Correlation of protein content to flatulent galactooligosaccharides and exogenous amino acids in seeds of *Phaseolus vulgaris* L.

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Abstract

In order to estimate the possible correlations among constituents of *Phaseolus vulgaris* seeds, the contents of protein, exogenous amino acids and flatulent galactooligosaccharides (raffinose and stachyose) were analyzed in 16 Polish bean cultivars for dry seeds. A negative correlation coefficient ($r = -0.9490$) was found between protein and methionine contents. High positive correlations among exogenous amino acids, such as lysine and isoleucine, valine and isoleucine, lysine and tyrosine, were observed indicating a chance of selecting for more than one at a time. The small-seeded bean cultivars contained higher contents of protein and galactooligosaccharides than the large-seeded ones.

Key words: *Phaseolus vulgaris*, seed, protein, amino acid, galactooligosaccharides, correlations

INTRODUCTION

Although kidney beans are high in protein, the level of the sulfur amino acids is lower than desirable if beans are to supply a balanced source of protein in a cereal diet. The amino acid and protein differences within *Phaseolus vulgaris* reported by King (1964) and others (Kelly 1971, Woolfe and Hamblin 1974) suggest that improved cultivars might be developed through selection and hybridization. Analyzing amino acids in 21 cultivars, Hackler and Dickson (1972) found surprisingly high correlations among many amino

acids, indicating an excellent chance of selecting for more than one at a time. It is assumed that genetic selection can solve other problems related to the quality of beans including the elimination of flatulence-causing factors of seeds. The oligosaccharides of the raffinose family of sugars (raffinose stachyose, verbascose) from beans have been identified as one of the important contributors to flatus in humans (Murphy et al. 1972, Cristofaro et al. 1973). Murphy (1973) reviewed the possibility of eliminating the flatulence effect by genetic selection, and examined a number of bean cultivars for flatulence activity.

The present study was undertaken to evaluate any possible correlation among some components of beans which affect the nutritive value of seeds protein, exogenous amino acids and galactooligosaccharides. The contents of these components were correlated to the mass of a thousand seeds.

MATERIALS AND METHODS

Sixteen Polish cultivars of bean (*Ph. vulgaris*) cultivated for dry seeds were chosen for analysis. The bean seeds originated from two Breeding Stations of Horticultural Plants, near Kraków and Warsaw, and from collection of bean cultivars of the Research Institute of Vegetable Crops in Skierniewice, Poland, harvest year 1986. Small and large-seeded cultivars with a 1000-seed mass from 184 to 598 g and with a range of protein contents from 23.1 to 28.6% were investigated. Protein was analyzed by the Kjeldahl method. Galactooligosaccharides (raffinose and stachyose) were determined by gas chromatography of the TMS derivatives, according to a previously described method (Kosson 1988a, b). Amino acids were assayed by an AAA 881 automatic amino acid analyzer.

RESULTS AND DISCUSSION

The results in Table 1 reveal negative correlation between the methionine and protein contents, and positive correlation between the leucine and protein contents. The first correlation coefficient ($r = -0.9490$) is of great importance because the sulfur amino acids, methionine and cystine are known as the limiting amino acids in bean protein, thus the higher methionine content may improve the nutritive value of the bean seed. It can be assumed that the nutritive value of bean protein decreases when its content increases in seeds. Similar results were obtained by Evans and Boulter (1980) who found a negative correlation ($r = -0.86$) between sulfur amino acids and protein content in beans. No significant correlation was found between the 1000-seed

Table 1
Correlation coefficients between protein content, mass of a thousand seeds and exogenous amino acid content (n=6)

	Lys	Tre	Val	Meth	Isol	Leu	Tyr	Phen
Protein content	-0.5087	-0.5872	-0.6733	-0.9490*	-0.6391	+0.8719**	-0.6630	+0.5405
Mass of 1000 seeds	+0.2363	+0.4396	+0.4272	+0.5092	+0.4105	-0.0690	+0.2637	-0.2399

Abbreviations: Lys - Lysine, Tre - Threonine, Val - Valine, Meth - Methionine, Isol - Isoleucine, Leu - Leucine, Tyr - Tyrosine, Phen - Phenylalanine.

*, **, - significant at $p = 0.005$ and 0.05 , respectively.

Table 2
Correlation coefficients between contents of exogenous amino acids

		(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lysine	(1)	-0.4667	+0.7046	+0.6179	+0.9196***	-0.5777	+0.9446**	+0.5681
Threonine	(2)		+0.1312	+0.3388	-0.2113	-0.3265	-0.2135	-0.8997***
Valine	(3)			+0.2381	+0.9232***	-0.6772	+0.8723***	+0.1326
Methionine	(4)				+0.2487	-0.8653	+0.4027	-0.5622
Isoleucine	(5)					-0.6587	+0.9819*	+0.4014
Leucine	(6)						-0.7526	+0.3395
Tyrosine	(7)							+0.3367
Phenylalanine	(8)							-

*, **, *** - significant at $p = 0.005$, 0.02 , and 0.05 , respectively.

Table 3
Variation in flatulent galactooligosaccharides (raffinose+stachyose) and protein contents of bean seeds

Cultivar or line	(1) Mass of 1000 seeds			(2) Raffinose+Stachyose (%)			Protein content (% of dw)		
	min.	max.	mean	min.	max.	mean	min.	max.	mean
'Atut', 'Bor' 'Wenta'	184	228	208	3.03	3.38	3.21	27.0	28.6	27.6
'Biała Wyborowa' 'Justynka'	259	308	283	2.46	3.37	2.91	25.5	26.2	25.8
'Florentynka', 'Augustynka' 'Słowianka'	367	420	389	2.50	2.88	2.70	24.5	25.1	24.7
'Igołomska', 'Aura' 'IGE 983'	431	486	464	2.52	2.79	2.68	23.7	24.6	24.3
'Wiejska', 'IGE 1284' 'IGE 900/82'	500	598	559	2.13	2.19	2.15	23.1	24.3	23.7

Correlation coefficients between mean values of: (1) and (2) = -0.9598, (2) and (3) = +0.9188, (1) and (3) = -0.9548.

mass and the content of exogenous amino acids. When analyzing 8 exogenous amino acids of bean seeds (Table 2), a high positive correlation among some amino acids was determined, indicating a possibility of selecting for more than one at a time, between lysine and isoleucine, valine and isoleucine, lysine and tyrosine, valine and tyrosine, isoleucine and tyrosine. The galactooligosaccharide and protein contents in 14 cultivars are given in Table 3. All the bean cultivars were grouped according to their increasing 1000-seed mass. It can be seen that the small-seeded cultivars contained a higher protein and galactooligosaccharide percentage, and conversely. This is an unfavourable characteristic when selecting *Ph. vulgaris* for high protein content, because of the high galactooligosaccharide content in seeds which can lead to decreasing the nutritive value of beans. The correlation between protein content and galactooligosaccharide content ($r = +0.9188$) is significant at $p = 0.05$. Because small-seeded bean cultivars show higher flatulence activity, it is suggested that people who are very sensitive to flatulence should prepare meals from large-seeded beans.

It must be emphasized that further investigations are needed to confirm the relationship between the mentioned characteristics of bean seeds.

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Korelacja między zawartością białka a zawartością galaktooligosacharydów gazotwórczych i aminokwasami egzogennymi w nasionach fasoli zwykłej (Phaseolus vulgaris L.)

Streszczenie

Na podstawie ilościowej analizy chemicznej niektórych składników nasion określono współczynniki korelacji między zawartością białka, zawartością aminokwasów egzogennych i zawartością galaktooligosacharydów gazotwórczych (rafinoza i stachioza) w 16 polskich odmianach fasoli uprawianej na suche nasiona. Stwierdzono m.in. ujemną korelację ($r = -0.949$) między zawartością białka i metioniny. Natomiast dużą dodatnią korelację stwierdzono między zawartością niektórych aminokwasów egzogennych: lizyny i izoleucyny, waliny i izoleucyny, lizyny i tyrozyny. Drobnonasienne odmiany fasoli charakteryzują się większą procentową zawartością białka i galaktooligosacharydów w porównaniu z odmianami grubonasiennymi.