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Variations in Grain Properties of Dry Bean (*Phaseolus vulgaris* L.)

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Abstract: Grain samples, collected for analysis six dry bean cultivars (Şehirali-90, Karacaşehir, Akman-98, Göynük-98, Öncüler-98 and Yunus-90) currently cultivated in Turkey, were analyzed for their thousand seed weight, protein, oil, cellulose, ash potassium, calcium, phosphorous, magnesium, sodium, iron and zinc content. Analyses of variance were important differences amongst the cultivars for all the properties studied and different groups were obtained by LSD range test. The highest protein content (28.78%) was obtained in Karacaşehir. The positive correlations were found between protein content and calcium (r = 0.954**), oil (r = 0.840**) and phosphorous content (r = 0.791**), while protein content correlated significant negatively with cellulose (r = -0.807**) and moisture content (r = −0.756**). The findings of this research will be useful for breeders in dry bean.

Key words: Dry bean, plant protein, mineral content

Introduction

Plants proteins provide 65% of the world protein supply for humans, with 45-50% coming from legumes and cereals, mainly for the populations of developing countries and vegetarians of the industrialized nations (Mahe *et al*., 1994). Food legumes are characterized by a relatively large content of proteins and carbohydrates. In general, pulses also contain significant amounts of minerals and vitamins and at the same time are poor in fats and sodium (Torija and Diez, 1999). Legumes in general contain appreciable quantities of iron and other minerals. Although legumes are often cited as a complement to cereals in terms of amino acid content, they also make a particularly important contribution to micro nutrient nutrition. The dry bean is most important grain legume for direct human consumption, being especially important in Eastern Africa, Asia and Latin America.

Micronutrients in foodstuffs include vitamins and minerals elements, as components which are found in very small amounts, but with an essential role in the metabolism of human body. Nutritional because trace metals such as Ca, Mg, Zn, Fe, P and K are necessary for maintenance of optimum health. Deficiencies of Fe, Zn, I and vitamin A in human populations are widespread, affecting up to two billion people (Anonymous, 1992).

The amount of nutrient per seed is more important measure of micronutrient supply in grain for human food than the total amount of nutrient per seed (Rengel *et al*., 1999). As seed develops on the parent plant, concentration of nutrients in seed is dependent on soil type, nutrient availability and crop species and to a lesser extent, season and cultivars (Ascher *et al*., 1994).

Plant breeders have recognized the importance of considering the quality requirements of end users when developing new varieties of pulse crops. Proteins are major components of grain legumes and their nutritional and functional properties dramatically affect the overall quality of seed (Duranti and Gius, 1997). Breeding a variety rich in protein content will also require consideration of some minerals elements of the grain.

Protein improvement in legumes has been hampered because breeding programmes have produced cultivars primarily for high yield and correlations between yield and seed protein have generally been negative (Henry *et al*., 1995). Negative correlations between protein content and thousand seed weight, cellulose content, but weak correlations protein content and nitrogen-free extracts, have been reported for dry bean seeds (Önder and Babaoglu, 2001). Environmental conditions exert significant influences on the chemical composition of bean (Beebe *et al*., 1999) and significant genetic variations in the chemical compositions (e.g., protein and Ca, Mg, Zn, Fe, P) of bean seeds have been (Beebe *et al*., 1999 and Mubarak, 2005).

The nutritional value of a food given mineral depends on the mineral content. Therefore, this study described here aimed at exploring potentially useful variability in quality characteristics among genetically diverse dry bean genotypes, so as to provide plant breeders with information on potential material for the selection criteria to be used in breeding programmes.

Materials and Methods

The six dry bean cultivars (Şehirali-90, Karacaşehir, Akman-98, Göynük-98, Öncüler-98 and Yunus-90) were taken from Anatolia Agriculture Research Institute. The dry beans were grown during the 2001 summer season in the farm of Cumra Agriculture Collage in Central Anatolia and were used in all laboratory experiments. The soil at the region had a pH 8.20 and soil phosphorous, nitrogen, potassium, calcium and organic matter were 55.9, 1.01, 2.2, 269 kg ha^{-1} and 1.87%, respectively. The crop in the previous year was a cereal. The fertilizer rate of 30 kg ha nitrogen was applied during sowing as Ammonium sulfate (21: N). Dry bean seeds were taken samples from the experimental. The thousand seed weight was determined by weighing 500 seeds in three replicates. Seeds were cleaned to remove foreign material and broken seeds before analysis. Protein, oil and cellulose contents were determined according to the Kjeldahl, Soxlet and Weender methods, respectively, using ground seeds. Kjeldahl nitrogen values were multiplied by 6.25 to obtain crude protein values. Ash content was measured by burning the ground material at 600°C, while moisture content was determined after placing the ground seeds in an oven at 105°C for 3 h. The 0.5 g ground material was digested with concentrate HNO_3 in Microwave system. Potassium, calcium, phosphorous, magnesium, sodium, iron and zinc in extracts were analyzed by ICP-AES (Varian-Vista Model). These values were expressed as mg/kg dry matter.

All data were subjected to a randomized complete blocks model of ANOVA and F-test applied to examine the statistical significance of differences amongst the varieties. Experimental data were analyzed by using TARIST.

Results and Discussion

All variables were significantly differences amongst the varieties (Table 1). TSW of 6 genotypes ranged from 182.21 to 407.44 g. TSW was highest in Göynük 98 (407.44 g) and lowest in Karacasehir (182.21 g) (Table 2). Similar interspecific variations have been reported earlier by Akcin (1974), Akdag (1997) and Önder and Babaoglu (2001). Significant positive genotypic correlations were found between thousand seed weight and cellulose content, zinc content and moisture content, whereas thousand seed weight was negatively correlated with protein content, oil content, calcium content and iron content (Table 3). These results are similar to that reported by Önder and Babaoglu (2001) for thousand seed weight, oil content and protein content.

Table 1: Summary of ANOVA for variables examined in various dry bean cultivars

SOV	SD	Thousand seed weight	Protein content	Oil content	Cellulose content	Ash content	Moisture content	Potassium content
General	17	4937.036	5.902	0.114	1.177	0.012	0.149	18461.626
Cultivars	5	16781.937**	19.924**	0.382**	3.995**	0.037**	0.499**	60803.822**
Error	12	1.661	0.060	0.002	0.003	0.001	0.003	819.045

Table 1: Continuous

SOV	SD	Calcium content	Phosphorous content	Magnesium content	Sodium content	Iron content	Zinc content
General	17	1426.206	1797.818	77.591	17.846	0.564	0.585
Cultivars	5	4817.394**	6055.288**	243.492**	56.993**	1.845**	0.001 **
Error	12	13.211	23.873	8.466	1.535	0.030	0.018**:

$p<0.01$

Table 2: Mean data and statistical groups of various dry bean cultivars with respect to variable analyzed

Cultivars	Thousand seed weight (g)	Protein content (%)	Oil content (%)	Cellulose content (%)	Ash content (%)	Moisture content (%)	Potassium Content (mg/100 g)
Şehirali 90	351.63b[1]	22.26d	1.54de	8.87a	3.50bc	7.07a	1873.88c
Karacaşehir	182.21f	28.78a	2.47a	5.57f	3.51b	6.10e	1919.61c
Akman 98	301.74e	23.49c	1.71c	6.79e	3.31d	6.32d	2248.34a
Göynük 98	407.44a	23.49c	1.87b	7.93d	3.53b	6.46c	1895.76c
Öncüler 98	329.81c	21.46e	1.63cd	8.13c	3.66a	6.89b	2079.68b
Yunus 90	322.67d	24.58b	1.51e	8.35b	3.43c	6.10e	2016.62b
Mean	315.92	24.01	1.79	7.61	3.49	6.49	2005.651

Table 2: Continuous

Cultivars	Calcium content (mg/100 g)	Phosphorous content (mg/100 g)	Magnesium content (mg/100 g)	Sodium content (mg/100 g)	Iron content (mg/100 g)	Zinc content (mg/100 g)
Şehirali 90	122.90c	663.66e	185.59b	49.01b	7.73c	2.25a
Karacaşehir	213.32a	770.50a	184.36b	54.65a	8.24b	1.85d
Akman 98	126.21c	713.98d	195.42a	43.15c	7.27d	2.05c
Göynük 98	143.21b	756.78b	172.75c	53.16a	6.70e	2.03c
Öncüler 98	94.60d	670.16e	176.51c	48.82b	8.85a	2.17b
Yunus 90	129.00c	742.29c	193.65a	45.61c	7.46cd	2.13b
Mean	138.21	719.56	184.71	49.07	7.71	2.08

[1]Means in the same row different letters are significantly different ($p<0.01$)

The protein content ranged from 21.46 to 28.78% of seed dry matter. The highest values were found in Karacasehir (28.78%). After Karacaşehir, Yunus-90 (24.58%), Akman-98 (23.49%) and Göynük-98 (23.49%) show the next highest levels of protein content. The remaining cultivars present lower contents: Sehirali-90, 22.26% and Öncüler-98, 21.46%. These results are agreed with the results obtained by Akcin (1974), Kadam *et al*. (1998), Önder and Babaoglu (2001) and Mubarak (2005). The positive correlations were found between protein content and calcium content, oil content and phosphorous content, while protein content correlated significant negatively with cellulose content and moisture content (Table 3). Önder and Babaoglu (2001) reported interaction with protein content and cellulose content.

The contents of oil found in this study range between 1.51 and 2.47%. The lowest content was found in Yunus-90. Karacaşehir had the highest content in this study. These results coincide with the data represents in the literature, which reveal that oil content represent between 1.44 and 2.84% (Önder and Babaoglu (2001) and Mubarak (2005)). Oil content was highly and positively correlated with calcium content, sodium content and phosphorous content, whereas the negative correlations were found between oil content and zinc content, cellulose content and moisture content (Table 3).

Table 3: Correlation coefficients between the grain variables and protein content in various bean cultivars

Variable	Thousand seed weight	Protein content	Oil content	Cellulose content	Ash content	Moisture content
Thousand seed W.	-----					
Protein content	-0.798**	-----				
Oil content	-0.707**	0.840**	-----			
Cellulose content	0.834**	-0.807**	-0.878**	-----		
Ash content	0.136	-0.208	0.064	0.265	-----	
Moisture content	0.492*	-0.756**	-0.478*	0.589*	0.486*	-----
Potassium content	-0.104	-0.242	-0.267	-0.163	-0.449	-0.182
Calcium content	-0.707**	0.954**	0.908**	-0.801**	-0.143	-0.612**
Phosphorous content	-0.347	0.791**	0.651**	-0.576*	-0.271	-0.877**
Magnesium content	-0.349	0.192	-0.197	-0.161	-0.795**	-0.403
Sodium content	-0.189	0.450	0.683**	-0.305	0.531*	-0.009
Iron content	-0.468*	0.001	0.131	-0.121	0.608**	0.304
Zinc content	0.655**	-0.850	-0.909**	0.890**	0.164	0.715**

Table 3: Continuous

Variable	Potassium content	Calcium content	Phosphorous content	Magnesium content	Sodium content	Iron content	Zinc content
Thousand seed W.							
Protein content							
Oil content							
Cellulose content							
Ash content							
Moisture content							
Potassium content	-----						
Calcium content	-0.393	-----					
Phosphorous content	-0.177	0.756**	-----				
Magnesium content	0.480*	0.018	0.024	-----			
Sodium content	-0.729**	0.612**	0.402	-0.693**	-----		
Iron content	0.075	-0.076	-0.419	-0.122	0.086	-----	
Zinc content	0.018	-0.85**	-0.806**	0.038	-0.468*	0.058	-----

*: p<0.05; **: p<0.01

Bean cultivars analyzed have cellulose contents ranging from 5.57 to 8.87%. The lowest content was found in Karacasehir and the highest in Sehirali-90. Previous finding indicated that bean cellulose content varies from 5.97 to 9.26% (Önder and Babaoglu (2001). The ash contents found range from 3.43 to 3.66%, levels that are similar to those described by other authors (Akçin (1974), Önder and Babaoglu (2001), Sanchez-Mata *et al.* (2003) and Mubarak (2005)). The moisture contents of cultivars were ranged from 6.10 (Karacasehir) to 7.07% (Sehirali-90). These results agree with the results of Akçin (1974), Önder and Babaoglu (2001) and Mubarak (2005), who found for moisture content in dry bean.

The positive correlations were found between ash content and iron content, between moisture content and zinc content. Cellulose content was negatively correlated with calcium content and phosphorous content. Ash content was most strongly negative associated with magnesium content. Moisture content had also a negative correlation with both calcium content and phosphorous content (Table 3).

Large variations resulted in statistically different groups with respect to potassium content (Şehirali-90, 1873.88 mg/100 g; Akman-98, 2248.34 mg/100 g), calcium content (Öncüler-98, 94.60 mg/100 g; Karacaşehir, 213.32 mg/100 g), phosphorous content (Şehirali-90, 663.66 mg/100 g; Karacaşehir, 770.50 mg/100 g), magnesium content (Göynük-98, 172.75 mg/100 g; Akman-98, 195.42 mg/100 g), sodium content (Akman-98, 43.15 mg/100 g; Karacasehir, 54.65 mg/100 g), iron content (Göynük-98, 6.70 mg/100 g; Öncüler-98, 8.85 mg/100 g) and zinc content (Karacaşehir, 1.85 mg/100 g; Şehirali-90, 2.25 mg/100 g) (Table 2). These results agree with reported by Beebe *et al.* (1999) and Mubarak (2005). Variations amongst the cultivars in the mineral composition can be attributed to varying genetic constitutions, similarly to previous reports by Beebe *et al.* (1999). As seed develops on the parent plant, concentration of nutrients in seed is dependent on soil type, nutrient availability and crop species and to a lesser extent, season and cultivars (Ascher *et al.*, 1994).

In this study, potassium content was significantly correlated with magnesium content. Similarly, calcium content had a positive correlation with both phosphorous content and sodium content. However, the negative correlations were found between potassium content and sodium content, between magnesium content and sodium content, between zinc content and calcium content, phosphorous content and sodium content. Other variables were unimportant; it could be positively and negatively correlation. This result is in agreement with reported by Bee *et al.* (1999), who found similar interrelations in bean.

Conclusions

The detailed descriptions of genotypes will be useful for pulse breeders in dry bean. The large variation observed in most of the properties measured increases their value. The positive correlations were found between protein content and calcium, oil and phosphorous content, while protein content correlated significant negatively with cellulose and moisture content. The findings of this research will be useful for breeders in dry bean

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