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Nutritional contribution of pollen from species pollinated by bees (*Apis mellifera* L.) in the Araucanía Region of Chile

Aporte nutricional de polen de especies polinizadas por abejas (*Apis mellifera* L.) en la Región de La Araucanía, Chile

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Abstract

The present paper aims to determine the nutritional contribution of pollen from four cultivated species (*Malus domestica* Borkh., *Eucalyptus globulus* Labill., *Brassica napus* L. ssp*. oleifera* and *Vaccinium corymbosum* L.) pollinated by bees (*Apis mellifera* L.) in Southern Chile. The pollen was collected in helicoidal pollen traps installed in hives in farms located in different parts of the Region, and was subsequently analysed at the Bromatology Laboratory. The results obtained matched the values described in the literature, with ranges of phosphorus between 0.59 and 0.80%, crude protein between 33.27 and 39.04%, ethereal extract between 1.83 and 7.72%, carbohydrates between 19.62 and 39.18% and total polyphenols contents ranging between 2,643.69 and 4,773.28 mg 100 g^{-1}. Thus the species evaluated may be considered sources rich in proteins, carbohydrates and polyphenols; however it is important to determine the composition and concentration of amino acids, sugars and fatty acids present in the pollens.

Keywords
compositional analysis • monofloral • nutrition • pollination

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Resumen

La investigación consistió en determinar el aporte nutricional del polen de cuatro especies cultivadas (*Malus domestica* Borkh., *Eucalyptus globulus* Labill., *Brassica napus* L. ssp. *oleifera* y *Vaccinium corymbosum* L.) polinizadas por abejas (*Apis mellifera* L.) en el Sur Chile. Para la recolección del polen se utilizaron trampas de polen helicoidal instaladas en colmenas de predios ubicados en distintos sectores de la región y luego fue analizado en el Laboratorio de Bromatología. Los resultados obtenidos arrojaron valores descritos por literatura, con rangos de fósforo entre 0,59 y 0,80%, proteína cruda con valores entre 33,27 a 39,04%, extracto etéreo entre 1,83 a 7,72%, carbohidratos con 19,62 a 39,18% y contenidos de polifenoles totales que varían entre 2.643,69 a 4.773,28 mg 100 g^{-1}. Por lo tanto, las especies evaluadas pueden ser consideradas una fuente rica de proteínas, carbohidratos y polifenoles, sin embargo es importante determinar la composición y concentración de aminoácidos, azúcares y ácidos grasos presentes en los pólenes.

Palabras clave
análisis bromatológico • monofloral • nutrición • polinización

Introduction

Pollination services are provided in an agricultural system which is ever more concentrated in monocultures. As a result bees, the main pollinators, are exposed to a less diverse pollen diet and may suffer serious nutritional deficiencies (4), which limits their development. Imbalances in macronutrients, particularly the protein: carbohydrate ratio, may mean that their diet will not cover all their nutritional needs (7, 19), causing damage to their physiology, especially their reproductive physiology (16). For this reason, and in view of the increment in apiculture, it is important to detect the principal pollen resources of a region, with their nutritional value and production levels (3), as it represents an important source of supply as well as contribute to the characterization of honey (Ciappini and Vitelleschi, 2013). If a polyfloral diet is available, its greater diversity will provide the proteins and amino acids, which bees need. This good nutrition will improve the bees' general health and immune response (1), since nutritional quality and diversity dictates their health and increases their tolerance to parasitic infestations (13). Parasite infestations in combination with poor pollen availability have the potencial to reduce bee populations due to health reasons (29). When pollen is abundant, the bees' nutritional requirements are satisfied (7). In this context, we evaluated the nutritional contribution of the pollen of four species cultivated in southern Chile.

Materials and methods

Pollen was collected from four species characteristic of the monofloral plantations, which are frequent users of polli-

nation services in southern Chile. The *M. domestica* pollen was collected from a 92.2 ha apple orchard between 15th and 20 th September (480 g); the *E. globulus* pollen from a 30 ha plantation between 10th and 15th August (380 g); *B. napus* from a farm with a 50 ha oilseed rape plantation between 10 th and 15 th October (750 g); and *V. corymbosum* from a 150 ha blueberry farm between 20 th and 25 th November (450 g).

Four bee colonies were used, placed in the centres of the collection sites, each with a brood chamber and one hive body, and fitted with a helicoidal pollen trap. The pollen was collected daily over a period of maximum 5 days to avoid night-time humidity. Once the samples had been collected, they were packed and transported in a thermal container to the Bromatology Laboratory of the Agronomy School of Universidad Católica de Temuco.

The pollens were separated by colour, analysed by optical microscopy and compared with references to confirm their botanical origin. The laboratory analysis was done using a 100 g sub-sample of the pollen of each species, dried in an oven for 24 h at 30°C. Bromatological analysis was then carried out to determine the contents of: phosphorus (%) using calcination and colorimetry by conversion to phosphomolybdate; crude protein (%) using the Kjeldahl method; ethereal extract (%) using the Goldfish method; carbohydrates (%) by the phenol-sulphuric method, measuring the absorbance at 490 nm wavelength and generating a quantification curve, following the methodology of Nielsen (21); polyphenols (mg Gallic Acid Equivalent (GAE) per 100 g dry base) were determined and extracted following the methodology of Folin Ciocalteau, described by Georgé *et al*. (2005).

Finally, the results were analysed by descriptive statistics and expressed as a mean percentage with standard deviation for six repetitions per species, using Excel 2007.

Results

Table 1 shows the Bromatological analyses obtained from the monofloral pollens of the four species studied.

Table 1. Results of proximate analysis dry base matter.
Tabla 1. Resultados del análisis proximal base material seca.

Species	Phosphorus (%)	Crude protein (%)	Ethereal extract (%)	Carbohydrates (%)	Polyphenols (mg 100 g^{-1})
M. domestica	0.67±0.01	35.55±0.04	1.85±0.21	19.62 ± 1.48	3112.69±289.45
E. globulus	0.59±0.01	33.27±0.57	1.83±0.22	39.18 ± 3.09	4773.28±201.94
B. napus	0.80±0.01	39.04±0.71	2.44±0.15	33.11 ± 4.56	2643.92±438.65
V. corymbosum	0.68±0.01	33.59±1.00	7.72±0.40	31.13 ± 1.64	4116.48±343.54

± Standard Deviation.
± Desviación standard.

The phosphorus and protein contents were the highest in *B. napus* and lowest in *E. globulus*, however all the species analysed presented protein values higher than 25%, with ranges between 33.27% and 39.04%. The highest values for ethereal extract were found in *V. corymbosum* (7.7%) and the lowest in *E. globulus* (1.83%). The carbohydrate content ranged between 19.62% (*M. domestica*) and 39.18% (*E. globulus*), while the values for oilseed rape and blueberry were similar. Finally, the highest polyphenols content was found in *E. globulus* and the lowest in *B. napus*.

Discussion

In general the results obtained fall into the established ranges in the literature. In the case of phosphorus, the values agree with those obtained in Brazil by Carpes *et al*. (2009), who reported values for these species of 0.57% and 0.87% dry base respectively.

However must taken into account that mineral levels in pollen may vary considerably due to differences in the floral origin; furthermore the bioavailability of mineral elements may be affected by soil characteristics (27).

The values obtained in this study for protein content are within the range of 10 to 40 g 100 g^{-1} dry matter base (8, 24). Girard *et al*. (2012) report that pollens of the Brassicaceae are of excellent proteic quality. Although the eucalyptus pollen presented the lowest protein values in this study, it was still higher than the obtain by Almeida-Muradian *et al*. (2005) and Somerville and Nicol (2006), who reported average protein values of 20% and 24.9% dry matter base in eucalyptus species.

This is the minimum acceptable value for correct bee nutrition (24); however eucalyptus is deficient in isoleucine, suggesting that an exclusive diet of this pollen would not be ideal.

Proper protein nutrition is needed to maintain the bees' health and reduce their susceptibility to disease (6). The pollens in this study present crude protein contents higher than 25%, meaning that they are considered to be of high quality (25), however they may be deficient in one or more other chemical components, particularly amino acids.

For this reason bees need to collect a mixture of pollens, which will give them a varied, balanced diet (12). This is the case especially when they are used as pollination agents in agricultural areas where a less diverse pollen diet is available, which does not provide all the nutrients which they require (7); it should be considered that weeds are an important pollen source in agricultural environments (23).

Turning to ethereal extract, the total lipids content in pollens is generally less than 10% dry base (20); thus the result of this study agrees with the literature and with the standards for the physical and chemical composition of pollens (8).

However it should be considered that not only do the lipids contents vary in different pollens, but the diversity and the relative proportions of fatty acids also vary (5).

The carbohydrates content is within the range established by Margaoan *et al*., 2010 (13 and 55 g 100 g^{-1} dry matter base), however, Girard *et al*. (2012) indicate that if the bees remain too long monoculture blueberry may suffer nutritional deficiencies, because it does not produce enough nectar, will therefore seek other food sources nearby to compensate their dietary needs.

Finally the total polyphenols contents found in this study are higher than those reported by Nozková *et al*. (2009) and Morais *et al*. (2011), who obtained values

of 799 mg to 1,550 mg kg^{-1} in *B. napus* subsp. *napus* L. and 1,050 mg to 1,680 mg GAE 100 g^{-1} in pollens from five Portuguese parks. However they are much lower than those reported by Ulusoy and Kolayli (2014) (4,407 and 12,410 mg 100 g^{-1}), indicating that the value depends on the geographical and botanical origin (18).

Balanced nutrition is therefore essential to keep the hives healthy and well-nourished, especially when they are placed in difficult environments or used for pollination (26). In these conditions, nutritional balance may be maintained by plant diversity, even in agricultural areas, since a natural mixture of different pollens is an excellent source of proteins and vitamins for the bees (11).

Conclusions

In general, the monofloral pollens evaluated from the species *M. domestica*, *E. globulus*, *B. napus* ssp. *oleifera* and *V. corymbosum* present values within the normal ranges described in the literature. The species evaluated may be considered rich sources of protein and polyphenols, that could give good to excellent results and protecting the bees against dietary problems; however it is important to determine the composition and concentration of amino acids, carbohydrates and fatty acids present in the pollens.

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