 1 mg/kg, but for other honeybee products, no MRLs are applicable until individual products have been identified and listed (*EU Pesticides Database*, 2021). The website of the International Honey Commission (IHC) is often quoted in scientific research in which maximum limits have been proposed for Pb (500 µg/kg), Cd (30 µg/kg) and Hg (10 µg/kg) in honey. Applying the data of Table 1, risk assessments for pesticide residues in bee pollen were performed in different studies. The results indicate that a major pesticide is thiacloprid.

Table 2 summarizes the literature data on the concentration of toxicologically important elements (As, Cd, Hg, Pb) in bee pollen. The mean values for Cd concentration of bee pollen samples exceeded 30 µg/kg in most studies, except in Brazil (*de Oliveira et al*., 2017). In some bee pollens from Europe, the Pb concentrations exceeded the 200 µg/kg limit (*Lambert et al*. 2012; *Adaškevičiūtė et al*., 2019).

Table 2. Toxic metal contamination of bee pollen from different studies

Mean concentration of toxic elements (µg/kg)					
Lead (Pb)	Arsenic (As)	Mercury (Hg)	Cadmium (Cd)	Country of origin	Reference
112	/	/	30	Italy	*Conti and Botré* (2001)
237	/	/	/	France	*Lambert et al*. (2012)
247	/	/	88	Europe	*Adaškevičiūtė et al*. (2019)
20	/	/	20	Chile	*Mejías et al*. (2018)
148	169	/	2	Brazil	*de Oliveira et al*. (2017)

Table 3. Mould contamination of bee pollen from different studies

Isolated mould	Country of origin	Reference
Alternaria Aspergillus Fusarium Mucor Penicillium Rhizopus	Serbia	*Kostić et al*. (2017)
Alternaria Aspergillus Cladosporium Penicillium Rhizopus	Ukraine, Slovakia	*Shevtsova et al*. (2014)
Alternaria Aspergillus Cladosporium Fusarium Mucor Paecilomyces Penicillium Rhizopus	Slovakia	*Kačániová et al*. (2011)

Over the past decades, several studies have been conducted in Europe on the mycotoxin content of bee pollen samples. The results of the reviewed studies are presented in Table 3. *Kostić et al*. (2017) reported that the average concentrations of aflatoxin-B1 exceeded the legal limit by more than four times in multifloral pollen samples from Serbia. The same authors isolated different moulds from bee pollen in Serbia: *Alternaria*, *Aspergillus, Fusarium, Mucor, Penicillium* and *Rhizopus*. Also, similar moulds were isolated in a study from Slovakia and Ukraine (*Shevtsova et al*., 2014).

2. Conclusions

Bee pollen is a very popular bee product that is presently not defined in most national regulations. In Europe, many studies have been conducted on this bee product, but little data is available from other continents. According to different studies, bee pollen is characterized by heterogenous food safety risks and could also be used as a potential environmental bioindicator. The common contaminants of bee pollen are pesticides, heavy metals, metalloids and mycotoxins. In this short overview, recent findings on the above-mentioned substances and data on concentrations determined in bee pollen were summarized, from different countries. A number of scientific works on the topic of bee pollen is associated with biomonitoring systems, and bee pollen can indeed be used as an environmental bioindicator, similar to the way other bee products (bee wax, honey and bee bread) are already in use.

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