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DIETARY FIBER CONTENT IN SOME DRY BEANS

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Dietary fibers are one of the main nutritive components, along with proteins, fats and oils, carbohydrates, minerals and vitamins. Also, they are one of the basic parameters of dry beans technological quality and nutritive value. Physical characteristics and the main chemical composition of sixteen dry bean varieties (Phaseolus vulgaris) had been examined in this study. Using statistical analyses, correlation between certain parameters of chemical composition was established.

KEY WORDS: Dry beans, physical characteristics, chemical composition, dietary fibers

INTRODUCTION

Dry beans (*Phaseolus vulgaris*) are very important in human diet (1, 2). They are one of the most important sources of plant proteins, carbohydrates, soluble and insoluble fibers, certain minerals and vitamins (3, 4, 5). Dietary fiber content is one of the most important parameters of technological quality and physiological value of dry beans and other legumes (6).

The definition of dietary fibers is still controversial and several definitions have been suggested. The most widely accepted definition is a physiological one, in which "dietary fibers" correspond to the plant wall residues that are resistant to enzymatic hydrolysis in the small intestine. A chemical definition describes dietary fibers as non-starch polysaccharides. The most commonly used definition of dietary fibers is the following: "dietary fibres are oligosaccharides, polysaccharides and the (hydrophilic) derivatives which cannot be digested by the human digestive enzymes to absorbable components in the upper alimentary tract" (7).

Dietary fibers do not constitute a defined chemical group, but are a combination of chemically heterogeneous substances such as celluloses, hemicelluloses, pectins, lignins, gums and polysaccharides from seaweeds or bacteria. Celluloses, hemicelluloses and pectins, also referred to as structural components of cell walls are also classified as dietary fibers: secreted gums (e.g. gum arabic), reserve gums (bean gums, guar gums) and poly-

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saccharides from seaweeds (carrageenans, agar, alginates); some workers also include resistant starch (fractions of starch that are not digested by small intestinal enzymes). Since then, intensive research of the role and importance of these compounds has been done (8). Dietary fibers show a number of health benefits, like prevention of cardiovascular diseases, decrease in blood cholesterol and glucose level, prevention of digestive system carcinogenic diseases, constipation prevention, etc (9).

The aim of this paper is to compare dietary fiber content in Serbian and bean varieties from other countries. The hierarhical cluster method of the multivariate analysis was used to classify the tested varieties according to the chemical composition of all dietary fiber. Their relative relationship regarding the total dietary fiber content was also examined.

EXPERIMENTAL

Sixteen dry beans varieties - domestic (Levač, Panonski tetovac, Balkan, Dvadesetica, Aster, Belko, Sremac, Galeb, Zlatko, Jovandeka, Slavonski Zeleni) and foreign (Spinel, Naya Nayahit, C-20, Igman and Prelom) were examined in this work. All samples were grown at the Institute of Field and Vegetable Crops, Novi Sad, Rimski Šančevi, in 2006.

The physical analyses of dry bean seeds were done in sample of 50 seeds. Physical measurements were done in whole seeds. Classification according to color of seed coat was performed visually. Determination of shape of bean seeds was conducted by the method of Dekaprelevic (3). According to the seed length-to-width and thickness-to-width ratio, the examined genotypes were classified into five botanical forms or groups (10).

Dry beans were milled and stored in hermetically closed jars. Chemical analyses included total dry matter (11); total dietary fibers (12); cellulose according to Kirschner-Gannak method (13), and pectin compounds (14, 15).

Pearson coefficient of correlation among traits were calculated. Hierarchical clustering of varieties (Single linkage method or nearest neighbour by Euclidean distance for Distance metric) was done using a computer statistical package STATISTICA.

RESULTS AND DISCUSSION

As has been said above, eleven domestic and five foreign varieties were chosen for the study. Domestic varieties have been currently used in the industry (2), while foreign varieties were chosen due to their origin and wide dispersion (16). All beans are from *Phaseolus vulgaris* species, except for Igman, which is from *Phaseolus coccineus*. In Serbia, varietis with determinate growth (I type of habitus) have been grown, and these were the samples of this research. Five varieties were indeterminate, while three of them upright (II type of habitus), and Spinel was type III of growth. Variety Levač is typical tetovac, internationally recognized market class from the Balkan Peninsula with IV type of growth (17). The origin, status, type of habitus, seed color and shape, and 1000 seed mass are given in Tables 1 and 2.

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Table 1. The main characteristics of dry bean samples

No.	Genotype	Origin of genotype	Status	Type of habitus
1	Levač	Serbia IFVCNS	Variety	IV
2	Aster	Serbia IFVCNS	Variety	I
3	Spinel	USA	Variety	III
4	Panonski tetovac	Serbia IVCSP	Variety	I
5	Balkan	Serbia IFVCNS	Variety	I
6	Naya nayahit	USA	Variety	II
7	Dvadesetica	Serbia IFVCNS	Variety	I
8	Sremac	Serbia IFVCNS	Variety	I
9	Jovandeka	Serbia	Landraces	I
10	Galeb	Serbia IVCSP	Variety	I
11	Prelom	Bulgaria	Variety	II
12	Belko	Serbia IFVCNS	Variety	I
13	C-20	USA	Variety	II
14	Igman	Bosnia and Herzegovina	Variety	I
15	Zlatko	Serbia IFVCNS	Variety	I
16	Slavonski zeleni	Serbia	Landraces	I

Seed color, seed shape and seed size according to mass of 1000 seeds are quality traits, important market characteristics and a stable cultivar trait (4, 18). Examined species could be distinguished according to seed color, and most had white seeds. The seeds had one of four shape forms (Table 2). The variation in 1000-seed mass from 161.8 g to 648.5 g measured in this study indicates that the tested genotypes differed significantly in their seed size.

Table 2. Seed color and shape and 1000 seed mass of dry bean samples

No.	Genotype	Seed colour		Seed shape		1000 seed mass
		English	Form	English	Form	
1	Levač	white	*albus*	kidney	*compressus*	592.7
2	Aster	white	*albus*	cylindr.	*oblongus*	412.0
3	Spinel	white	*albus*	semi-flat	*subcompr.*	329.9
4	Panonski tetovac	white	*albus*	semi-flat	*subcompr.*	394.8
5	Balkan	white	*albus*	ellipsoid	*ellipticus*	317.7
6	Naya nayahit	black	*niger*	ellipsoid	*ellipticus*	168.3
7	Dvadesetica	white	*albus*	kidney	*compressus*	339.8
8	Sremac	greenish-yellow	*griseus*	cylindr.	*oblongus*	349.2
9	Jovandeka	seed coat patterns	*versicolor*	cylindr.	*oblongus*	405.0
10	Galeb	white	*albus*	ellipsoid	*ellipticus*	353.7
11	Prelom	white	*albus*	ellipsoid	*ellipticus*	223.0
12	Belko	white	*albus*	ellipsoid	*ellipticus*	294.1

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Table 2. Continuation

No.	Genotype	Seed colour		Seed shape		1000 seed mass
		English	Form	English	Form	
13	C-20	white	*albus*	ellipsoid	*ellipticus*	179.2
14	Igman	white	*albus*	ellipsoid	*ellipticus*	648.5
15	Zlatko	gold-yellow	*aureus*	cylindr.	*oblongus*	380.0
16	Slavonski zeleni	greenish-yellow	*griseus*	cylindr.	*oblongus*	342.5

Dry matter symbolizes the content of chemical compounds out of water. It consists of soluble (sugars, acids, etc.) and insoluble compounds (starch, cellulose, hemicellulose, protopectin, etc.). In our research, the lowest dry matter was measured in the variety C-20, and the highest in Igman (Table 3), which are higher values than those given by Kojnov (3), Costa et al. (6) and Todorović et al. (2).

Table 3. Total dietary fiber (TDF), cellulose and pectin content (g/100g dry matter) in dry bean samples

Genotype	Dry matter	TDF	Cellulose	Pectins			
				pectin	pectic acid	protopectin	total
Levač	90.57	21.22	4.23	0.61	0.23	1.16	2.00
Aster	90.67	26.97	4.84	0.66	0.27	1.78	2.71
Spinel	92.00	30.62	4.36	0.45	0.25	1.46	2.16
Panonski tetovac	91.32	21.74	4.84	0.54	0.19	2.46	3.19
Balkan	90.65	17.98	3.88	0.38	0.24	2.00	2.62
Naya nayahit	90.61	30.96	3.68	0.28	0.14	1.51	1.93
Dvadesetica	90.46	31.69	5.33	0.41	0.15	1.47	2.04
Sremac	90.85	19.20	3.93	0.34	0.19	1.20	1.73
Jovandeka	91.69	27.58	3.47	0.38	0.15	1.24	1.77
Galeb	91.11	30.93	4.29	0.35	0.17	1.59	2.12
Prelom	90.83	19.12	4.52	0.38	0.19	1.51	2.08
Belko	90.80	33.76	4.15	0.59	0.22	1.23	2.04
C-20	90.45	26.50	4.05	0.42	0.17	1.28	1.87
Igman	92.46	25.14	5.45	0.31	0.12	0.87	1.30
Zlatko	91.27	23.82	3.65	0.47	0.19	1.32	1.99
Slavonski zeleni	91.05	27.55	4.20	0.35	0.19	1.48	2.02
Mean	91.05	25.92	4.30	0.43	0.19	1.47	2.10

As dietary fibers are compounds from edible parts of plants, resistant to digestion and absorption in human intestine, and prone to complete or partial fermentation in human colon, they have a growing importance in the diet of modern people, being exposed to stress and environmental pollution. In this research, cellulose, pectic acid and protopectin are characterized as insoluble, and pectin as soluble dietary fiber.

According to the literature, dry beans contain 15-25% of TDF (19, 20, 21, 6), which was also confirmed by this research (Table 3). Examined dry bean varieties contained 17.98-33.76 % (in dry matter), with mean value of 25.92%. According to the results of this work, dry beans can be characterized as rich in dietary fibers.

Dry beans belong to cellulose-rich foods. Vasić et al. (22) reported cellulose content in dry beans of 3.83-5.43%, Granito et al. (21) 4.65-5.61%, while Tepić et al. (5) reported 3.47-3.89%. In this research, cellulose content in dry beans was in the range from 3.18% for Jovandeka to 5.04% for Igman. The mean value of 4.30% agrees well with the literature data.

Pectin compounds are of polysaccharide origin, and are considered as soluble fibers. They can be found in all fruits and vegetables. Pectin compounds have beneficial effects in human organism, as lowering fats and cholesterol absorption, influencing the maintenance of glucose level in blood, increase the feces mass, thus preventing cardiovascular and digestion system carcinogenic diseases, etc. (9, 8). Because of the importance of pectins, dry beans should be included in the diet.

Among examined dry bean varieties, Igman contained the least pectin compounds (1.21%) (Table 3). Panonski Tetovac was the variety richest in pectin compounds, with 2.91%. In average, the examined dry beans had 2.10% of total pectin compounds. Pectin content was the lowest for Igman, and highest for Aster (0.30 and 0.60%, respectively); lowest and highest pectic acid content was for Igman (0.11%) and Aster (0.24%), respectively; the poorest in protopectin was Igman (0.80%) and richest Panonski Tetovac (2.25%).

The mutual correspondence between different pectin compounds is more obvious after the analyses of correlation between all features (Table 4). All pectin compounds are in significant correlation with total pectin content, with protopectin being in almost complete correlation (r = 0.95). Pectic acid and pectin are also in high correlation. However, they are not in correlation with protopectin.

Table 4. Pearson's coefficients of correlation between examined dry bean features

	Habitus	**Seed color**	**Seed shape**	**1000 seed mass**	**Dry matter**	**TDF**	**Cellulose**	**Total pectins**	**Pectin**	**Pectic acid**
Origin	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Habitus	1.00									
Seed color	-0.29	1.00								
Seed shape	0.44	-0.22	1.00							
1000 seed mass	-	-	0.36	1.00						
Dry matter	-	-	-	**0.51***	1.0					
TDF	-	-	-	-0.21	-	1.00				
Cellulose	-	**-0.60***	0.35	0.42	0.21	-	1.00			
Total pectins	-	-0.29	0.24	-	-0.28	-	-	1.00		

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Table 4. Continuation

	Habitus	Seed color	Seed shape	1000 seed mass	Dry matter	TDF	Cellulose	Total pectins	Pectin	Pectic acid
Pectin	0.23	-0.23	0.43	0.25	-0.23	-	-	**0.52***	1.00	
Pectic acid	0.28	-0.23	0.21	-	-0.24	-	-	**0.57***	**0.70***	1.00
Protopectin	-0.22	-0.25	-	-0.27	-0.23	-0.21	-	**0.95***	0.23	0.35
*p = 0,05, r = 0.05										

Among mutual correlation between pectin compounds, only two more signifficant correlations were observed – (dry matter content : 1000 seed mass) and (seed color : cellulose content) (Table 3). The dependence between seed color and cellulose content was also observed in previous investigations (3, 18, 16), especially when they were more detailed and connected with edible and technological quality of seeds (4, 17).

In the research aiming at examining a larger number of genotypes, the most effective way of perceiveing the whole set of data is the use of some methods of multivariate analyses. The hierarhical cluster method (Single linkage method or nearest neighbor) of multivariate analysis was used to classify the tested varieties according to the chemical composition of all dietary fiber, out of origin, type of habitus and seed color and shape. The dendogram or Cluster Tree (Figure 1.) was constructed using the Euclidien distance.

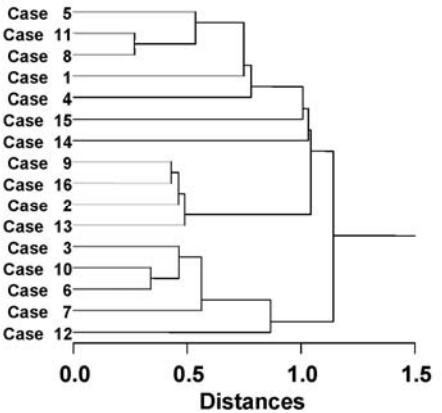

Fig. 1. Dendogram of connection of examined dry bean varieties depending on their dry matter and dietary fiber content

The distances are not high (1.5), but from cluster tree, there are clearly distinguisheable three groups, with four members and four genotypes, which make a separate group. In each separate group, one genotype with colored seed, of domestic and foreign variety, of different type of growth is placed, which points out that TDF content was not in correlation with the main morphological features of dry beans. The dendogram starts with

the group of varieties with lowest TDF content, and ends up with the group of varieties containing a maximum of TDF. The most distant, i.e. the most different from other varieties, was Belko, with the highest TDF, and Igman with highest dry matter.

CONCLUSION

According to the correlation between pectin compounds content in dry beans, their mutual correspondence was observed. Two more significant correlations, between dry matter-to-1000 seed mass, and seed colour-to-cellulose content, were also noticed. The hierarchical cluster method of multivariate analyses showed that TDF content was not in correlation with the main morphological features of eleven examined dry beans varieties, which should be a subject of further research in dietary fiber distribution in dry bean seeds. However, on the basis of total dietary fiber content, dry beans can be characterized as dietary fiber-rich food.

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САДРЖАЈ ДИЈЕТЕТСКИХ ВЛАКАНА У НЕКИМ СОРТАМА ПАСУЉА

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Дијететска влакна се сматрају основним хранљивим компонентама, заједно са протеинима, мастима, угљеним хидратима, минералима и витаминима. Један од основних параметара технолошког квалитета и нутритивне вредности пасуља је и садржај дијететских влакана. У раду су испитане физичке карактеристике и садржај основних компоненти хемијског састава шеснаест сорти пасуља селекције Научног института за ратарство и повртарство, са посебним освртом на садржај дијететских влакана. Статистичком анализом утврђена је корелација између појединих параметара хемијског састава.

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