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CHEMICAL COMPOSITION OF WHOLE GRAINS IN COMMON BEANS LANDRACES AND BREEDING GENOTYPES

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ABSTRACT

The common bean has been object of breeding programs aiming the development of new cultivars adapted to varied production system and shown differentiated nutritional characteristics. Due a genetic diversity existent the landraces can be used directly for cropping, for present characteristics desirable. Little information exists about mineral content and other quality traits for those bean landraces. The aim of this paper was to verify the variability for grain nutritional characteristics in breeding cultivars and landraces of bean from Rio Grande do Sul state, Brazil. The experiment was conducted in 2009/2010 in Experimental Station Cascata, of Embrapa Temperate Agriculture. In whole grain of 54 bean genotypes with black and no black coat were determined macroelements (nitrogen, phosphorus, potash, calcium, magnesium and sulfur), oligoelements (iron, manganese, zinc and cuprum), protein and ash content, insoluble fiber, digestive nutrient and antioxidant astragalina. The results shown that the landraces varieties presents nutritional composition of macro and oligoelements, fibers, protein and ash contents in whole grain similar than that of breeding lines and cultivars. The black coat grain from breeding programs showed better nutritional quality for macro and oligoelements content than coloured grain, highlighting TB 02-04 e TB 01-01. The landraces with coloured grains TB 02-26, TB 02-24 and TB 03-13 showed the high levels of astragaline.

KEYWORDS: *Phaseolus vulgaris*. Macroelement. Oligoelement. Fiber. Protein. Astragaline. Correlation.

COMPOSIÇÃO QUÍMICA DE GRÃOS INTEIROS DE CULTIVARES CRIOULAS E MELHORADAS DE FEIJÃO

RESUMO

Os programas de melhoramento de feijão visam o desenvolvimento de novas cultivares adaptadas aos diferentes sistemas de cultivo, e que apresentem grãos com características nutricionais diferenciadas. Devido à diversidade genética, cultivares crioulas poderiam ser utilizadas por apresentarem tais características. Existem poucas informações sobre a composição química dos grãos de cultivares crioulas de feijão. O objetivo deste trabalho foi investigar a variabilidade existente entre genótipos de feijão oriundos da pesquisa e cultivares crioulas quanto a sua composição nutricional. O experimento foi conduzido em 2009/2010 na Embrapa Clima Temperado. Foram determinados os teores dos macronutrientes: nitrogênio, fósforo, potássio, cálcio, magnésio e enxofre, e dos micronutrientes: ferro, manganês, zinco e cobre, bem como proteína total, cinzas, fibra, nutrientes digestivos totais e do antioxidante astragalina, em 54 genótipos. As variedades crioulas apresentaram teor de macro e micronutrientes, nutrientes digestivos totais, fibra insolúvel, cinzas e proteína total em grãos inteiros de feijão semelhante às cultivares provenientes dos programas de melhoramento; as cultivares e linhagens do melhoramento de grão preto apresentaram-se nutricionalmente superiores quanto ao teor de macro e micronutrientes em relação às cultivares de grãos de cor, destacando-se TB 02-04 e TB 01-01; as maiores concentrações de astragalina foram encontradas em cultivares crioulas de tegumento não preto, destacando-se TB 02-26, TB 02-24 e TB 03-13.

PALAVRAS-CHAVE: *Phaseolus vulgaris*. Macronutriente. Micronutriente. Correlação. Astragalina. Fibras.

1 INTRODUCTION

The concern with global health and the importance of proper and effective nutrition with foods biologically safe are motivations for various research projects. As the beans are considered a staple food in Brazil and are consumed by all social classes, participate in specific research and breeding programs under the nutritional, economic and environmental point of view. The plant grown in different soil types and climates, is cultivated, preferably as subsistence crop, although in recent years has attracted the interest of large farmers using modern technologies of sowing and reaping. The grains is a particular food, having low biological protein value than compared with milk and meat, but the Brazilian people have the habit of eating rice and beans, making the value of vegetable protein close to the proteins of animal origin, as cited by Lajolo *et al*. (1996).

Food quality and economic viability has been common objectives in breeding programs in several countries. The bean breeding program of Embrapa are looking for cultivars that have highlighted features of the nutritional point of view due to the recognized fact that inadequate intake of micronutrients leads to numerous disorders and metabolic abnormalities (FRANCO, 1999). Minerals are vital nutrients for life and are found naturally in soil; are passed to the plant and its grain, which are consumed by animals and humans.

Beans are a major source of nutrients in the diet of Brazilians people, is likely to meet a significant portion of the main substances for maintaining health such as antioxidants. Apart from being a source of essential nutrients, the grains have chemical constituents that are considered to share functional components such as flavonoids and anthocyanidins. Present in large quantities in plants, phenolic compounds are linked as chemical mediators between plants and microorganisms. Among these compounds, the flavonoids are the most interesting because they are related to various functions such as protection, resistance to various types of stress, nitrogen fixation, and others (GONZALEZ de MEJIA *et al*., 2005). The highest concentration of polyphenols is found in seed coats color no black, other anatomical parts of the seed have low concentrations (BRESSANI *et al.*, 1991).

Genetic resources are basic to the survival of humanity, to supply the basic needs and help solve problems like hunger and poverty (CEREZO and ESQUINAS-ALCÁZAR, 1986). The availability of representing variability is essential to the success of breeding programs for virtually all traits of economic importance (RAMALHO *et al*., 1993). However, these features have been under constant pressure, by various causes, among which the use of uniform varieties, which is a market requirement of modern agriculture conceptually regarded (RODRIGUES *et al.*, 2002). These highly specialized varieties respond to current needs, contributing to increased food production, but the replacement of landraces for breeding materials can result in serious losses as increasing genetic erosion and biodiversity loss (CEREZO and ESQUINAS-ALCÁZAR, 1986).

The new cultivars show higher yields in terms of physical performance of crops, such an idea is that prevalent in breeding programs. As happen in wheat, in breeding cultivars the yield was almost double comparing to old varieties, and all correlations between yield and mineral content were negative (DAVIS, 2009). The rate of decline of six minerals was 0.33% per annum (Fe, Zn, Cu, P, S and Se), which corresponds to 22-39% in a period of just over 100 years. According to the same author, in maize it was also similar. The explanation for this phenomenon is the dilution effect due to increased biomass production and mainly water, without concomitant increase in absorption of nutrients.

Genetic variability was detected among the different groups and also between lines within each group, black and no black (SILVA *et al*., 2012). In general, the protein, iron and zinc contents were highest in the black bean lines. The carioca grain was outstanding for manganese and magnesium and the other grain colors for calcium and positive correlations between most nutrients were observed. Pinheiro *et al*. (2010) analyzing germplasm from Portugal, observed high degree of variability for P, Fe, Zn, Cu, Mn and Ca. The high mineral variability observed in the seeds can be useful for the selection of cultivars with higher nutrition value and for the improvement of seed nutrition quality traits. The creoles genotypes for its wide genetic variability may be the source of new cultivars with outstanding nutritional characteristics for various components.

Aimed to quantify the levels of macro and micronutrients, fibers, protein and antioxidant astragalina levels in whole grains, in breeding cultivars from diverse research institutes and landraces, cropping in Pelotas, and the effect of selection in a breeding program on the levels of the main chemical components of the grain.

2 MATERIAL AND METHODS

54 bean genotypes were analyzed, including cultivars and breeding lines derived from EMBRAPA and other research institutions, and landraces cultivated in Rio Grande do Sul state, as shown in (Table 1). The samples were composed by grains of different sizes and colors, so as to have an adequate representation regarding these characteristics. The seeds used in this work are derived from testing conducted at the Experimental Station Cascata, Embrapa Temperate Agriculture (Pelotas, RS). The seeds were sown in October 2009 and harvested in January 2010.

Fertilization of tests was made with 300 kg ha^{-1} of NPK fertilizer formulation 10-30-10, without the use of topdressing nitrogen. The soil analysis showed the following nutrient levels available: pH: 6.3; Clay: 22%; MO: 1.7%; K: 66 mg dm^{-3}; P: 2.7 mg dm^{-3}; Fe: 1.3 g.dm^{-3}, B: 0.3 mg dm^{-3}; Mn: 6.0 mg dm^{-3}; Zn: 1.6 mg dm^{-3} and Ca and Mg: 18 mmol dm^{-3}.

The analytical part was carried out in the Laboratory of Food Science and General Chemistry Unit in Embrapa Temperate Agriculture, and antioxidant analysis was performed at the College of Pharmacy, Universidade Federal do Rio Grande do Sul.

After harvesting the plants, the seed were dried under ambient air until they reach moisture content between 12 and 13%, being then cleaned and weighed. The samples were again dried in a forced air oven at 65 °C until they reached between 8 and 9% moisture, to carry out milling of grains efficiently. Whole beans were ground in mill type Wiley, yielding bean flour. The beans flour were packed in amber glass jars with plastic lid, allowing the storage of samples safely, keeping the initial moisture content.

The contents of nitrogen, phosphorus, potassium, sulfur, calcium and magnesium were analyzed. For this, approximately 250 mg of each material (in triplicate) were weighed in analytical balance, adding 5 ml of nitric acid and 1 ml of hydrogen peroxide. The samples were introduced in the microwave at 170°C for 40 minutes to occur wet digestion process (closed system). After digestion, 19 ml of deionized water were added to complete the ideal volume for dilution of samples (25 ml).

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Table 1. Information of bean cultivars from Rio Grande do Sul state analyzed. Pelotas, RS, Brazil

Breeding cultivar	Grain coat color	Released year	Landraces	Grain coat color
Guateian 6662	black	-	AM 5	black
Rio Tibagi	black	1976	Biriva 264	black
BR Ipagro Minuano	black	1991	Guabiju brilhante	black
BR Ipagro Macanudo	black	1989	Mato Grosso	black
BR Ipagro Macotaço	black	1994	Preto Ibérico	black
FT Soberano	black	2007	TB 0220	black
FT Nobre	black	1996	TB 0221	black
Fepagro 26	black	2004	TB 0222	black
BRS Campeiro	black	2004	TB 0223	black
FT Bionobre	black	-	TB 0225	black
BRS Expedito	black	2004	TB 0301	black
IPR 85 Uirapuru	black	2005	TB 0302	black
BRS Guerreiro	black	2014	TB 0306	black
BRS Pampeano	black	2014	TB 0303	black
Iapar 31	brown	1997	TB 0305	black
Carioca	brown	1976	TB 0308	black
FT Bonito	brown	2001	TB 0309	brown
Pérola	brown	1999	TB 0310	red
Iraí	striped	1981	TB 0224	red
Breeding lines			TB 0226	red
TB 0201	black	-	TB 0304	brown
TB 0203	black	-	TB 0307	red
TB 0207	black	-	TB 03-13	yellow
TB 0210	black	-	Mouro 187	purple
TB 0211	black	-	Rosinha Precoce	rose
TB 0212	black	-	Roxo Redondo	purple
TB 0219	black	-		
03 FPJ CF 29-1	black	-		

Potassium (K) was analyzed through atomic emission mode, calcium (Ca) and magnesium (Mg) were evaluated by the method of Miyazawa *et al.* (1992b), using atomic absorption spectrophotometry (AAS), as describedby Silva (1999). The determination of phosphorus (P) was made by UV-VIS spectrophotometry,) and for nitrogen (N) and sulfur (S) was used technique in combustion equipment CHN elemental analyzer TruSpec-S as quoted by Silva (1999).

The oligoelements were analyzed by the following methods: copper (Cu) - using the Perkin-Elmer (1982), Miyazawa *et al.* (1992b), Malavolta *et al.* (1989); iron (Fe) - by means of the method Ohlweiler (1974) and Malavolta *et al*. (1989); manganese (Mn) - methodology with Perkin-Elmer (1982), Miyazawa *et al.* (1992b); and zinc (Zn) - method using Perkin-Elmer (1982) and Malavolta *et al.* (1989), by atomic absorption spectrophotometry (AAS), all as stated by Silva (1999).

The crude protein content was determined according to the Kjeldahl method, considering the mean of two readings per sample, multiplying the amount of total nitrogen by a factor of 6.25 (AOAC, 1995). The content of the antioxidant astragalina was determined using HPLC techniques according Correia *et al*. (2006).

The cultivars were divided into two groups, the first compound for different cultivars and lines of breeding programs and the second with landraces and compared two groups by variance analysis. Were used two replication during analysis and calculating the data standard deviation, where were considered superior to those showed mean plus one standard deviation, as appropriate, and lower opposite, in each group. For Magnesium element, due high number of superior genotypes presents was considered values above the mean plus two standard deviation.

3 RESULTS AND DISCUSSION

The results of macronutrient content in landraces and breeding cultivars are shown in (Table 2). The grains were, on average, 37.8 g kg^{-1} N, which was the most abundant element, followed by K: 13.1 g kg^{-1}, P: 6.29 g kg^{-1}, S: 2.25 g kg $^{-1}$, Ca: 1.77 g kg^{-1} and Mg: 0.33 g kg^{-1}. The results indicate high variability for chemical components and that bean grain is a great source of phosphorus and potassium, in addition to N due to its high protein content. However it show low content of Ca and Mg, reflecting the low translocation of nutrients from leaves to developing seeds (Marschner, 1995). Paredes *et al*. (2009), analyzing genotypes from Chile, indicated the presence of a wide variability for some macro and micronutrients, such as N, Fe, and Zn, fact confirmed in this work.

Table 2. Calcium (Ca), potassium (K), magnesium (Mg), phosphor (P), nitrogen (N) and sulfur (S) levels in whole bean grains in breeding genotypes and landraces from Rio Grande do Sul state. Brazil, 2012

Cultivars		Ca	K	Mg	P	N	S
		....	....	g kg^{-1}	....	....	
	General media	1.77	13.1	0.33	6.29	37.8	2.25
Landraces	Media	1.73	12.75	0.31	6.12	37.2	2.3
	St deviation	0.82	0.71	0.05	0.56	3.5	0.5
	Minimum	0.96	11.68	0.23	5.07	30.6	1.6
	Maximm	3.57	14.01	0.42	6.90	42.1	3.2
Breeding	Media	1.81	13.44	0.35	6.46	38.3	2.2
	St deviation	0.75	0.99	0.05	0.85	3.7	0.5
	Minimum	1.09	11.33	0.27	4.84	28.5	1.1
	Maximum	4.01	14.89	0.52	7.89	46.7	4.0

According to statistical analysis, the landraces varieties did not show higher values than breeding cultivars, for all macro elements analyzed (Table 2). This fact contradicts the results of Davis (2009), who analyzed seeds of wheat and maize, noted that landraces showed higher levels of nutrients than breeding cultivars. It can be inferred that the breeding programs of various institutes have been effective to select grains of new cultivars with more nutrient, resulting more efficient genotypes of nutritional point of view. For other hand, agree with Paredes *et al*. (2009) that observed no significant differences between the Chilean bean genotypes compared from other races, including breeding genotypes and landraces.

The black coat grain color cultivars had higher levels of Ca, Mg, S and N, observed by the number of genotypes with levels above the mean and the upper limit reached. Can be highlighted breeding line TB 02-04 for N content; cultivars Rio Tibagi, FT Bionobre and BRS Expedito for calcium content; TB 02-11 and TB 02-10 for S content; TB 02-10, TB 02-11, TB 02-04 and BRS Guerreiro, besides landrace TB 03-09 for Mg content. It can be seen that all genotypes that stood out about the high levels of macronutrients come from breeding programs and are black grains, except TB 03-09.

Regarding calcium, breeding genotypes showed similar values in relation of landraces, although the first showed higher minimum and maximum limits. The genotypes from breeding programs showed concentrations ranging from 1.09 g kg^{-1} to 4.01 g kg^{-1}. These values are well above those observed by Barampama and Simard (1993) in genotypes cultivated in Africa, which varied from 0.6 to 2.8 g kg^{-1}.

For phosphorus grain level, although the large variation displayed on the results obtained, no differed from the mean. Although the values were similar to average, in breeding cultivars was observed minimum and maximum values of 4.84 and 7.89 g kg^{-1}, respectively, and 5.07 and 6.90 g kg^{-1}, respectively, in landraces. According to Mesquita *et al*. (2007), analyzing the content of P in genotypes from Santa Catarina and Paraná states it were found values varying from 4.5 to 7.3 g kg^{-1} of dry matter (DM). According to the authors, the P levels is related to protein content in grain. Lines with lower protein content showed P concentrations between 4.5 and 5.9 g kg^{-1} DM and those with greater protein showed levels of phosphorus from 5.5 to 7.3 g kg^{-1} DM. This was not proven in this study. Another study examining bean genotypes cultivated in Africa, shown P concentrations ranging from 3.7 to 5.4 g kg^{-1} DM (Barampama and Simard, 1993). The results found in this study are higher than other studies, in vary world regions and this may be related to climate and soil factors.

For potassium, the breeding cultivars ranged from 11.33 to 14.89 g kg^{-1}, while in the landrace the range was 11.68 at 14.01 g kg^{-1}. The results shown are partially in agreement with those observed by Barampama and Simard (1993) considering landraces and breeding genotypes grown in Africa in which the variation was between 5.2 and 19.6 g kg^{-1}. This study can be shown that the genotypes studied had less variation than that found by the authors. For magnesium grain content, breeding cultivars showed also minimum and maximum values above the landraces, 0.27 at 0.52 mg kg^{-1} and 0.23 at 0.42 mg kg^{-1}, respectively. The variation between the levels was also quite significant, demonstrating the possibilities of selecting materials with higher levels of this element. These values are in agreement with Mesquita *et al*. (2007), who noted in breeding genotypes evaluated in Paraná, levels ranging from 0.28 to 0.45 g kg^{-1}. Regarding the sulfur content, the amplitude observed for the element was significant, ranging from 1.1 to 4.0 g kg^{-1}, for breeding cultivars and 1.6 to 3.2 g kg^{-1} for landraces. These values are in agreement with the authors, who noted sulfur contents ranging from 1.8 to 3.4 g kg^{-1} in Paraná state.

The breeding cultivars show higher levels of microelements iron e manganese than landraces varieties, differently of what happened with macroelements (Table 3). For cuprum and zinc the results the breeding cultivars and landraces are the same. Results showed that cultivars above average, at least one of the micronutrients assessed, only three cultivars are landraces and the others are from breeding programs. Besides, none of the cultivars showed up more than average for all micronutrients examined. This fact demonstrates that the effectiveness of breeding programs to select materials more efficient at absorbing and metabolizing nutrients.

Iron (Fe) is the most abundant micronutrient in the whole grain with an average of 31.4 mg kg^{-1}, followed by zinc, manganese and copper, respectively 26.1 mg kg^{-1}, 19.07 mg kg^{-1} and 10.16 mg kg^{-1}. These results are confirmed by Ribeiro *et al*. (2008), studying breeding genotypes cultivated in Santa Maria, RS. However, the Fe content was twice than that observed in Pelotas.

This fact should be related to availability of that element in the soil and genotype and ambient interaction. In research conducted in Africa, according Barampama and Simard (1993), the Fe content ranged from 71 - 101 mg kg^{-1}, Zn: 20 - 36 mg kg^{-1} and Cu 4 - 9 mg kg^{-1}. The Chilean beans presents Fe levels from 68.9 to 152.4 mg kg^{-1} and Zn from 27.9 to 40.7 mg kg^{-1} (PAREDES *et al*., 2009). The information partly agree with those obtained in this study, except for Fe, which was lower and allow to select genotypes with higher elements and to improve the current cultivars.

Table 3. Cuprum (Cu), iron (Fe), manganese (Mn) an zinc (Zn) levels in whole grain of breeding genotypes and landraces of bean, from Rio Grande do Sul state. Pelotas, RS, Brazil, 2012

Cultivars		Cu	Fe	Mn	Zn
		............................mg kg^{-1}	....		
	General media	10.16	31.39	19.07	26.1
	Media	9.15	27.67	15.95	23.42
Landraces	St deviation	1.55	6.54	3.8	4.07
	Maximum	12.30	35.86	25.85	33.04
	Minimum	7.47	19.02	11.24	19.34
	Media	11.16	35.10*	22.19*	28.78
	St deviation	1.21	6.68	7.03	4.39
	Maximum	12.5	41.6	31.47	33.93
Breeding	Minimum	9.21	17.46	13.87	19.49

*media statistically different at 5%

BRS Expedito, Fepagro-26 and Minuano and lines TB 02-04 and TB 02-01 were those that showed the highest concentrations, all black coat grain. Guateian and FT Soberano showed the highest concentrations of Cu, Fe and Zn. Ribeiro *et al*. (2008) confirmed these features in Guateian, though this fact was not confirmed to FT Soberano. FT Bonito showed the highest concentrations of Fe and Zn, on the other hand Macanudo and Macotaço cultivars had the highest concentrations of Cu and Fe and Rio Tibagi and FT Bionobre showed elevated levels of Cu and Zn, all from breeding programs and black grain. Among landraces, Cubano Cerrito, Preto Comprido and TB 02-24 showed high levels of Cu, Zn and Mn, respectively, only the latter being tegument not black.

The astragalina average results in landrace were similar those from breeding programs (Table 4). The variability in the distribution of the phenolic component among the materials analyzed was quite pronounced. The fact was revealed by the elevated standard deviation founded. The average antioxidant content was 1.62 mg 100^{-1}g in landraces and 1.35 mg100^{-1}g in breeding cultivars. As for the minimum and maximum values, the landraces varieties showed 0.015 and 11.55 mg 100^{-1}g , respectively.

Table 4. Astragaline antioxidant, protein total, ash, total digestive nutrients (TDN) and fiber total (FB) in whole grains of landraces and breeding bean genotypes from Rio Grande do Sul state, Brazil. 2012

Cultivars		Astragaline mg%	Protein %	Ash %	TDN %	FB %
	Média general	1.5	27.6	4.12	84.5	7.34
Landraces	Média	1.5	28.9	4.27	84.34	7.63
	St deviation	3.26	1.87	0.3	0.77	0.71
	Maximum	11.05	31.1	3.97	83.08	6.8
	Minimum	0.025	24.9	4.79	85.18	8.75
Breeding	Média	1.62	26.2	3.97	84.66	7.04
	St deviation	3.15	2.46	0.28	1.35	0.94

Maximum	11.55	30.3	3.68	83.31	6.09
Minimum	0.015	20.8	4.26	86.01	7.98

Landraces cultivars of red coat beans TB 02-24 and TB 02-26 stood out for the levels of the antioxidant, along with TB 03-13, yellow grain, and 02-20 TB, black grain. As breeding genotypes stood out FT Nobre and TB 02-11, both black grains, demonstrating that the distribution was dependent on the genotype in question, though the materials of red beans have excelled toward the other. According to Hu *et al.* (2006), the highest astragaline levels were observed in grains with coat not black. In the analysis of the levels of antioxidant, unlike the contents of macro and micronutrients, the astragalina was more expressive in grains not black. However can be expected that for other antioxidants be different.

The breeding cultivars showed similar levels of total protein in relation of landraces, 28.9% and 26.2%, respectively. For landraces, the minimum and maximum limits were 20.3% and 30.3%, respectively, while the breeding cultivars limits were higher, 24.9% and 31.2%, respectively. These results are in agreement with results presented in other works, like Mesquita et al. (2007), evaluating breeding genotypes in Paraná, Barampama and Simard (1993), with African genotypes, and Paredes *et al*. (2009), in Chilean beans. Already Elias *et al*. (2007), evaluating breeding genotypes, detected in Santa Catarina average crude protein in the grain of 21.4%, with very little variation between the analyzed material (19.6% to 22.9%). Values above 23% characterize high protein content in bean and notes that if offers superior genotypes for this trait (ANTUNES *et al*., 1995; DALLA CORTE *et al*., 2003).

The lines with black coat showed, on average, higher protein content compared to colored coat, respectively 28.7% and 26.3%. These results are in agreement with Ribeiro *et al*. (2005), evaluating breeding genotypes in Santa Maria, found that it ranged from 31 to 25% and 30 to 21% for black coat and colored coat, respectively. The cultivars FT Nobre, FT Soberano and BRS Expedito, all breeding genotypes and black coat, can be stand out with high protein content. Among the landrace varieties stood out TB 02-26, with red grain. The conflicting results in the literature suggest that selection for higher protein content in beans is efficient, since it has a better understanding of the genetic, environmental and interaction of these under this characteristic, given that significant effects of genotype x environment have been reported for protein in beans (DALLA CORTE *et al*., 2003).

Analyzing ash content in the grain, can be observed the similar results in breeding cultivars and landraces, 4.27% and 3.97%, respectively, with low variation among genotypes. However, landraces were better than breeding genotypes, as to the upper limit, 4.26% and 4.79%, respectively. Regarding the content of total digestive nutrients (TDN) and insoluble fiber, the breeding cultivars showed similar results as landrace varieties. This results indicate that the breeding cultivars are nutritionally similar in relation with landraces.

The coat grain color showed influence in ash content, and stood out above the average Preto Comprido and Guabiju, landraces varieties, and Macanudo and Rio Tibagi, breeding cultivars. As for total fibers, stood out Preto Comprido, Guabiju and Grosso Amarelo landraces varieties, and already in breeding cultivars stood out BRS Expedito and FT Nobre. Breeding line TB 01-01 and landrace Cubano Cerrito stood out the content of neutral fiber. Among the cultivars cited, only Grosso Amarelo has grain colored, the others are all black grain.

In a comprehensive manner, the correlations between various components in whole grains beans were quite low, as is seen in (Table 5). In opposite Silva *et al*. (2012), that observed positive correlations between most nutrients, indicating the possibility of obtaining lines with higher nutritional value by selection. Thus, we can highlight that potassium correlated positively with phosphorus and copper, with a correlation coefficient of 0.57 and 0.43, respectively. Nitrogen showed high positive correlation with iron (R = 0.42) and, as expected, was correlated with the total protein content, although it may be considered reasonable. This fact is related with the different methods used for the determination of N.

Table 5. Correlation coefficients between macro and microelements, antioxidant astragalina (AST) and protein content in whole grains of bean landraces and breeding cultivars from Rio Grande do Sul state. Brazil, 2012

	K**	Mg	P	N	S	Cu	Fe	Mn	Zn	AST	Protein
Ca	0.18	0.0009	0.23	-0.35	-0.1	0.16	0.09	0.21	0.09	0.14	-0.22
K	#	-0.04	0.57*	0.25	-0.29	0.43*	0.25	0.17	0.14	0.32	-0.23
Mg		#	0.009	0.16	0.31	0.08	0.21	0.32	0.27	0.04	-0.33
P			#	0.3	0.04	0.29	0.39	0.28	0.14	0.14	-0.35
N				#	-0.03	-0.08	0.42*	0.12	-0.05	-0.1	0.68*
S					#	-0.22	-0.16	0.03	-0.37	-0.29	0.17
Cu						#	0.18	-0.02	0.44*	0.43*	-0.48*
Fe							#	-0.21	0.64*	-0.15	-0.44*
Mn								#	-0.02	-0.02	-0.003
Zn									#	0.24	-0.49*
AST										#	-0.17

*correlation significative at 5% probability.

**K: potassium; Mg: magnesium; P: phosfhorus; N: nitrogen; S: sulfur; Cu: cuprum; Fe: iron; Mn: manganese; Zn: zinc

These data show that in breeding, the lines selection for high levels of macronutrients and oligoelements in grain of bean can be realized without problems, thus specific nutrient such iron and calcium, not exhibit negative correlations with other important nutrients.

According to the table of oligoelements, copper and iron showed high positive correlation with zinc (R = 0.44 and 0.64, respectively). These results are in agreement with Mesquita *et al*. (2007) where the authors reported a high correlation between Zn, Fe and Cu, and Ribeiro et al. (2008) who detected a high correlation between the levels of oligoelements particularly between Cu and Zn and Mn and Cu. The high correlation between oligoelements already evident in other works allows selecting new lines with high levels of the elements. Among all nutrients analyzed only copper showed positive correlation (R = 0.43) with the content astragalina, the other elements had no correlation with that component. As the correlation with the nutrient content of protein, only the oligoelements, copper, iron and zinc showed a high negative correlation with protein content in grain, with a correlation coefficient of - 0.48; - 0.44 and - 0.49, respectively. This may demonstrate that increasing levels of oligoelements may negatively affect protein and antioxidants in the grains. These results disagree with Mesquita *et al*. (2007), in which the strains analyzed showed higher protein contents also stood out in relation to P content, however high protein was not associated with high potassium content. For Paredes *et al*. (2009) the N content was positively correlated with protein, P, Cu, Zn, and S content. Fe content was positively correlated with Mn and Ca content and Zn was positively correlated with the N, P, Cu and S content.

4 CONCLUSION

Whole grain of bean landraces presents nutritional composition of macro and oligoelementes, total digestive nutrients, insoluble fiber, protein and ash similar to those of breeding lines and cultivars; breeding lines of bean with black coat grain are nutritionally superior for macro and oligoelements content than the non-black coat, highlighting TB 01-01 and TB 02-04; the highest concentrations of antioxidant astragalina is found in landrace varieties with no black coat grain, especially TB 02-26, TB 02-24 TB and TB 03-13.

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