PROTEIN CONTENT AND AMINO ACID COMPOSITION OF BEE-COLLECTED POLLEN FROM SELECTED BOTANICAL ORIGINS

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S u m m a r y

The objective of the study was to investigate the protein and amino acid composition of honeybee-collected pollen from selected botanical origins. The following unifloral pollen samples were selected and analysed: Onagraceae, Caryophyllaceae, *Artemisia*, *Agrimonia*, *Rheum*, *Cornus*, *Fragaria*, *Syringa*, *Ranunculus*, *Majorana* type, *Brassica*, *Sinapis alba*, *Sinapis arvensis*, *Campanula patula*, *Chelidonium maius*, *Polygonum bistorta*.

The concentration of amino acids and crude protein content was dependent on the floral origin of pollen. Pollen from plants belonging to Brassicaceae family (*Brassica*, *Sinapis arvensis*, *Sinapis alba*) and *Chelidonium maius* pollen was characterized by high content of crude protein and amino acid concentration. *Artemisia* and *Polygonum bistorta* pollens were characterised by a low content of these components. The concentration of essential amino acids expressed as percentages of total amount of amino acids was relatively stable and not dependent on the botanical origin of pollen. Pollen belonging to ruderal plants, especially *Sinapis arvensis*, *Sinapis alba* and *Chelidonium maius* is an important source of protein and amino acids for bees and for human purposes.

Keywords: Honeybee-collected pollen, protein, amino acids, botanical origin.

INTRODUCTION

Pollen, either hand-collected or harvested by bees as pollen loads has been a subject of study for many years, not only because of its importance in bee nutrition, but also because it provides a rich source of easily digestible protein and essential amino acids for humans (Naumkin 1984, Čeksterite 1988, 1991; Campos et al. 1997).

Protein content in pollen depends on the plant origin. Many papers have reported these values that vary between a large range from 3.8 to 40.8%, with 25% being the average (Stanley and Linskens 1974; Herbert and Shimanuki 1978; Talpai 1978; Youssef et al. 1978; Vachonina and Bodrova 1979; Solberg and Remedios 1980; Rabie et al. 1983, Syrocka and Zalewski 1985; Zalewski and Kosson 1985; Echigo et al. 1986, Loper and Kohen 1987; Muniategui et al. 1990; Naumkin 1991; Serra Bonvehi et al. 1991; Serra Bonvehi and Escola Jorda 1997; Szczęsna et al. 1995a; Sommerville 1997). Previous studies have also found that the protein content of pollen from the same species may vary depending on ambiental factors (climatic conditions, soil etc.) (Cirnu et al. 1969, Stanley and Linskens 1974, Bosi and Ricciardelli D'Albore 1975). Pollen from insect-pollinated species was also found to be richer in protein compared to that from anemophilous plants (Serra Bonvehi et al. 1986).

Previous studies have shown pollen pro-

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tein to contain from 15 to 19 amino acids, including all essential amino acids. Pollen was found to be particularly rich in glutamic acid, aspartic acid, proline, leucine and lysine (Bosi and Ricciardelli D'Albore 1975; McLellan 1977; Kauffeld 1980; Gilliam et al. 1980; McCaughey et al. 1980, Naumkin 1984; Kim 1986, Čeksteryte 1988; Kim and Son 1991, Szczęsna et al. 1995 b), and also in arginine (Solberg and Remedios 1980), and in serine (Szczęsna et al. 1995 b). The authors found substantial differences in the content of individual amino acids depending on the plant origin. Serine, cysteine and histidine was found to show the most extensive variation (McLellan 1977), as well as valine, leucine, isoleucine and lysine (Somerville 1997). Conversely, Solberg and Remedios (1980) found that the proportion of different amino acids in pollen protein from different plant species remain at a similar level. McCaughey et al. (1980) in their study of pollen from 9 desert plant species showed that the crude protein content of pollen in these species was generally low (7 – 15%). Nonetheless, the pollen contained all amino acids essential to bees. Čeksterite (1991) determined that pollen loads from dandelion, because of its lysine-to-arginine ratio and high lysine content, are the best protein food for bees. She also gave high marks to mixed pollen loads harvested in the spring when the fruit trees were in bloom and in the summer during the flowering period of Brassicaceae and Leguminose.

Some local researchers point to the high beekeeping value of plant species, especially those growing at ruderal sites, providing an important pasture for honeybees and for wild pollinators in suburban areas (Jabłoński et al. 1999, Denisow 2004, Teper 2004). The investigators based their assessment on observations of blooming and insects visitation dynamics (Denisow 2004), palynological analysis of pollen loads collected by those insects (Teper 2004) and palynological analysis of their faeces (Teper 2006). The usefulness of pollen from plants of different origin both for bees and for humans may be assessed based on protein content and amino acid composition of pollen loads collected by bees.

The objective of the present study was to investigate the protein and amino acid composition of honeybee-collected pollen from selected botanical origins.

MATERIAL AND METHODS

The study was carried out at Kon-Kuk University, Animal Resources Research Center, Seoul, Korea. Multifloral bee-collected pollen samples were harvested during two flower production months (June and July) in 1996 – 1997 at apiaries of the Apiculture Division, Institute of Pomology and Floriculture in Pulawy, Poland. Collected samples were hand-sorted by colour and appearance, and the origin of each fraction determined by melissopalynological analysis. All the selected unifloral pollen subsamples were submitted to dry matter, crude protein content and amino acid composition analysis. Subsamples were kept frozen (-21°C) until ready for analysis.

Melissopalynological analysis was carried out in accordance with the International Commission of Bee Botany of International Union of Biological Sciences described by Louveaux et al. (1978).

Dry matter content was analysed by drying at 105°C to a constant weight (Serra Bonvehi and Casanova 1987). Dry matter content was recorded as percentage of the total samples.

The nitrogen content was determined by the conventional Kjeldahl method. Crude protein content was calculated as total N x 5.60 (Rabie et al. 1983).

Amino acid analysis was done on acid hydrolysates of pollen samples by the ion-exchange chromatography technique using an Amino Acid Analyzer (Pharmacia LKB Alpha Plus) (Szczęsna et al. 1995 b). Approximately 1 g of pollen sample was hydrolysed in 25 ml of 6N HCl in a sealed tube at 110°C for 24 h. Before the acidic hydrolysis, the material was treated with performic acid in order to prevent the decomposition of sulphur containing amino acids. Next, the hydrolysates were dried at about 40°C under a vacuum using an EYELA Rotary Vacuum Evaporator. The residue was dissolved in 50 ml of water, filtered through a membrane filter (pore size 0.45 μm) and 100 μl of filtrate was taken for amino acid analysis. The amino acids identification was done by comparing the retention time of the amino acids in the standard and in the tested solution (qualitative analysis). The quantitative analysis was done by comparing the area of the peaks corresponding to those amino acids.

The data concerning the content of protein and amino acids were converted into dry matter. The essential amino acids content was also expressed as the percentage of total concentration of all amino acids in the tested samples.

The nutritive value of protein in bee pollen samples was determined using the chemical measure of protein quality (Chemical Score – CS), also known as the limiting amino acid index and essential amino acids index EAAI (FAO 1973). In the calculations for cysteine, the value of 1 mg/g DM was adopted.

The data of protein and amino acids for analysed pollen origins were compared statistically using one-way ANOVA. The significance of differences between means was measured using Duncan's multiple range test at a significance level of α=0.05.

RESULTS

Based on the results of the melissopalynological analysis, the bee pollen samples were classified under the following families, genus, species or pollen types: Onagraceae, Caryophyllaceae, *Artemisia*, *Agrimonia*, *Rheum*, *Cornus*, *Fragaria*, *Syringa*, *Ranunculus*, *Majorana* type, *Brassica*, *Sinapis alba*, *Sinapis arvensis*, *Campanula patula*, *Chelidonium maius*, *Polygonum bistorta*.

The crude protein content in the examined samples ranged from 13.06% DM for *Artemisia* pollen to 24.54% DM for that of *Sinapis alba*; the mean value was 20.55% DM (Table 1). The pollen belonging to Brassicaceae family (*Brassica*, *Sinapis alba*, *Sinapis arvensis*) and that of *Campanula patula* and *Chelidonium maius* pollen contained the largest concentration of the tested component. A similar high content of crude protein was also found in the pollen of Onagraceae, Caryophyllaceae, *Agrimonia*, *Fragaria*, *Syringa*. Among the pollen varieties with the lowest protein content were that of *Artemisia*, as well as *Polygonum bistorta*, which contained 15.29% DM of this component. The crude protein content in the other pollen types (*Rheum*, *Cornus*, *Ranunculus*, *Majorana* type) was close to the average value and ranged from 17.83 to 19.52% DM.

The total amino acid content of pollen samples ranged from 108.73 mg/g DM for *Artemisia* pollen to 241.17 mg/g DM for *Sinapis alba* pollen, with the mean value of 186.71 mg/g DM. An equally high concentration of total amino acids, as in *Sinapis alba* pollen, was found in that of *Sinapis arvensis*, *Brassica* and *Chelidonum maius* pollen. Only slightly lower content was found for pollen of Onagraceae, Caryophyllaceae and *Syringa*. Among the pollen varieties with the lowest amino acid concentration was pollen of *Artemisia*, *Polygonum bistorta* and *Ranunculus*.

Table 1

Crude protein, total amino acids and essential amino acid composition of pollen from selected botanical origins.

Botanical origin	Number of samples	Crude protein (% DM)	TAA* (mg/g DM)	TAA* (mg/g DM)	EAA** (%)	CS*** (%)	EAAI**** (%)
Onagraceae	6	21.51 b,c	202.17 c	74.98 b,c	37.07 a	61	108
Caryophyllaceae	6	21.02 b,c	198.12 b,c	74.19 b,c	37.46 a	74	109
Artemisia	9	13.06 a	108.73 a	39.96 a	36.79 a	67	96
Agrimonia	7	21.74 b,c	189.48 b	71.60 b,c	37.75 a	78	103
Rheum	8	19.52 b	192.24 b,c	71.70 b,c	37.23 a	85	114
Cornus	6	19.27 b	161,27 b	59.96 a,b	37.18 a	71	98
Fragaria	6	21.61 b,c	184.53 b,c	63,79 b	34.59 a	72	98
Syringa	6	21.54 b,c	200.88 c	72.65 b,c	36.14 a	71	104
Ranunculus	8	17.83 b	140.54 a	51.51 a,b	36.60 a	71	91
Majoranum type	6	18.55 b	174.79 b	63.99 b	36.59 a	81	109
Brassica	9	24.08 c	228.79 c	88.86 c	38.75 a	78	112
Sinapis alba	11	24.54 c	241.17 c	92.34 c	38,31 a	76	114
Sinapis arvensis	12	23,46 c	222.26 c	83.75 c	37.67 a	72	109
Campanula patula	7	23.60 c	187.59 b,c	70.90 b,c	37.75 a	74	94
Chelidonium maius	7	22.24 c	219.32 c	87.66 c	39.89 a	89	121
Polygonum bistorta	9	15.29 a	135.48 a	51.19 a,b	37.77 a	71	105
General means		20.55	186.71	69.94	37.35	74	105
SD		0.70	35.87	14.57	1.17	7	8
Min.		13.06	108.73	39.96	34.59	61	91
Max.		24.54	241.17	92.34	39.89	89	121

* – Total Amino Acids.
** – Essential Amino Acids.
*** – Chemical Score (the limiting amino acid index).
**** – essential amino acids index (calculated for all essential amino acids without histidine and arginine).
a,b – statistically significant differences between the mean values compared in the columns at the significance level α=0.05.

Seventeen amino acids were found in the examined samples, including all the essential amino acids (lysine, isoleucine, leucine, methionine, phenylalanine, valine and threonine), except for tryptophan. This amino acid was decomposed during the acidic hydrolysis of pollen samples. Cysteine was found in the concentration of belove 1 mg/g DM in all the pollen samples.

Glutaminic acid, aspartic acid and proline were found in the highest concentration (Table 2). Aspartic acid content ranged from 12.52 to 30.22 mg/g DM, 22.49 mg/g DM on average; glutaminic acid content ranged from 12.87 to 29.25 mg/g DM, 23.16 mg/g DM on average and proline content – from 11.39 to 28.79 mg/g DM, 21.93 mg/g DM on average. Pollen of *Sinapis alba*, *Sinapis arvensis* and *Chelidonium maius* contained the highest content of aspartic acid, and the pollen of *Brassica*, Oenotheraceae and *Rheum* contained also similar level of this amino acid.

Table 2

Amino acid composition of pollen from selected botanical origins (mg/g DM).

Botanical origin	ASP	THR	SER	GLU	PRO	GLY	ALA	VAL	MET	ILE	LEU	TYR	PHE	HIS	LYS	ARG
Onagraceae	24.85	9.62	10.43	26.43	24.97	9.76	11.47	11.93	2.65	10.23	16.09	5.20	10.24	4.63	14.22	9.45
Caryophyllaceae	21.52	9.53	11.43	22.47	28.79	9.58	10.41	9.81	3.33	8.82	18.80	4.77	9.71	6.16	14.19	8.80
Artemisia	12.52	5.01	6.34	12.87	12.73	5.87	6.80	5.74	1.45	4.77	8.43	2.63	5.03	4.34	9.53	4.68
Agrimonia	23.97	8.81	10.10	22.96	20.16	9.50	11.32	10.11	3.68	8.48	16.42	4.84	9.67	6.07	14.43	8.97
Rheum	26.45	9.81	10.44	24.32	20.05	9.35	11.31	9.74	3.59	7.81	17.57	4.87	9.50	4.44	13.67	9.30
Cornus	19.52	7.31	8.07	19.87	20.48	8.14	9.20	9.24	2.80	7.60	12.40	3.82	7.94	4.81	12.67	7.40
Fragaria	21.87	8.76	10.15	23.81	26.44	9.03	10.99	9.74	3.34	8.04	14.97	4.43	9.16	4.93	13.11	9.08
Syringa	21.83	9.25	10.96	23.24	32.27	9.77	10.61	10.10	3.28	8.67	16.89	4.71	9.63	5.79	14.84	9.07
Ranunculus	16.47	6.85	7.98	16.83	17.25	7.49	8.76	6.90	2.53	6.04	10.93	3.05	7.06	4.33	11.20	6.88
Majoranum type	20.79	8.40	10.20	21.55	20.26	9.10	10.45	8.87	3.16	7.54	14.34	4.45	8.26	5.90	13.43	8.09
Brassica	25.45	12.49	13.27	26.89	28.02	11.47	12.61	10.70	4.30	8.92	21.49	5.87	10.75	5.35	20.23	11.00
Sinapis alba	30.22	11.65	14.20	29.25	26.98	12.76	12.94	11.79	4.16	9.88	22.26	5.62	11.46	5.57	21.14	11.26
Sinapis arvensis	28.30	11.32	13.26	26.33	24.60	12.01	12.76	11.13	3.68	9.52	19.43	5.30	10.59	5.30	18.09	10.64
Campanula patula	23.05	9.11	11.06	24.03	17.26	9.72	11.49	9.45	3.89	7.95	17.05	5.21	9.50	5.72	13.95	9.16
Chelidonium maius	27.01	11.44	11.94	27.90	19.18	10.79	12.54	11.60	4.52	9.72	23.10	5.85	11.08	5.72	16.19	10.72
Polygonum bistorta	16.09	7.24	7.53	21.86	11.39	7.26	8.58	7.16	1.99	6.26	10.18	3.14	6.63	3.15	11.72	5.30
General means	22.49	9.16	10.46	23.16	21.93	9.48	10.77	9.63	3.27	8.14	16.27	4.61	9.14	5.14	14.54	8.74
SD	4.74	1.97	2.18	4.15	5.84	1.77	1.72	1.77	0.83	1.49	4.29	0.99	1.75	0.82	3.09	1.90
Min.	12.52	5.01	6.34	12.87	11.39	5.87	6.80	5.74	1.45	4.77	8.43	2.63	5.03	4.33	9.53	4.68
Max.	30.22	12.50	13.27	29.25	28.79	12.76	12.94	11.90	4.52	10.23	23.10	5.87	11.50	6.16	21.14	11.30

Explanations: ASP – aspartic acid, THR – threonine, SER – serine, GLU – glutamic acid, PRO – proline, GLY – glycine, ALA – alanine, VAL – valine, MET – methionine, ILE – isoleucine, LEU – leucine, TYR – tyrosine, PHE – phenylalanine, HIS – histidine, LYS – lysine, ARG – arginine.

The highest concentration of glutaminic acid was found in pollen of *Sinapis alba* and *Chelidonium maius*, the mean values equalling 29.25 and 27.90 mg/g DM, respectively. Only slightly lower content of this amino acid was found in *Sinapis arvensis*, *Campanula patula*, Onagraceae and *Rheum* pollen. The concentration of proline was found to be the highest in pollen of *Syringa*, followed by pollen of Caryophylaceae and *Brassica*; the mean values being equal to 32.27, 28.79 and 28.02 mg/g DM, respectively. The concentration of this amino acid in the pollen of Onagraceae, *Fragaria*, *Sinapis alba* and *Sinapis arvensis* was only slightly lower. Pollen of *Artemisia* contained the lowest amounts of these three amino acids among the pollen varieties analysed, and that with the lowest proline concentration was also *Polygonum bistorta* pollen. These three above-mentioned amino acids accounted for about 36% of the total amino acids content in the pollen samples.

Leucine and lysine was also found in the samples in relatively high concentrations. Leucine content ranged from 8.43 to 23.10 mg/g DM, 16.27 mg/g DM on average; lysine content ranged from 9.53 to 21.14 mg/g DM, 14.54 mg/g DM on average. Together, these two amino acids accounted for about 17% of the total amino acids content in the pollen samples. Pollen of *Sinapis alba* and *Chelidoniu maius* contained the highest concentraiton of leucine and that of *Sinapis alba* and *Brassica* contained significantly the highest content of lysine. The pollen of *Artemisia* shown the lowest concentration of these amino acids. The concentration of these amino acids in the pollen of *Polygonum bistorta* and *Ranunculus* was also at the low level.

Such amino acids as threonine, serine, glycine, alanine, valine, isoleucine, phenylalanine and arginine accounted for about 40% of the total amino acids content in the pollen samples. Their average concentration ranged from 8.14 mg/g DM (isoleucine) to 10.77 mg/g DM (alanine). Pollen from Brassicaceae family (*Brassica*, *Sinapis alba*, *Sinapis arvensis*) contained the highest content of these amino acids, while that of *Artemisia* contained the lowest. Among the species and the types with the lowest concentration of some of the amino acids from the discussed group (valine, isoleucine, phenylalanine, arginine) there was also *Polygonum bistorta* pollen. However, the content of the discussed amino acids in pollen of *Chelidonium maius*, Onagraceae, Caryophyllaceae was only slightly lower than in the pollen from the Brassicaceae family.

The concentration of methionine, tyrosine and histidine was relatively low – the percentage of the total amino acids accounted to an about 7%. The content of individual amino acids ranged from 1.45 mg/g DM (methionine) to 6.16 mg/g DM (histidine). The highest concentration of methionine and tyrosine were found in pollen of *Brassica*, *Sinapis alba* and *Chelidonium maius*, and that of histidine – in Caryophyllaceae and *Agrimonia*. The concentration of the amino acids in pollen of *Artemisia* and *Polygonum bistorta* was the lowest.

Of all the amino acids tested in this study, the most variable concentrations between the varieties were found for proline, leucine and methionine; the lowest variability was found for alanine and histidine .

The pollen of the Brassicaceae family (*Brassica*, *Sinapis alba*, *Sinapis arvensis*) and that of *Chelidonium maius* contained the highest concentration of essential amino acids – 90 mg/g DM (Table 1). However, the amino acids concentration expressed as the percentage of the total amino acids in the pollen samples (with a mean value of 37%) did not differ significantly between the compared pollen varie-

ties, in which the limiting amino acids were methionine and cysteine.

The chemical score CS (the limiting amino acid index) ranged from 61% for pollen of Onagraceae, to 89% for *Chelidonium maius*; the mean value was 74%. Among the pollen varieties with the highest CS values there was pollen of *Rheum* (CS=85%) and *Majoranum* type (CS=81%), and among those with low values of CS there was the pollen of *Artemisia* (67%). The essential amino acids index EAAI ranged from 91% for *Ranunculus* pollen to 121% for *Helidonium maius* pollen, with 105% on average.

DISCUSSION

The results of studies into protein concentration and amino acids composition in pollen collected by bees from selected plant species confirm the results of earlier reports by foreign (Bosi and Ricciardelli D'Albore 1975; McLellan 1977; Kauffeld 1980; Gilliam et al. 1980; McCaughey et al. 1980, Naumkin 1984; Kim 1986, Čeksteryte 1988; Kim and Son 1991) and by domestic researchers (Szczęsna et al., 1995 b, Szczęsna 2006). The highest concentration was found for aspartic acid, glutaminic acid and proline. Relatively high concentrations were also detected in the case of leucine and lysine. This relationship was shown to be valid for all tested pollen varieties.

Protein content and the concentration of amino acids in pollen of some Brassicaceae plant species (e.g. *Sinapis alba*, *Sinapis arvensis*), which are part of ruderal flora, has not been the subject of detailed studies. The literature contains only individual publications on the issue, but its treatment is far from comprehensive. For example, McLellan (1977) described the amino acid composition of several pollen varieties, with one species from Brassicaceae family and *Ranunculus* species, Čeksterite (1991) assessed the biological value of pollen from Brassicaceae family. The authors highly valued both of the varieties in terms of the components that they studied.

According to the results obtained by Denisow (2004), ruderal plants from Brassicaceae family are very useful to provide honey bees and wild pollinators with pasture. This could be confirmed by the results obtained in this study which show that, compared to other ruderal plants (*Artemisia*, *Polygonum bistorta*), the pollen of *Sinapis alba* and *Sinapis arvensi*, as well as that of *Chelidonium maius*, contained relatively high content of crude protein and amino acids. The concentration of amino acids in the pollen of *Artemisia*, *Polygonum bistorta* was relatively low, yet it contained all essential amino acids, and their percentage in the total amino acid content was similar to that found for all the tested pollen varieties (37%). The chemical score CS for the protein of those two pollen species (*Artemisia*, *Polygonum bistorta*) was close to 70%, whereas the same parameter for pollen of plants from Brassicaceae family (*Sinapis arvensis*, *Sinapis alba*) was higher by 5%. Pollen of *Chelidonium maius* contained protein with the highest nutritive value (CS=90%, EAAI=121%). The pollen of *Rheum* and *Majoranum* type also contained protein of high nutritive value. In the study of Szczęsna (2006) limiting essential amino acid index (CS) and essential amino acids index (EAAI) in pollen samples from Poland, Korea and China reached also high values (CS=80%, EAAI=110%). CS and EAAI values were calculated also by Rogala and Szymaś (2004) for bee pollen and found to be substantially lower (CS=56%, EAAI=75 – 80%).

CONCLUSIONS

1. The concentration of amino acids and crude protein content was dependent on the floral origin of pollen. Pollen from plants belonging to Brassicaceae family (*Brassica*, *Sinapis arvensis*, *Sinapis alba*) and *Chelidonium maius* pollen was characterized by a high content of both crude protein and amino acid concentration. *Artemisia* and *Polygonum bistorta* pollens were characterised by low content of these components.
2. The concentration of essential amino acids expressed as percentage of the total content of amino acids was relatively stable and not dependent on the botanical origin of pollen.
3. Pollen belonging to ruderal plants, especially *Sinapis arvensis*, *Sinapis alba* and *Chelidonium maius* is an important source of protein and amino acids for bees and for human purposes.

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ZAWARTOŚĆ BIAŁKA I SKŁAD AMINOKWASOWY OBNÓŻY PYŁKOWYCH POCHODZĄCYCH Z WYBRANYCH ROŚLIN

Szczęsna T.

S t r e s z c z e n i e

Celem badań było określenie zawartości białka oraz składu aminokwasowego pyłku odmianowego zbieranego przez pszczoły z wybranych gatunków roślin. W badaniach uwzględniono próbki pyłku należące do następujących rodzin, gatunków i typów budowy: Onagraceae, Caryophyllaceae, *Artemisia*, *Agrimonia*, *Rheum*, *Cornus*, *Fragaria*, *Syringa*, *Ranunculus*, *Majorana* typ, *Origanum*, *Brassica*, *Sinapis alba*, *Sinapis arvensis*, *Campanula patula*, *Chelidonium maius*, *Polygonum bistorta*. W próbkach tych wykonano oznaczenia zawartości białka ogółem oraz zawartości aminokwasów, po uprzedniej hydrolizie białka w materiale badawczym, a uzyskane wyniki przeliczono na suchą masę pyłku. Badania aminokwasów przeprowadzono techniką chromatografii jonowymiennej za pomocą Automatycznego Analizatora Aminokwasów (Pharmacia LKB Alpha Plus).

W próbkach pyłku odmianowego oznaczono 17 aminokwasów, w tym wszystkie aminokwasy egzogenne, z wyjątkiem tryptofanu. Aminokwas ten w warunkach hydrolizy kwasowej jakiej poddany był pyłek ulegał rozłożeniu. Cysteinę oznaczono w stężeniu poniżej 1 mg/g s.m. we wszystkich badanych próbkach. W największych ilościach oznaczono kwas glutaminowy, kwas asparaginowy i prolinę, a następnie leucynę i lizynę. Zawartość w/w pięciu aminokwasów stanowiła około 50% ogólnej zawartości aminokwasów w badanym produkcie. Uzyskane wyniki wykazały, że zawartość białka ogólnego oraz skład aminokwasowy zależał od pochodzenia botanicznego pyłku. Pyłek z rodziny Brassicaceae (*Brassica*, *Sinapis arvensis*, *Sinapis alba*) i pyłek *Chelidonium maius* charakteryzował się wysoką zawartością badanych składników, natomiast pyłek *Artemisia* i *Polygonum bistorta* – niską. Zawartość aminokwasów egzogennych wyrażona w procentach ogólnej zawartości aminokwasów w badanych próbkach stanowiła około 37% i nie zależała od pochodzenia botanicznego pyłku. Aminokwasem ograniczającym w przypadku wszystkich badanych odmian pyłku okazała się metionina i cysteina. Pyłek roślin ruderalnych, w szczególności *Sinapis arvensis*, *Sinapis alba* i *Chelidonium maius* stanowi ważne źródło białka oraz aminokwasów, w tym egzogennych zarówno dla pszczół jak i dla człowieka.

Słowa kluczowe: Obnóża pyłkowe, białko ogólne, aminokwasy, pochodzenie botaniczne.