Nitrogen composition of bean cultivars grown for dry seeds

RYSZARD KOSSON and JÓZEF BAKOWSKI

Research Institute of Vegetable Crops, Department of Processing and Freezing, ul. 22 Lipca 1/3, 96-100 Skierniewice, Poland

(Received: February 23, 1987)

Abstract

Polish bean cultivars grown for dry seeds were characterized in respect to total nitrogen content and protein nitrogen content, and were compared to foreign cultivars. The effect of two different regions of cultivation on total nitrogen content in seeds of some bean cultivars was evaluated also. Based on the differential solubility of bean proteins, the contents of albumins, globulins and other fractions in the seeds of six Polish bean cultivars (*Phaseolus vulgaris* and *Phaseolus multiflorus*), cultivated for dry seeds, were determined. It was found that the total nitrogen content in the seeds of Polish cultivars was lower on average, by $0.3^{0}/_{0}$, in comparision to foreign cultivars. Seeds of the same cultivar grown in 2 regions did not differ in total nitrogen content. The protein nitrogen content in seeds makes up $82.2^{0}/_{0}$ of total nitrogen and does not depend on the total nitrogen content in each cultivar. It was found that globulins made up on average $70^{0}/_{0}$ of the proteins in the investigated bean cultivars.

INTRODUCTION

Bean seeds, because of their high protein content, are an important component of diets in human nutrition. The protein content and its quality are of special importance in those countries where bean foods are the basis of human nutrition.

According to Rutger (1970) the total protein content in cultivars varies from 19 to $31^{\circ}/_{0}$. The protein content in 15 cultivars of beans grown in Latin America was found to be on the level of $20.3^{\circ}/_{0}$ whereas beans in North America were on the level of $25.5^{\circ}/_{0}$ (Koehler and Burke, 1981). Cultivars from India contained $27.8-35.1^{\circ}/_{0}$ protein (Pusztai et al., 1979) and those from England $21.3-31.3^{\circ}/_{0}$ protein. Representative investigations of Woolfe and Hamblin (1974) on 336 breeding lines and cultivars from Africa have shown a wide range of protein content in bean seeds, from 20.0 to $33.0^{\circ}/_{0}$.

Globulins are — quantitatively — the dominating protein fraction of bean seeds (Kulka and Grzesiuk, 1978). They play the role of reserve proteins in beans. Pusztai et al. (1979) have shown that the globulin content in seeds oscilates from 11.4 to $19.4^{\circ}/_{0}$, which makes up $53.6-62.6^{\circ}/_{0}$ of total proteins. According to Ishino and Ortega (1975), globulins of bean cultivars cultivated in Central America make up $75^{\circ}/_{0}$ of the proteins. Globulins of beans cultivated in India compose $58.8-61.0^{\circ}/_{0}$ of proteins (Pant and Tulsiani, 1969), in Brazil $52.3^{\circ}/_{0}$ of protein (Marquez and Lajolo, 1981).

Albumins are — quantitatively — a smaller group of proteins in bean seeds. The albumin content in seeds of leguminous plant species is varied and ranges from 10 to $25^{\circ}/_{0}$ of total proteins (Basha and Beevers, 1975; Gottschalk et al., 1976; Mironenko, 1975). According to other authors, the albumin content in beans range from 5.5 to $7.2^{\circ}/_{0}$ (Pant and Tulsiani, 1969); from 12.0 to $19.9^{\circ}/_{0}$ (Pusztai et al., 1979); from 9.4 to $17.5^{\circ}/_{0}$ (Sgarbieri et al., 1979); from 14.4 to $17.1^{\circ}/_{0}$ (Sajanova and Gofman, 1965); $31.5^{\circ}/_{0}$ (Marquez and Lajolo, 1981).

The purpose of this study was the characterization of Polish bean cultivars grown for dry seeds from the point of view of total nitrogen content and protein nitrogen content. Polish cultivars were compared to American and Dutch ones. Quantitative analysis of protein fractions of six Polish cultivars of bean cultivated for dry seeds was conducted.

MATERIAL AND METHODS

The bean cultivars originated from the Breeding Station of Horticultural Plants at Igolomia, Breeding Station of Horticultural Plants at Snowidza and from the Department of Outdoor Vegetable Production of the Institute of Vegetable Crops at Skierniewice. The field experiment with comparision of home-grown and foreign cultivars was conducted in 1981 in the Department of Outdoor Vegetable Production at Skierniewice.

The effect of the region of cultivation on the total nitrogen content in beans was carried out in the Department of Outdoor Vegetable Production at Skierniewice and in the Breeding Station of Horticultural Plants at Igolomia, near Kraków. Fractionation of bean proteins was done for the seeds if five cultivars of *Phaseolus vulgaris*; Bomba, Słowianka, Igolomska, Biała Wyborowa, Jubilatka and one cultivar of *Phaseolus multiflorus*, Piękny Jaś. Before protein fractionation, the homogenized seeds were defatted with petroleum benzine. Albumins, globulins, glutelins and prolamins were extracted according to Pant and Tulsiani (1969). Total nitrogen, protein nitrogen and nitrogen of each protein fraction were determined by the Kjeldahl method. The protein content was analyzed according to the Official Methods of Analysis (Gaines, 1977) and was based on the precipitation of proteins in

a $10^{0}/_{0}$ solution of TCA. The protein was also determined by another method based on the amino acid composition of protein (Kosson, unpublished data, Kosson and Bakowski, 1980).

RESULTS AND DISCUSSION

The results of the determination of the total nitrogen content in the domestic-grown and foreign cultivars are shown in Tables 1-2.

It was found that the total nitrogen content in 13 Polish cultivars of bean may oscilate from $3.26^{\circ}/_{0}$ to $4.31^{\circ}/_{0}$, on average $3.83^{\circ}/_{0}$ (Table 1). Significant

Table 1

Total nitrogen content in domestic-grown cultivars of bean

	Location of cultivation			
Cultivar	Institute of Vegetable Crops in Skierniewice	SHRO Igolomia near Kraków		
	total nitrogen (g/100 g of dry matter)			
Wiejska	4.20±0.18*	4.08 ± 0.00		
Biała Wyborowa	3.95 ± 0.10	3.88 ± 0.01		
Igołomska	3.31 ± 0.09	3.38 ± 0.14		
Słowianka	3.47 ± 0.08	3.34 ± 0.25		
Piękny Jaś	3.26 ± 0.26	3.12±0.12		
Bomba	4.31 ± 0.18			
RAH-179	4.21 ± 0.05			
Atut	4.41 ± 0.00			
Bor	4.06 ± 0.05			
Jubilatka	3.87 ± 0.16			
Aura	3.78 ± 0.00			
Perłowa Żółtostrąkowa**	3.65 ± 0.00			
Vistula**	3.59 ± 0.10			
Mean	3.83			

^{* -} Mean value ± confidence limits at p = 0.95, evaluated according to the Dean and Dixon test.

differences in total nitrogen content were found between the investigated cultivars. The highest total nitrogen content was in cultivars Bomba and RAH-179, the lowest in Piękny Jaś and Igołomska. The average total nitrogen content in Polish cultivars was lower by $0.30^{\circ}/_{0}$ as compared to foreign ones.

The field experiment with five cultivars, Wiejska, Biała Wyborowa, Igołomska, Słowianka and Piękny Jaś, grown in the Breeding Station of Horticultural Plants at Igołomia and in the Institute of Vegetable Crops at

^{** -} Cultivars from SHRO Snowidza.

Table 2

Total nitrogen content in seeds of foreign bean cultivars grown in Skierniewice

Cultivar	Country of origin	Total nitrogen (g/100 g of dry matter)		
Red Kote	USA	4.72 ± 0.07		
Sanilac	-,,-	4.53 ± 0.07		
California	-,,-	4.50 ± 0.05		
Royal Red	-,,-	4.27 ± 0.07		
T-39	-,,-	4.25 ± 0.09		
Ui-114	-,,-	4.20 ± 0.12		
Red Cloud	-,,-	3.87 ± 0.04		
TV-203	Netherlands	4.07 ± 0.40		
TV-206	-,,-	4.01 ± 0.07		
TV-207	-,,-	4.01 ± 0.03		
TV-205	-,,-	3.88 ± 0.07		
VOR-RS	-,,-	3.83 ± 0.01		
Allerfrüheste				
Weisse	France	3.58 ± 0.08		
Mean		4.13		

Skierniewice, showed no significant differences in the total nitrogen content (Table 1).

The obtained results agree with earlier studies of Tandon et al. (1957); Rutger (1970); Koehler and Burke (1981) on the effect of the bean cultivar on the protein content in seeds. Other authors suggest that soil-climatic conditions of growth affect the protein content in beans (Lantz et al., 1958; Posypanov et al., 1978; Posypanov and Bukhanova, 1980).

From the point of view of total protein content (as total nitrogen \times 6.25) domestic-grown cultivars are similar to beans cultivated in North America and South America (Lantz et al., 1958; Koehler and Burke, 1981; Sgarbieri et al., 1979; Marquez and Lajolo, 1981).

Only part of the total nitrogen in bean seeds comes from proteins. As shown in Table 3, about $82^{0}/_{0}$ of the total nitrogen comes from proteins. There were no significant differences in protein nitrogen contents (expressed as a percent of total nitrogen content) between the investigated cultivars, irrespective of total nitrogen content. The protein nitrogen content determined by two methods, is significantly different in the analyzed cultivars (Table 4).

The globulin content of beans, expressed as globulin nitrogen, fluctuated in the total nitrogen ratio from $51.97^{\circ}/_{\circ}$ (Jubilatka cv.) to $65.72^{\circ}/_{\circ}$ (Igołomska cv.) (Table 5). Similar results were obtained by Ishino and Ortega (1975) for beans cultivated in Central America, and Pant and Tulsiani (1969) for beans cultivated in India.

Table 3

Total nitrogen and protein nitrogen contens in bean seeds according to the AOAC method (Gaines, 1977)

Cultivar	Total nitrogen (g/100 g of dry matter)	Protein nitrogen (g/100 g of dry matter)	% of protein nitrogen
Bomba	4.28	3.53 ± 0.12	82.55 ± 2.73
Słowianka	3.40	2.80 ± 0.04	82.35 ± 1.16
Igołomska	3.48	2.83 ± 0.04	81.32 ± 1.13
Piękny Jaś	3.22	2.66 ± 0.00	82.61 ± 0.00
Biała Wyborowa	3.88	3.25 ± 0.04	83.76 ± 1.00
Jubilatka	3.95	3.20 ± 0.04	81.02 ± 0.99
Mean	3.70	3.05	82.27

Table 4

Protein nitrogen content determined by the amino acid composition method and by the AOAC method

	Protein nitrogen			
Cultivar	according to amino acid composition method	according to AOAC method		
	g of protein nitrogen/100 g of dry matter			
Bomba	3.48 ± 0.06	3.53 ± 0.12		
Słowianka	2.80 ± 0.01	2.80 ± 0.04		
Igołomska	2.94 ± 0.06	2.83 ± 0.04		
Piękny Jaś	2.70 ± 0.06	2.66 ± 0.00		
Biała Wyborowa	3.05 ± 0.12	3.25 ± 0.04		

The second group of proteins present in bean seeds is albumins. Their highest content was found in Jubilatka $-26.19^{\circ}/_{\circ}$, Piękny Jaś $-19.70^{\circ}/_{\circ}$, Bomba $-18.06^{\circ}/_{\circ}$ and the lowest content was found in Igolomska $-12.83^{\circ}/_{\circ}$. Considerable differentiation of albumin content can be observed among the investigated cultivars. The above results confirm earlier investigations of Sgarbieri et al. (1979), Pusztai et al. (1979), Marquez and Lajolo (1981), Pant and Tulsiani (1969).

Because of their insigificant contribution, the content of glutelins, prolamins and conjugated proteins is given in Table 5 as a sum of these fractions. The non-protein nitrogen content in the investigated bean seeds fluctuated from $13.9^{\circ}/_{0}$ to $23.1^{\circ}/_{0}$, depending on the cultivar.

Table 5

Protein fraction composition of bean seeds $\left(\frac{\text{nitrogen of faction}}{\text{total nitrogen}}100\right)$

	Bean cultivar					
Fraction	Bomba	Słowianka	Igołomska	Piękny Jaś	Biała Wyborowa	Jubilatka
Globulins	58.73 ± 2.23*	63.32 ± 4.03	65.72 ± 2.40	56.38 ± 0.59	54.40 ± 1.30	51.97 ± 1.18
Albumins	18.06 ± 1.28	16.65 ± 2.73	12.83 ± 2.16	19.70 ± 3.60	17.20 ± 0.00	26.19 ± 0.29
Glutelins Prolamins Conjugated proteins	9.65 ± 0.07	4.35±0.65	5.58 ± 0.10	11.65 ± 0.43	6.80 ± 0.00	5.98 ± 0.00
Non-protein nitrogen	13.88 ± 0.61	16.02 ± 1.21	17.73 ± 0.66	18.00 ± 0.36	23.13 ± 3.71	15.87 ± 2.08

^{*} Mean value ± confidence limits at p = 0.95 evaluated according to the Dean and Dixon test.

REFERENCES

- Basha S. M. M., Beevers L., 1975. The development of proteolytic activity and protein degradation during the germination of *Pisum sativum L. Planta* 124: 77.
- Gaines T. P., 1977. Determination of protein nitrogen in plants. JAOAC, 60, 3: 590-593.
- Gottschalk W., Miller H. P., Wolff G., 1976. Evaluation of seed protein alternations by mutation breeding. IAEA, Viena.
- Ishino K., Ortega M. L. D., 1975. Fractionation and characterization of major reserve proteins from seeds of *Phaseolus vulgaris*. J. Agric. Food Chem. 23, 3: 529-533.
- Koehler H. H., Burke D. W., 1981. Nutrient composition, sensory characteristics and texture measurements of seven cultivars of dry beans. J. Amer. Soc. Hort. Sci. 106, 3: 313-318.
- Kosson R., Bakowski J., 1980. Skład aminokwasowy a zawartość białka w pieczarkach hodowlanych. Przem. Spoż. 4: 144-146.
- Kulka K., Grzesiuk S., 1978. Białka nasion strączkowych. Post. Nauk Roln. 1: 53-90.
- Lantz E. M., Gough H. W., Cambell A. M., 1958. Effect of variety, location and years on the protein and amino acid content of dried beans. J. Agric. Food Chem. 6: 58-60.
- Marquez U. M. L., Lajolo F. M., 1971. Composition and digestibility of albumin, globulin and glutelin from *Phaseolus vulgaris*. J. Agric. Food Chem. 29: 1068-1074.
- Mironenko A. W., 1975. Biokhimja ljupina. Izd. Nauka i Tekhnika, Minsk.
- Pant R., Tulsiani D. R. P., 1971. Solubility, amino acid composition and biological evaluation of proteins isolated from leguminous seeds. J. Agric. Food Chem. 17, 2: 361-366.
- Posypanov G. S., Bukhanova Ł. A., 1980. Soderzhanie svobodnykh aminokislot w semenakh fasoli v zavisimosti ot uslovja wyrashchivanija. Izviestija TSCHA 6: 183.
- Posypanov G. S., Bukhanova Ł. A., Demjanov S. I., 1978. Aminokislotnyjj sostav semjan fasoli w zavisimosti ot uslovja vyrashhivanija. Izviestija TSCHA 3: 125-130.
- Pusztai A., Clarke E. M. W., King T. P., Stewart J. C., 1979. Nutritional evaluation of kidney beans (*Phaseolus vulgaris*). Chemical composition, lecitin content and nutritional value of selected cultivars. J. Sci. Food Agric. 30: 843-848.
- Rutger J. N., 1970. Variation in protein content and its relation to other characters in beans *Phaseolus vulgaris* L. Dry Bean Res. Conf. Davis, Calif. 10: 59-69.

- Sajanova V. V., Gofman J. J., 1965. Ob opredelenii soderzhanija albuminov semjan. Biokhimija 2: 209-211.
- Sgarbieri V. C., Antunes P. L., Almeida L. D., 1979. Nutritional evaluation of four varieties of dry bean (*Ph. vulgaris L*). J. Food Sic. 44: 1306-1308.
- Tandon O. B., Bressani R., Scrimshaw N. S., 1957. Nutrients in Central America beans. J. Agric. Food Chem. 5: 137.
- Woolfe J. A., Hamblin J., 1974. Within and between genotypes variation in crude protein content of *Phaseolus vulgaris* L. Euphytica 23: 121.

Zawartość azotu w odmianach fasoli uprawianej na suche nasiona

Streszczenie

Scharakteryzowano polskie odmiany fasoli uprawiane na suche nasiona pod względem zawartości azotu ogólnego i białkowego na tle odmian zagranicznych. Stwierdzono, że średnia zawartość azotu ogólnego w polskich odmianach fasoli jest nieznacznie niższa — około $0.3^{\rm o}/_{\rm o}$ — w porównaniu z odmianami zagranicznymi. Nasiona tych samych odmian uprawianych w 2 różnych rejonach nie różnią się zawartością azotu ogólnego. Procentowa zawartość azotu białkowego w nasionach nie zależy od zawartości azotu ogólnego w poszczególnych odmianach i stanowi średnio $82.2^{\rm o}/_{\rm o}$ azotu ogólnego.

Na podstawie zróżnicowanej rozpuszczalności białek fasoli oznaczano zawartość albumin, globulin, i innych frakcji w nasionach sześciu odmian fasoli uprawianej na suche nasiona. Stwierdzono, że globuliny stanowią dominującą frakcję białek — średnio około $60^{0}/_{0}$ azotu ogólnego.