Prospective directions of using flower pollen as a source of food protein

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Abstract. The work studied the nutritional value of five samples of fresh and dried pollen from various species of plants: Rosales, Brassicaceae, Legumes, Asteraceae, Apiaceae. The results of the studies showed that all the studied pollen samples, collected at different periods of pollen-bearing plants flowering, contain a high amount of protein (19.63-21.09%) and practically correspond to the formula of ideal protein. It is more advisable to use pollen mixtures collected in the spring and summer and processed in a certain way, as an alternative source of food protein.

1 Introduction

Being a part of the universe, humans are in continuous search of a source for food protein that could fully satisfy his needs. The beekeeping products are the point of contact between the vegetable and animal worlds with the mind and warmth of human hands. The quality of the products determines their function - to help maintain health through nutritional status.

Therefore, new sources of food ingredients are sought that would make it possible to replenish the missing substances to improve the quality of life of a living organism. Flower pollen, as one of the beekeeping products, is a protein feed for bees and its only source. During its physiological activity, a bee family brings a lot of pollen to the hive. The amount of pollen used by an average family is 45.5 kg per year [1].

It has been established that 0.5 kg of pollen enables the family to raise 4.500 bees. Flower pollen is important in the early spring for the development of a bee family and in the winter, so that the bee family can raise a sufficient number of the winter bees and have resources of bee bread before the first honey plants begin to bloom. Pollen is the only source of proteins for bees.

However, it is important to know what sources of pollen are available near the apiary. Subject to the influence of the biological effect on bees [2], pollen is divided into three groups: the first group includes the pollen of chestnut, grasses, maize, fruit trees, red clover and creeping clover; the dandelion pollen, maize pollen collected by hand, belongs to the second group; the third group includes the pollen of the coniferous trees. Bees raised on the pollen of the first group have normally developed pharyngeal glands and a fat body; their life expectancy is longer than that of bees raised on the pollen of the third group. The pollen of the third group reduces life expectancy, as does syrup [3].

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The criterion for pollen quality is the development of the pharyngeal gland in bees, as well as the content of the essential amino acids in the crude protein of pollen [4]. Since there is no information in the scientific literature on the use of pollen as an alternative source of protein, there are no comparative calculations on the amino acid composition of the pollen proteins, the purpose of this work is to substantiate the use of pollen as a source of food protein.

2 Materials and methods

To determine the nutritional value of pollen, five samples of fresh and dried pollen were taken. A botanical analysis of these samples was carried out. The pollen was collected in 2024 at some private apiaries in the Bryansk region. The botanical analysis showed that pollen in our conditions is not diverse and is mainly collected from orchards and cultivated plants. However, pollen from various plant species (Rosales, Brassicaceae, Legumes, Asteraceae, Apiaceae) gets into the mixture, which creates a variety that allows us to determine the common and different properties of pollen.

Table 1. Characteristics of experimental samples, %.

Botanical type of pollen	**Quantitative content in the sample, %**
Sample 1, spring pollen taken from May 5 to June 6	
caraway	80.6
common winter cress	11.32
dandelion officinalis	2.9
chestnut tree	0.4
willow	0.4
fruit trees	0.4
red clover	0.9
white clover	0.7
lupine	0.7
not defined	0.7
Sample 2, summer pollen taken from 15 to 27 June	
red clover	5
white clover	32
common rapeseed	39
cruciferous	9
meadow chamomile	15
Sample 3, summer pollen, taken on August 8	
red clover	100
Sample 4, spring pollen taken on May 29	
dandelion officinalis	100
Sample 5, spring pollen taken from May 5 to 15	
spring rape	20
fruit trees	60
dandelion officinalis	20

Each sample was divided into two parts: the fresh pollen stored in a refrigerator at -5°C and dried at 40-42°C to 5-8% humidity. The samples were stored in hermetically sealed glass containers.

In each sample, amino acids were determined by acid hydrolysis method at 105°C for 24 hours, followed by the determination on a KLA-3B analyzer. Total nitrogen was determined by the Kjeldahl method [5], protein nitrogen - by the Barnstein method [6]. Crude and true protein were calculated by multiplying total and protein nitrogen by a factor of 6.25.

As a basis for the nutritional value, calculations were made for essential amino acids in crude protein, and the results were compared with literature data on the amino acid requirements in bee feed.

3 Results and Discussion

In the scientific literature, there is a discussion about the quantitative content of amino acids in the crude protein of pollen and whether there are any fundamental differences in this indicator depending on the botanical species. The amount of crude protein in samples where the pollen of winter cress, caraway, and rapeseed predominates differs insignificantly from the content of crude protein in the red clover pollen, but differs significantly from the dandelion pollen. In the fresh dandelion pollen, crude protein is 10.81% less than in the fresh red clover pollen.

According to Orlov B.N. [7], in dried pollen, the amount of crude protein is less by 10%. In the spring honey flow, in which the fruit trees pollen makes up 38%, the amount of crude protein is 20% less compared to the sample where the legumes make up 37%, cruciferous - 48%. Consequently, the amount of nitrogen in the pollen of rapeseed, winter cress, caraway, red and creeping clover, orchard crops is almost the same, and in the dandelion pollen it is half as much. This statement was scientifically based in this work, where amino acids make up 70.7-104.4% of crude protein.

Not all nitrogenous substances are part of amino acids, so the total amount of amino acids is less than 100%. Since amino acids add water during hydrolysis, in some samples the total amount of amino acids is over 100%. In the spring and summer pollen of 2023, in the monofloral pollen of red clover collected in 2024, in the spring pollen of 2024, the following amino acids dominate: lysine, aspartic and glutamic acids. The amount of proline is from 10-19.9%.

This fact is explained by the growing conditions, soils, the number of sunny days, and the level of precipitation during the vegetation period of the studied pollen plants. It is interesting that the dandelion pollen, poor in crude protein and true protein, is dominated by lysine, and aspartic and glutamic acids are twice as less as compared to other samples. According to some researchers, the amount of lysine in this weed plant varies greatly depending on the place of its growth [8]. The mass fraction of leucine is less than lysine, but more than other essential amino acids and remains within the same limits in all samples. Therefore, we conducted the studies of the amino acid profile of pollen protein of various botanical plant species.

As a result of our own studies, the conditional nutritional value of essential amino acids of five pollen samples used in the experiment was calculated. According to the FAO/WHO standard, the conditional amount of threonine is 3, and on this basis, the possible deficiency amount of essential amino acids was calculated. The data are compared with the experimentally established [9] needs of the bee' organism for essential amino acids.

All amino acids were recalculated according to the conditional amount of threonine – 3. Since threonine is partially destroyed during hydrolysis, the results were multiplied by the correction factor of 1.082 [10].

Table 2. Mass fraction of amino acids in crude protein, g/100 g.

Amino acids	Sample No.									
	fresh	**dry**	**fresh**	**dry**	**fresh**	**dry**	**fresh**	**dry**	**fresh**	**dry**
Lys	8.8	7.0	11.8	10.5	10.5	8.8	13.9	13.2	9.4	8.9
His	4.4	4.2	3.3	4.1	2.4	2.1	2.8	2.7	3.0	3.1
Arg	5.3	4.9	6.3	6.5	4.9	5.5	3.7	3.0	6.3	6.8
Asp	9.2	9.0	9.5	10.1	11.2	10.7	6.5	5.7	11.9	11.4
Thr	4.0	3.7	4.0	4.2	3.5	3.2	2.4	1.6	4.2	4.1
Ser	5.9	5.7	5.2	5.3	3.9	3.8	2.7	2.5	6.5	6.6
Glu	10.5	9.4	10.8	11.5	13.6	13.2	7.7	5.3	14.4	14.1
Pro	19.9	17.8	10.0	12.3	16.3	15.2	11.1	10.0	4.4	3.7
Gly	4.6	4.5	4.4	4.8	5.2	5.1	4.6	4.1	6.8	5.1
Ala	5.1	4.9	5.2	5.3	9.1	9.0	10.2	7.9	5.9	5.9
Val	4.5	4.3	5.7	6.2	5.7	5.6	4.3	3.3	2.1	1.8
Ile	3.8	3.6	4.5	4.7	4.1	4.8	3.6	2.7	3.3	3.4
Leu	6.6	6.3	7.3	7.9	8.2	7.3	6.3	4.8	7.1	7.3
Tyr	2.9	2.5	3.2	3.3	2.3	2.5	2.4	1.5	2.9	2.9
Phe	4.1	3.9	4.4	4.8	3.5	3.7	2.9	1.9	4.4	4.2
Total amount of amino acids	99.6	91.7	95.6	101.5	104.4	90.9	85.1	70.7	92.5	89.3
Crude protein	24.82	23.8	24.09	21.33	24.91	25.4	14.1	14.4	22.1	23.2

Essential amino acids methionine and tryptophan were not determined. All the pollen sources correspond to the amount of the listed amino acids necessary for the organism for isoleucine, arginine, histidine, phenylalanine, but isoleucine in the first, second, third and fifth samples, as well as valine in the first and fifth samples are deficient.

Lysine exceeds the needs of bees more than other amino acids. In the fresh and dried dandelion pollen, the excess of lysine is from 6.3 to 8.9 times. The dandelion pollen does not have a deficiency in all essential amino acids, since the true amount of threonine in this sample is low. In the red clover pollen, the deficiency in isoleucine in the fresh sample is .1.2%, in the dried one - 0.1%.

In the mixtures of the spring and summer pollen, the isoleucine balance is most disturbed in the spring pollen of 2024 and amounted to half of the required amount in other samples, the deficiency is 1.3-1.9%. The deficiency of valine in the first sample is insignificant - 0.2-0.3%, in the fifth - 2.5-2.6%. In the studied samples, the deficiency is mainly observed in the spring pollen. Foraging on various sources, bees can maintain a normal balance of essential amino acids and protect the body from premature wear.

Based on the results in Table 3, it can be concluded that the dandelion pollen has an excess of all essential amino acids and the greatest deviations from the norm. Other pollen sources are closer to the experimentally determined norm in terms of the amount of amino acids in crude protein [11]. Feed protein is used more efficiently if its composition is close to the needs of a living organism.

Table 3. Comparison of pollen sources by essential amino acids in crude protein (g/100 g) with the needs of the bee organism (conditional amount of threonine - 3).

Sample No.		Amino acids							
		Thr	**Lys**	**Leu**	**Ile**	**Arg**	**His**	**Val**	**Phe**
1	a)	3.0	7.1	5.41	3.1	4.3	3.6	3.7	3.4
	b)	3.0	6.2	5.5	3.1	4.3	3.7	3.8	3.5
2	a)	3.0	9.6	6.0	3.7	5.1	2.7	4.7	3.6
	b)	3.0	8.1	6.1	3.7	5.1	3.1	4.8	3.7
3	a)	3.0	9.7	7.6	3.8	4.5	2.3	5.3	3.2
	b)	3.0	9.0	7.4	4.9	5.6	4.3	5.7	3.8
4	a)	3.0	18.8	8.4	4.9	5.0	3.8	5.8	3.9
	b)	3.0	26.8	9.7	5.5	6.1	5.5	6.7	3.9
5	a)	3.0	6.9	5.2	2.5	4.7	2.2	1.5	3.2
	b)	3.0	7.0	5.7	2.7	5.4	1.6	1.4	3.4
The amount of amino acids required for bees (1)		3.0	3.0	4.5	5.0	3.0	1.5	4.0	2.5

1 – Data De Groot; a) – fresh; b) – dry.

From the data in Table 4, it is clear that all the pollen sources contain a high amount of protein (19.63-21.09%), except for the dandelion pollen, which has 50% less protein. For comparative purposes, the leucine to isoleucine ratio should be 2:1, lysine to arginine - 1:1. In terms of the leucine to isoleucine ratio, most samples show a slight deficiency, except for the fresh red clover pollen (sample 3a) and the spring pollen with a predominance of cruciferous and fruit (samples 5a and 5b).

Table 4. Protein and amino acid content in different pollen sources.

Sample No.		Amount of true protein	Sum of amino acids		Ratio	
			irreplaceable	replaceable	Leu / Ile	Lys / Arg
1	a)	18.25	41.6	58.1	1.76	1.66
	b)	18.56	37.9	53.7	1.76	1.42
2	a)	21.9	47.3	48.3	1.62	1.87
	b)	19.59	48.9	52.6	1.68	1.62
3	a)	18.63	42.8	60.9	2.0	2.1
	b)	19.63	41.0	59.5	1.60	1.6
4	a)	10.54	39.9	45.2	1.75	3.8
	b)	8.63	33.2	37.5	1.77	4.4
5	a)	20.79	39.8	52.8	2.15	1.50
	b)	21.0	39.6	51.0	2.14	1.31

a) – fresh; b) – dry.

The lysine to arginine ratio in all samples shows a discrepancy, since the amount of lysine in all samples is high (Table 2). A particularly large discrepancy is observed in dandelion pollen (sample 4a and 4b) because the amount of lysine in the crude protein of this sample is especially high (13.2-13.9%), and the amount of arginine is lower than in other pollen sources (3.0-3.7%). The ratio of essential to replaceable amino acids is optimal.

Therefore, the amount of protein and crude protein cannot fully characterize pollen as food for bees. For a more complete characterization, it is necessary to determine the essential amino acids and compare them with the needs of bees for the essential amino acids found in the crude protein of pollen.

4 Conclusion

The results of the studies showed that all the studied pollen samples collected at different periods of pollen plants flowering contained a high amount of protein (19.63-21.09%), which can be used as an alternative source of food protein.

Dandelion pollen is worse than other pollen sources in terms of crude protein, true protein, the ratio of lysine to arginine in crude protein and a large deviation of lysine from the needs of the bee organism.

It is more advisable to use non-monofloral pollen, mixtures of different pollen collected during the flowering period of gardens until the end of flowering, as well as in the summer, when cruciferous and legumes bloom - a good source of food protein.

Mixtures of pollen collected in the spring and summer, processed in a certain way, should be used as a source of food protein. Beekeepers should pay attention to pollen sources located near the apiary.

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