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CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF PROTEIN OF THE PEA SEEDS - EFFECT OF HARVESTING YEAR AND VARIETY

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Summary

We tested nutritional usability of pea seeds (*Pisum sativum* L.) at full maturity. Four white-flowering and 5 colour-flowering new Polish cultivars were compared. We determined proximate composition of ground seeds collected over 4 years period as well as amino acids, minerals (Ca, P, Na, K), tannins and fiber fractions (NDF,ADF, ADL). The seeds contained between 224 and 260 $g \cdot kg^{-1}$ of crude protein which was rich in Lys (6.8±0.8 g) but poor in Met+Cys (2.0±0.2 $g \cdot 16\ g^{-1}$ N). The amount of tannins (as tannic acid equivalent) in white-flowering cvs was 4.3±0.9 g and in colour-flowering - 7.4±2.2 g. The calculated protein nutritional values were compared against amino acid standards of human and animal nutrition and the whole egg protein. Effects of the cropping year and variety variance in respect of chemical composition of seeds were examined. Crude protein, crude oil, N-free extractives, tannins, K, amino acid content: Leu, Phe+Tyr and Ala content were influenced significantly by the cultivar, while the cropping year had a significant influence on dry matter, crude ash, crude protein, crude fibre, crude oil, N-free extractives ADF and ADL fiber fractions, content of P, Na and K, most of the amino acid levels and on nutritional values of the protein measured by means of CS and EAAI indices.

key words: pea, nutrients, protein, tannins, fiber, minerals

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Abbreviations
AA - total amino acids; amino acids: Ala - Alanine, Arg - Arginine, Asp - Aspartic acid, Cys - Cysteine, Glu - Glutamic acid, Gly - Glycine, His - Histidine, Ile - Isoleucine, Leu - Leucine, Lys - Lysine, Met - Methionine, Phe - Phenylalanine, Pro - Proline, Ser - Serine, Thr - Threonine, Trp - Tryptophan, Tyr - Tyrosine, Val - Valine; ADF - acid detergent fiber; ADL - acid detergent lignin, CF - colour-flowering cultivars; CP - crude protein; CS - chemical score; DM - dry matter; EAA - essential amino acids; EAAI - essential amino acid index; NVP - nutritional values of protein; WF - white-flowering cultivars

INTRODUCTION

Peas (*Pisum sativum* L.) are important in global agriculture, providing biologically fixed nitrogen, breaking cereal disease cycles and contributing to locally grown food and feed. Its low production cost is also of importance (Davies 1985).

Pea seeds are of great nutritional value due to high-quality protein and energy content. They have 21-32% of protein rich in lysine (Nikolopoulou *et al.* 2007, Wang *et al.* 1998) which is the limiting amino acid in most of the plant products (Palander *et al.* 2006, Biel *et al.* 2009). The participation of Lys is comparable to soy seeds and middling (Mcdonough *et al.* 1989, Valencia *et al.* 2008), but similarly to lupine, pea proteins are low in sulphur-containing amino acids (Sujak *et al.* 2006). The nutritional value of pea seeds is restrained by naturally occurring compounds, called anti-nutritional factors (ANFs) such as tannins, oligo saccharides, phitynians, trypsin inhibitors, lectins and other, known to negatively affect nutrient digestibility, palatability and food intake (Nikolopoulou *et al.* 2007, Alonso *et al.* 2000, Urbano *et al.* 2005).

Peas and their protein concentrates may be used as a substitute of soy and its derivatives used in concentrate mixes for growing pigs and poultry (Valencia *et al.* 2008, Salgado *et al.* 2002).

As food component peas are rich in starch, protein and dietary fiber, they have significant amounts of vitamins and minerals and are characterized by a relatively high antioxidant activity (Han & Baik 2008). They are known for a cholesterol-lowering effect (Martins *et al.* 2004). Low glycemic index of cooked pea (GI=22) (Foster-Powell *et al.* 2002) generates slow and moderate postprandial glucose and insulin response and has a beneficial effect on the management of diabetes and hyperlipidemia (Jenkins 2007, Rizkalla *et al.* 2002). Therefore consumption of pea by humans is highly demandable.

Chemical content of pea seeds can vary. Genetic (variety) and environmental factors (location of cultivation area, soil characteristics, exchangeable cations, trace elements, cropping year, total rainfall, relative humidity, solarisation, temperature) are of importance (Kraus *et al.* 2003, Wang *et al.* 2010, Nikolopoulou *et al.* 2006) as well as technological treatments (dehulling, cooking, soaking, germination, extrusion) (Martinez-Villaluenga *et al.* 2008, Wang *et al.* 2008, Al-Marzooqi & Wiseman 2009).

A relatively high number of new pea cultivars is registered in Poland. Although the post-registration tests indicate their higher yielding and plants proliferacy (COBORU 2008),

the unfavourable weather conditions may negatively influence crop yielding and protein content in pea seeds (Szwejkowska 2005). Because of differences in climate, soil, varieties, and agronomic practices, field peas may have different chemical components when grown in various parts of the world.

In the available literature no data concerning environmentally-drawn changes (harvesting year) in amino acid content of the pea seed protein or peas nutritional values were found. Little information can be found on comparison of pea protein quality as food or fodder for people or animals. Therefore the purpose of this study was updating the data on chemical composition of new, organically grown, Polish pea cultivars, earmarked for cultivation in moderate warm climates. The aim was the determination of the influence of cultivar and of a cropping year on changes in chemical composition and nutritional values of protein of the pea seeds as related to different standards of nutrition.

MATERIALS AND METHODS

Pea seeds of 9 cultivars characteristic of the cultivation in central-western Poland were selected for analysis. Among them, Bohun, Set, Merlin and Marych cultivars represented white-flowering cultivars (WF), whereas Milwa, Pomorski, Roch, Sokolik and Wiato were colour-flowering cultivars (CF). Cultivars Bohun, Set are appropriate for human consumption while Marych, Milwa, Pomorski, Roch, Sokolik, Wiato can be used as feed. Universal cultivar Merlin is grown both for human consumption as well as for fodder purposes (Paczocha 2010). The seeds were collected over 4 harvesting years 2005-2008 (total 36 samples). During the vegetation period (IV-VII) temperature was 14-16^{o}C on average and the total rainfall amounted to 160-330 mm. Light soil or fertile soil occurred in the area of cultivation. No artificial fertilizers were used in the cultivation process.

Preparation of samples. Ground seeds were produced by using a laboratory KNIFETEC 1095 sample mill, Foss Tecator. Analyses were usually performed in duplicate.

Proximate chemical composition. Dry matter (DM), crude ash, crude protein (CP), crude oil and crude fiber were determined. All determinations were expressed in g·kg^{-1} of DM. The meal had its proximate composition determined by conventional methods for moisture, protein (N x 6.26), ash, and lipids, as described in AOAC (1990). N-free extractives were determined by difference.

Determination of fibre fractions. Neutral detergent Fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1991), using ANCOM 220 fibre analyzer. Analyses of fibre fractions were performed in triplicate.

Determination of macro elements. Cleaned of dust and dried, the materials were ground to fine powder and used for dried ashing. Sodium (Na), potassium (K) and calcium (Ca) were determined using flame photometry (FLAPHO 4, Carl Zeiss, Jena). Phosphorous was determined by using the colorimetric method (PN-R-64781:

1976).

Tannins. Tannins were determined as tannic acid equivalent according to the procedure published previously by Tyczkowska (1977).

Amino acids. Amino acids (without tryptophan - Trp) were determined using an AAA 400 automatic amino acid analyzer (INGOS, Czech Republic). Prior to analysis, samples were subjected to acid hydrolysis in the presence of 6M HCl at 110^{o}C for 24 hours. Sulphur-containing amino acids were determined separately in 6M HCl after oxidative hydrolysis (formic acid + hydrogen peroxide, 9:1 v/v, 20 h at 4^{o}C). Tryptophan was determined after papain-induced (2 g·L^{-1}) hydrolysis at alkaline pH adjustment and centrifugation, followed by analysis by an amino acid analyzer (AOAC, 1990). The concentration determination was based on specific colour reaction of tryptophan with p-dimethylo-benzaldehyde (formaldehyde) (Chrastil 1986).

Estimation of nutritional values of pea proteins. The quality of proteins was estimated by determination of total amino acids (AA), the fraction of the exogenous amino acids (EAA), the protein chemical score (CS) as well as the essential amino acid index (EAAI); (Sujak *et al.* 2006).

The nutritional values were referred to the egg protein amino acid standard (Lys - 7, Met+Cys - 5.7, Thr - 4.7, Ile - 5.4, Trp - 1.7, Val - 6.6, Leu - 8.6, His - 2.2, Phe+Tyr - 9.3; EAA=51.2 g·100 g^{-1} (NRC 1989) and to the two different standards for mature human (1: Lys - 5.5, Met+Cys - 3.5, Thr - 4, Ile - 4, Trp - 1, Val - 5, Leu - 7, Phe+Tyr - 6; EAA=36 g·100 g^{-1} (FAO/WHO 1991); 2: Lys - 3.1, Met+Cys - 2.7, Thr - 2.6, Ile - 3.0, Trp - 0.6, Val - 2.3, Leu - 4.4, Phe+Tyr - 3.3; EAA=22 g·100 g^{-1} (Millward 1999).

The protein usability for animal feeding was estimated on the basis of standard for 6-8 weeks chicken broilers (Lys - 4.7, Met+Cys - 3.3, Thr - 3.8, Ile - 3.4, Trp - 0.9, Val - 3.9, Leu - 5.2, His - 1.5, Phe+Tyr - 5.8; EAA=32.5 g·100 g^{-1} (NRC 1994) as well as the standard for 20-50 kg growing pigs (Lys - 7, Met+Cys - 3.6, Thr - 4.5, Ile - 4, Trp - 1.2, Val - 5.2, Leu - 8, His - 2.5, Phe+Tyr - 8; EAA=44 g·100 g^{-1} (Boisen *et al.* 2000). Universal cultivar Merlin was evaluated by using all the listed above standards of nutrition.

Statistical analysis. In order to verify the effect of cultivar on the level of the analysed traits, the following mixed model was used (Aczel 1996):

$Y_{ijk} = \mu + a_i + \beta_j + a\beta_{ij} + \varepsilon_{ijk}$

Y_{ijk} - analysed trait
μ - overall mean
a_i - fixed effect of the cultivar
β_j - - random effect of the year
$a\beta_{ij}$ - random effect of the year × cultivar interaction
ε_{ijk} - random error

In each year the particular parameter was calculated as an average from 3 or 4 samples. The differences between the mean values of the traits for individual cultivars were estimated using the Spjotvoll-Stoline test (Dobosz 2001). Differences were considered significant at the level of $P \leq 0.05$. The contribution of individual variance components to the variation of the examined traits was also estimated and given as percentage. The Statistica 9.0 software was used for analyses (StatSoft 2009).

RESULTS

Table 1 shows the basic chemical composition, fiber fractions, macroelements and tannins in the examined pea seeds (as mean per 1 kg of DM) with the statistical analysis. Seeds contained 886±10 $g \cdot kg^{-1}$ DM, between 224 to 260 g of crude protein, between 11 and 17 g crude fat and from 3.3 to 9.4 g tannins (6.0 g on average). Among other chemical components and nutrients were: 30g of crude ash, 53g of crude fiber, 135 g NDF, 6g ADL, 1.0 g Ca, 3.8 g P and 0.2 g Na and from 5.5 to 7.0 g K. Significant difference was found only for ADF fraction in white and colour-flowering cultivars amounting 72 and 83 g, respectively. Twice less tannins on average were found in WF cultivars than in CF cultivars, even though no statistical differences between these two groups were found. The presented research reveals the smallest tannin content in WF cultivars such as Merlin, Bohun and Marych ranging from 3.3 to 4.7 g as well as in CF cv Milwa (4.2 g) assigned as CF cultivar due to light pink colour of flowers.

The effect of harvesting year on chemical content was, in most cases, greater than the effect of cultivar which was expressed by F- test values and a relatively higher percentage variance share. F-test values indicated statistically significant effect of a factor (year and, in some cases, cultivar) on the examined traits. No statistically significant influence of the harvesting year on tannins, NDF and Ca content was found. The 88% contribution of tannins in the variance was an effect of cultivar ($P \leq 0.01$). The level of interaction variance for harvesting year and cultivar was relatively low. Significant differences ($P \leq 0.01$) were found for crude protein and N-free extractives between Bohun, Marych and Wiato cultivars, for crude fat and tannins at $P \leq 0.01$ or $P \leq 0.05$ between different cultivars and for K ($P \leq 0.05$) between cv. Milwa and Wiato.

The amino acid composition of the protein (in $g \cdot 100g^{-1}$ of protein) from the examined pea seeds and nutritional values of the seed protein from seeds determined on the basis of the egg protein standard (CS, EAAI) are shown in Table 2. Generally, proteins from the examined peas are a good source of Lys (6.8 g on average) but they are deficient in other essential amino acids, especially in sulphur-containing amino acids, 2.0 g on average. Amino acids limiting the nutritive values of proteins (NVP) are mainly these containing sulphur, followed by isoleucine, tryptophan and valine. Cv Wiato (CF) and universal cv Merlin (WF) had the biggest amount of EAA, AA and EAAI. No statistical differences were found in AA and NPV between WF and CF varieties. Harvesting year influenced amino acid content and NVP more than the cultivar. F values were statistically significant ($P \leq 0.01$ or $P \leq 0.05$) for most of the amino acids excluding Trp, Tyr, Pro and Ala. The variance participation for harvesting year was the biggest for all amino acids apart from Trp and Ala. The highest percentage share of variation for interactions of cropping year and cultivar was observed exclusively for Trp. Statistically significant influence of the variety and significant differences ($P \leq 0.05$) between the levels of Leu, Phe+Tyr and Ala were observed.

Table1. Mean values for the chemical composition (g · kg^{-1} DM) of the pea seeds of white-flowering (WF) and colour-flowering (CF) cultivars and the analysis of variance (ANOVA) for cultivar (C) and the year of harvest (Y)

Item	Cultivars[1]									Cultivars[2]			Value F[3]		Variance (%)		
	White-flowering				Colour-flowering					mean	WF	CF					
	Bohun	Set	Merlin	Marych	Milwa	Pomor-ski	Roch	Sokolik	Wiato	± SD	± SD	± SD	cultivar	year	cultivar	year	CxY
Dry matter (g·kg^{-1})	890	890	873	882	877	888	893	887	886	886±10	884±17	887±10	2.4	6.3**	29	61	10
Crude ash	30	32	30	31	30	29	30	30	27	30±2	31±2	29±2	2.1	5.5**	33	57	10
Crude protein	224^{A}	230	238	260^{AB}	247	241	243	239	224^{B}	239±20	239±26	239±15	5.1**	28.6**	17	80	3
Crude fibre	57	47	49	48	51	57	52	50	57	53±6	52±8	54±5	2.4	7,0**	24	67	9
Crude oil	17^{ABCa}	17^{bc}	11^{Ab}	11^{Bcd}	13	13^{a}	12^{C}	15^{d}	14	13±3	13±3	13±2	8.9**	6.8**	52	42	6
N-free extractives	672^{A}	675	667	651^{AB}	664	660	661	666	678^{B}	665±15	665±19	665±15	4.1**	35.1**	12	86	2
NDF	113	122	141	142	151	147	138	128	134	135±18	130±18	140±17	2.2	1.5	47	32	21
ADF	74	69	72	73	79	81	83	84	91	79±11	72±10^{A}	83±10^{B}	1.9	5.6**	24	64	12
ADL	4	9	6	8	7	4	7	7	4	6±3	7±3	5±2	2.4	6.1**	27	63	10
Ca	0.8	0.7	0.9	1.3	1.0	1.0	1.0	0.9	0.9	1.0±0.2	1.0±0.3	1.0±0.2	2.4	0.5	64	11	25
P	3.7	4.2	3.6	4.1	3.8	3.7	4.0	3.8	3.3	3.8±0.6	3.9±0.5	3.7±0.5	0.8	4.1*	19	65	16
Na	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2±0.04	0.2±0.0	0.2±0.0	1.1	8.9**	9	82	9
K	6.4	6.6	6.1	6.8	7.0^{a}	6.9	6.5	6.7	5.5^{a}	6.5±0.7	6.5±0.6	6.7±0.8	2.8*	6,0**	27	62	11
Tannin	4.7^{AE}	3.8^{BFa}	3.3^{CGI}	4.7^{DH}	4.2	6.3	9.4^{ABCD}	7.3^{Ia}	9.2^{EFGH}	6.0±2.3	4.3±0.9	7.4±2.2	14.1**	1.3	88	7	5

[1] Means in the same rows with the same letters are significantly different; A, B, C, D, F, G, H: P ≤ 0.01; a, b, c, d: P ≤ 0.05
[2] Means in the same rows with the same letters are significantly different; A, B: P ≤ 0.01
[3] **P≤ 0.01; * P≤ 0.05; There were no cultivar × year interactions for any parameter.

Table 2. Mean values for the amino acid composition (g·100 g^{-1}) and nutritional value of the protein of the pea seeds of white-flowering (WF) and color-flowering (CF) cultivars and the analysis of variance (ANOVA) for cultivar (C) and the year of harvest (Y)

Item	White-flowering cultivars				Colour-flowering cultivars					Mean	WF[1]	CF[1]	Value F[2]		Variance (%)		
	Bohun	Set	Merlin	Marych	Milwa	Pomorski	Roch	Sokolik	Wiato	± SD	± SD	± SD	cv.	year	cv.	year	CxY
Essential amino acids (g·100 g^{-1})																	
Lys	6.7	7.1	6.9	6.4	6.6	7.1	6.9	6.6	7.2	6.8±0.8	6.7±0.8	6.9±0.7	0.7	10.4**	7	85	8
Met+Cys	2.0	2.1	1.9	1.8	2.1	2.1	2.0	2.0	2.0	2.0±0.2	1.9±0.2	2.0±0.2	1.0	7.2**	11	78	11
Cys	1.2	1.2	1.1	1.0	1.2	1.2	1.2	1.2	1.2	1.2±0.2	1.1±0.2	1.2±0.2	0.9	5.1**	12	74	14
Thr	3.4	3.6	3.7	3.2	3.4	3.8	3.5	3.5	3.7	3.5±0.5	3.4±0.4	3.6±0.5	1.0	11.5**	8	85	7
Ile	3.1	3.1	3.0	2.7	2.7	2.9	3.0	2.9	3.3	3.0±0.5	2.9±0.5	3.0±0.5	1,0	13.4**	8	86	6
Trp	0.9	1.0	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9±0.1	0.9±0.1	0.9±0.1	0.8	0.6	33	24	43
Val	3.6	3.9	4.1	3.7	3.9	4.0	3.6	3.5	3.7	3.8±0.4	3.8±0.4	3.7±0.4	1.3	5.3*	16	71	13
Leu	6.3[a]	6.6	7.4[a]	6.4	6.4	6.7	6.5	6.4	6.8	6.6±0.5	6.6±0.5	6.6±0.4	2.9*	6.2**	29	61	10
His	2.3	2.5	2.6	2.5	2.6	2.4	2.3	2.3	2.5	2.4±0.2	2.5±0.2	2.4±0.2	1.5	1.8*	31	44	25
Phe+Tyr	6.5	6.3[ab]	7.1[a]	6.5	6.8	7.0[b]	6.4	6.4	6.8	6.6±0.5	6.6±0.4	6.7±0.5	3.0*	8.1**	25	67	8
Tyr	2.5	2.3	2.7	2.5	2.5	2.6	2.6	2.6	2.5	2.5±0.3	2.5±0.3	2.6±0.3	0.6	2.5	10	64	26
Non-essential amino acids (g·100 g^{-1})																	
Arg	8.6	8.2	9.5	9.8	9.3	8.9	9.2	8.7	8.6	9.0±1.0	9.1±1.2	8.9±0.8	1.1	4.1*	18	66	16
Asp	11.6	11.9	13.0	12.0	12.2	12.2	12.0	12.2	12.5	12.2±0.7	12.1±0.7	12.2±0.7	1.4	4.5*	21	65	14
Ser	4.6	4.6	5.0	4.6	4.6	4.7	4.5	4.4	4.8	4.6±0.4	4.7±0.4	4.6±0.3	1.5	8.7**	13	78	9
Glu	18.1	18.4	19.6	18.3	18.0	19.1	19.0	18.6	19.1	18.7±1.4	18.5±1.4	18.8±1.2	1.3	11.4**	9	84	7
Pro	3.5	3.7	3.8	3.4	3.2	3.7	3.7	3.5	3.8	3.6±0.6	3.6±0.4	3.6±0.7	0.2	2.5	8	66	26
Gly	4.0	4.2	4.5	4.2	4.3	4.4	4.2	3.9	4.3	4.2±0.5	4.2±0.5	4.2±0.5	1.1	16.3**	6	89	5
Ala	3.5	3.3[ab]	4.3[a]	3.9	4.2[b]	3.8	3.5	3.5	3.6	3.7±0.4	3.8±0.5	3.7±0.4	3.1*	0.9	61	18	21
EAA (g·100g^{-1})	34.8	36.1	37.6	34.1	36.2	36.7	35.2	34.6	37.1	35.7±2.8	35.4±2.7	35.8±2.9	1.4	14.2*	10	84	6
AA (g·100g^{-1})	88.7	90.5	97.2	90.4	91.3	91.5	91.3	89.3	93.8	91.8±6.0	91.4±5.9	91.9±5.5	1.2	7.6**	13	77	10
CS[3]	35.7	36.6	33.5	31.3	36.2	36.1	35.7	35.5	35.4	35.0±4.0	34.0±3.9	35.8±4.0	1.0	7.2**	11	78	11
EAAI[3]	64.5	66.4	68.0	62.5	65.4	67.3	65.4	64.4	68.1	65.6±4.8	65.0±4.1	66.1±4.7	1.6	19.7**	9	87	4

[1]No significant statistical difference between white- and colour-flowering cultivars;[2]**P≤ 0.01; * P≤ 0.05; There were no cultivar×year interactions for any parameter
[3]CS (chemical score), EAAI (essential amino acid index) - based on egg standard (NRC 1989); first limiting amino acids: Met+Cys, second: Ile, Trp or Val;

Table 3. Mean values±SD for the nutritional values of proteins of the pea seeds

Specification	Edible cultivars			Total
	Bohun	Set	Merlin	
Standard[1]				
EAA (g·16g^{-1} N)	32.5±3.1	33.6±4.7	35.0±1.0	33.6±2.8
CS	58.1±6.8	59.6±6.9	54.5±6.5	57.3±6.2
EAAI	82.6±4.8	85.4±8.0	85.3±3.0	84.1±4.6
Standard[2]				
EAA (g·16g^{-1} N)	32.5±3.1	33.6±4.7	35.0±1.0	33.6±2.8
CS	75.4±8.8	77.2±9.0	70.7±8.5	74.2±8.0
EAAI	95.9±1.9	95.7±3.0	94.9±1.5	95.5±1.8

Specification	Fodder cultivars							Total
	Merlin	Marych	Milwa	Pomorski	Roch	Sokolik	Wiato	
Standard [3]								
EAA (g·16g^{-1} N)	37.6±1.2	34.1±1.7	36.2±3.9	36.7±2.4	35.2±3.5	34.6±4.1	37.1±2.4	35.8±2.8
CS	57.3±6.9	53.5±5.0	62.9±6.4	61.6±8.0	61.0±6.5	60.7±7.9	60.4±9.7	59.5±7.0
EAAI	91.9±2.0	88.2±2.2	91.0±4.1	91.6±3.1	90.5±4.2	90.3±5.4	92.6±3.4	90.8±3.4
Standard [4]								
EAA (g·16g^{-1} N)	37.6±1.2	34.1±1.7	36.2±3.9	36.7±2.4	35.2±3.5	34.6±4.1	37.1±2.4	35.8±2.8
CS	53.0±6.3	49.5±4.6	57.9±5.3	56.5±7.0	56.5±6.0	56.2±7.3	56.0±9.0	55.0±6.3
EAAI	81.3±3.4	74.7±3.2	79.3±7.6	79.8±4.9	77.3±5.9	76.3±7.8	81.1±3.9	78.4±5.2

[1] Standard for mature human (FAO/WHO, 1991); first limiting amino acids: Met+Cys. second: Val or Ile
[2] Standard for mature human (Millward 1999); first limiting amino acids: Met+Cys. second: Ile
[3] Standard based on nutrient requirement of 6-8 weeks chicken broilers (NRC 1994) first restrictive amino acids: Met+Cys, second: Ile, Thr or Val
[4] Standard based on nutrient requirements for growing pigs. 20-50 kg (Boisen *et al.* 2000); first restrictive amino acids: Met+Cys. second: Val, Ile, Trp or Thr

Table 3 shows the predicted nutritional values of the pea seed protein. For the fodder and universal cultivars the nutritional indices (EAA, CS and EAAI) were calculated based on standards of nutrition for 6-8 week broilers and the nutrition standard for growing pigs. Edible cultivars were compared against two different standards of nutrition for mature human: one more rigorous according to FAO/WHO (1991) and the other, less rigorous, proposed by Millward (1999). According to the second standard peas are rather a good source of the plant-originating protein for mature human nutrition (EAAI amounting 95.5 and CS 74.2). To a lesser degree pea protein covers the nutritional requirements for exogenous amino acids for young animals in particular of the pigs (20-50 kg), because it is deficient in sulphur-containing amino acids (Met+Cys). This fact is expressed by the lowest CS and EAAI indices. Among forage cultivars the highest CS value was found for Cv Milwa, and the highest EAAI for cv Merlin and Wiato both for young chicken as well as for young pigs.

DISCUSSION

The results obtained in this study show that the variety had significant influence ($P \leq 0.01$) on the levels of crude protein, crude fat and on N-free extractives but didn't influence crude ash and crude fibre. The harvesting year affected all the basic components ($P \leq 0.01$). Wang *et al.* (2010) found the influence ($P < 0.05$) of the cultivar and cropping year on crude ash, crude protein, crude oil and on crude fibre content for the cultivars grown in Canada. The effect of genotype and environment on tannins was reported by Kraus *et al.* (2003). In the presented study, we observed the significant influence ($P \leq 0.01$) of the cultivar but not a harvesting year on tannins. The similar effect was observed by Wang *et al.* (1998).

The mean values of CS and EAAI were lower than those reported by Zdunczyk *et al.* (1997) for the other Polish white-flowering cultivars (40.7±0.40 and 69.7±0.25) and the results reported by Stanek *et al.* (2004), for white-flowering cultivars (43.7 and 76.8 on average) and for color-flowering cultivars of 44.6 and 77.4, respectively.

Differences in CS values for pea depended on the standards used which was confirmed also by Frias *et al.* (2011), who used the standards of nutrition based on the food requirement of 3-10 years old children (according to FAO, 2007; Met+Cys= 1.91 $g \cdot 100^{-1}$ of protein, CS=80) and also by Schumacher *et al*. (2011), who used the standard worked out by FAO/WHO (1991) (mean value Met+Cys=2.4 $g \cdot 100^{-1}$ of protein; CS=66.7). In the examined peas sulphur amino acids requirements were similar according to all used standards of nutrition. Similar CS indices (between 55.0 and 59.5) based on FAO/WHO (1991) standard of nutrition were obtained by Schumacher *et al*. (2011) and also based on ideal protein for growing pigs (mean value CS=66.7 and 64.9, respectively). In any of the above mentioned cases Met and Cys were the limiting amino acids. Therefore peas should be combined with foods or fodders rich in

methionine or supplemented with Met (Castell *et al.* 1996). Canadian pea varieties (Wang *et al.* 2004) were characterised by a relatively high CS value (94) for sulphur containing amino acids (average content of Met+Cys=3.3 $g \cdot 100^{-1}$ of protein), and Trp was the first limiting amino acid (mean value CS=82; according to FAO/WHO 1991).

CONCLUSIONS

Based on the experiments presented in this study, the cultivar and the cropping year both affected chemical content of pea seed. Crude protein, crude oil, N-free extractives, tannins, potassium, amino acid content: Leu, Phe+Tyr and Ala content were influenced significantly by the cultivar, while the cropping year had a significant influence on dry matter (DM), crude ash, crude protein, crude fibre, crude oil, N-free extractives ADF and ADL fiber fractions, content of P, Na and K, most of the amino acid levels and on nutritional values of the protein measured by means of CS and EAAI indices. In most cases, the cropping year had a higher percentage contribution to the variance of chemical composition than the variety. White- and colour-flowering cultivars differed significantly ($P \leq 0.01$) only in ADF fraction.

The important point to be made here is that all the peas examined can serve as a source of good quality food protein for adult humans, according to the standard of nutrition proposed by Millward. The examined peas meet the requirement for exogenous amino acids in 6-8 weeks chicken broilers to a lesser degree and they were most amino acid deficient in the case of growing pigs (20-50 kg).

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SKŁAD CHEMICZNY ORAZ WARTOŚCI ODŻYWCZE BIAŁEK NASION GROCHU SIEWNEGO - WPŁYW ROKU ZBIORU ORAZ ODMIANY

Streszczenie

W niniejszej pracy oceniono użyteczność żywieniową nasion grochu siewnego (*Pisum sativum* L.) w pełnej dojrzałości nasion. Badaniom podlegały 4 nowe odmiany biało kwitnące oraz 5 kolorowo kwitnących. Oszacowano skład podstawowy rozdrobnionych nasion zbieranych przez okres 4 lat, skład aminokwasowy, zawartość składników mineralnych (Ca, P, Ca, P), taniny oraz udział frakcji włókna (NDF, ADF, ADL). Odmiany biało kwitnące porównano z kolorowo kwitnącymi. Nasiona zawierały pomiędzy 224 a 260 $g \cdot kg^{-1}$ suchej masy białka bogatego w Lys (6.8±0.8g), ale ubogiego w Met+Cys (2.0±0.2 $g \cdot 16\ g^{-1}$ N). Zawartość tanin liczona jako równoważnik kwasu taninowego wynosiła 4.3±0.9 g dla nasion grochu biało kwitnącego oraz 7.4±2.2 g dla grochu kolorowo kwitnącego. Przydatność żywieniowa białka nasion grochu oceniona została poprzez oszacowanie udziału aminokwasów egzogennych (EAA), obliczenie wskaźnika aminokwasu ograniczającego (CS) oraz wskaźnika aminokwasów egzogennych (EAAI). Obliczoną wartość odżywczą białka nasion grochu porównano ze standardami żywieniowymi dla człowieka i zwierząt oraz ze standardem białka jaja kurzego. Rozpatrywano również procentowy udział wariancji roku zbioru i odmiany w odniesieniu do składu chemicznego nasion. Stwierdzono, że rok zbioru oddziaływał w większym stopniu na zawartość składników pokarmowych, niż odmiana. Odmiana miała istotny statystycznie wpływ na zawartość białka ogólnego, tłuszczu surowego, BAW, tanin, potasu, aminokwasów: Leu, Phe+Tyr, Ala, natomiast rok zbioru miał istotny wpływ na zawartość suchej masy, popiołu surowego, włókna surowego, tłuszczu surowego, BAW, frakcji włókna ADF i ADL, zawartość P, K, Na, większości aminokwasów i wartość odżywczą białka mierzoną wskaźnikami CS i EAAI.