



Nutritional and protein quality of dry Brazilian beans (*Phaseolus vulgaris* L.)

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Abstract

Brazil is the world's largest producer of common beans (*Phaseolus vulgaris* L.), which are one of the most widely consumed grain legumes in the world. Seven improved genotypes of dry, coloured, Brazilian common beans were analysed for their nutritional (chemical composition, oligosaccharides, phenolic compounds and antioxidant capacity) and protein quality (amino acid profile, amino acid score, trypsin inhibitor activity and *in vitro* protein digestibility). The grain bean cultivars studied showed a high content of fibre, with some aromatic amino acids present at higher levels than the Food and Agriculture Organization reference protein. The dry beans had intermediate protein digestibility, ranging from 50.3% in the BRS Notável cultivar to 66.9% in the Jalo Precoce cultivar. The studied dry beans contained anti-nutritional and flatulence factors, such as trypsin inhibitors and oligosaccharides. However, total phenolic compounds and antioxidant activity were high. Improved grain beans have important nutritional characteristics that need to be preserved, and some negative, anti-nutritional characteristics. The results presented in this study can be used to assist the identification of appropriate processing techniques that maintain the positive features of dry beans and eliminate their negative attributes.

Keywords: antioxidant capacity; chemical composition; *in vitro* protein digestibility; total phenolic compounds.

Practical Application: Our results can be applied in development of products to maintain a better profile of amino acids, in recommended of daily intake, in menu planning and in the separation of amino acids as an isolated nutrient.

1 Introduction

Common grain beans (*Phaseolus vulgaris* L.) have been recognised as a staple and low-cost protein source, consumed in both several under-developed countries, where protein malnutrition is widely prevalent, as well as in developing countries where protein malnutrition is low, such as Brazil (Drewnowski, 2010; Food and Agriculture Organization, 2013; Sathe, 2002; Shimelis & Rakshit, 2007).

Beans are rich in protein, carbohydrate, dietary fibre, and are a good source of antioxidants, as well as vitamins and minerals (Campos-Veja et al., 2010; Luthria & Pastor-Corrales, 2006). Animal proteins are better assimilated than vegetable proteins because plant proteins are deficient in sulphur amino acids (methionine and cysteine), and tryptophan. Therefore, a diet that combines protein-containing foods with complementary cereal amino acids is important to gain the complete amino acid pool (Karababa, 2006; Melo et al., 2012).

Beans contain many bioactive substances that play important physiological roles *in vivo*, including, protein digestibility enzyme inhibitors, others types of enzyme inhibitors and fermentable-non-digestible oligosaccharides (Campos-Veja et al., 2010; Drewnowski, 2010; Food and Agriculture Organization, 2013; Ranilla et al., 2007). There is room for improvement the bioactive properties of unprocessed dry bean and thus a need to examine new cultivars (cvs.).

The beans researched in this study are cvs. developed by the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária, 2013) breeding program. These cvs. present one or more of the following characteristics: suitability to direct mechanical harvesting, high productivity and yield, disease resistance and early maturity, besides desirable culinary and nutritional characteristics, such as ease of cooking, good palatability, soft texture seed coat and improved protein content (Melo et al., 2012). Furthermore, these beans studied are widely consumed in Brazil and the cvs. show market acceptable virtues regarding shape, size, colour and brightness.

2 Materials and methods

2.1 Samples

The beans (Figure 1) were provided by Empresa Brasileira de Pesquisa Agropecuária Rice and Beans, located in Santo Antônio de Goiás, Brazil (16°30'23.62"S and 49°17'00.75"W). and harvested in the winter of 2013. The local climate is classified as warm and semi-humid with a well-defined dry season, from May to September, and an annual average temperature of 23.2 °C, with minimum and maximum averages of 17.9 and 29.8 °C, respectively.

Received 03 Mar., 2017

Accepted 24 July, 2017

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Figure 1. Grain Brazilian bean (*Phaseolus vulgaris* L.) improved genotypes. (1) BRS Ametista; (2) BRS Notável; and (3) Pérola (light beige beans with brown stripe); (4) BRS Esplendor (black); (5) BRS Executivo (beige with streaks and dark red scores); (6) BRS Pitanga (light purple); (7) Jalo Precoce (yellow).

2.2 Mass determination

Mass (Karababa, 2006) was determined by weighing 100 randomly chosen beans, using an analytical balance with a precision of ± 0.1 g. This procedure was performed in triplicate.

2.3 Sample preparation

Broken and damaged beans, as well as foreign materials, were removed. Then, the samples were ground in a mill to obtain a fine and homogeneous powder (60 mesh) using an Ultra Centrifugal Mill (Retsch ZM200, Haan, Germany), and maintained at -18°C until analysis.

2.4 Nutritional quality

Moisture content was determined by oven drying at 105°C to constant weight (Instituto Adolfo Lutz, 2008). The Bligh & Dyer (1959) method determined the total lipids. Total dietary fibre was quantified according to Horwitz & Latimer (2010). Total carbohydrates were calculated by summing the values of starch, total dietary fibre and oligosaccharides. The oligosaccharide raffinose family contents were performed as described by Cicek (2001). For mineral content determination, samples were incinerated using a heater plate and then placed in a muffle at 550°C to constant weight (Horwitz & Latimer, 2010). Starch content was obtained according to Diemair (1963).

Total phenolic compounds (TPC) were determined using the Folin-Ciocalteu method. The results were expressed as milligram gallic acid equivalents per gram of sample ($\text{mg GAE}\cdot\text{g}^{-1}$ sample) (Singleton & Rossi, 1965). Antioxidant activity was assessed using the stable free radical, 2,2-diphenyl-1-picrylhydrazyl (DPPH), according to Brand-Williams et al. (1995).

2.5 Protein quality

Protein content was determined using the micro-Kjeldahl method and a conversion factor of 6.25 (Horwitz & Latimer, 2010). The total amino acids were verified as described by White et al. (1986) and Hagen et al. (1989). The separation and identification of phenylthiocarbamide-amino acid (PTC-AA) derivatives were

performed using a high-resolution liquid chromatograph (Shimadzu Corporation, Tokyo, Japan) equipped with a Phenomenex-Luna C18 reverse phase column (250×4.6 mm, $5\ \mu\text{m}$; Phenomenex Inc., Torrance, USA). The mobile phase consisted of an acetate buffer pH6.4 and acetonitrile solution at 40%.

Essential amino acids (EAA) in the samples were evaluated by amino acid score (AAS), which was based on the recommended EAA levels established by the World Health Organization (2007) of 3-10-year-old children.

The *in vitro* protein digestibility ($_{IV}PD$) was determined according to the method described by Akesson & Stahmann (1964). This involved sample digestion with pepsin and pancreatic enzymes, followed by precipitation of the undigested proteins in a solution of sodium azide 0.01%, and their quantification by micro-Kjeldahl (Horwitz & Latimer, 2010). The results were expressed as a percentage of the total protein. The trypsin inhibitor activity (TIA) was determined by an enzymatic method using a solution of D-benzoyl *p*-nitroanilide L-arginine as substrate and expressed as trypsin inhibitor units (TIU) per g of protein (Rackis et al., 1974).

2.6 Statistical analysis

The results were expressed as the mean \pm standard deviation. The comparison between cvs. was verified by analysis of variance followed by a comparison of means by Tukey's test. Differences were considered significant when $p < 0.05$. Statistical analyses were performed using R 3.1.0 software (R Development Core Team, 2012). Pearson's correlation was performed between the TPC and antioxidant activity and between the *in vitro* protein digestibility and trypsin inhibitor activity in the dry beans.

3 Results

3.1 Beans

Many varieties, including cv., botanical taxon, commercial group and color, of dry beans, are consumed by the world population, and some of them were studied in the present study. The common bean Brazilian cvs. are separated in to

commercial groups according to the type of grain, and the most consumed ones are the carioca (79%) and black group (17%) (Melo et al., 2012). The beans of this study belong to the carioca (BRS Ametista, BRS Notável and Pérola), black (BRS Esplendor) and special commercial groups (BRS Pitanga, BRS Executivo and Jalo Precoce) (Empresa Brasileira de Pesquisa Agropecuária, 2013). As noted by the mass of the beans, the commercial groups most consumed by Brazilians are those of smaller size (carioca and black).

There were significant differences ($p < 0.05$) in the mass among all cvs. The BRS Executivo cv. had the largest mass, while BRS Esplendor cv. had the lowest (Table 1).

3.2 Nutritional quality

For all cvs. studied, significant differences ($p < 0.05$) were observed in most of the nutrient contents (Table 2). The total of lipid, carbohydrate and oligosaccharide contents (raffinose and stachyose) were statistically similar ($p < 0.05$) among the cv. In accordance with their classification as a rich source of fibre (Wu et al., 2004), the total fibre contents of the beans ranged from 21 g.100 g⁻¹ (Pérola) to 24 g.100 g⁻¹ (BRS Ametista).

All the bean cvs. studied showed a high TPC (>2 mg GAE.g⁻¹), with the Jalo Precoce cv. revealing the highest TPC at 9 mg EAG.g⁻¹ (Table 3). This cv. also had the highest antioxidant activity (63 µmol Trolox g⁻¹). A positive and significant correlation ($r = 0,988$, $p < 0.05$) between the TPC and antioxidant activity was evident.

3.3 Protein quality

The protein values ranged 19 to 23 g.100 g⁻¹. In the cvs. studied, glutamic acid and aspartic acid were the predominant non-essential amino acids (NEAA), while the aromatic amino acids, phenylalanine + tyrosine, followed by lysine and leucine were the predominant EAA (Table 4). The lysine content varied from 93 to 104 mg/g protein (BRS Esplendor and BRS Ametista, respectively), while the leucine content ranged from 72 to 78 mg.g⁻¹ protein (BRS Esplendor and BRS Notável, respectively).

Almost all the eight EAA could satisfy the reference values needs (Table 5), ranging the EAS from 1.2 to 2.6, except for the deficient amino acids, namely cysteine and methionine (0.8).

For both the ¹⁵N PD and TIA analyses, the results displayed a significant difference between cvs. ($p < 0.05$) (Table 6).

4 Discussion

4.1 Beans

The common bean Brazilian cvs. are separated in to commercial groups according to the type of grain, and the most consumed ones are the carioca (79%) and black group (17%). The beans of this study belong to the carioca (BRS Ametista, BRS Notável and Pérola), black (BRS Esplendor) and special commercial groups (BRS Pitanga, BRS Executivo and Jalo Precoce) (Empresa Brasileira de Pesquisa Agropecuária, 2013). As noted by the mass of the beans, the commercial groups most consumed by Brazilians are those of smaller size (carioca and black).

Table 1. Average mass of Brazilian bean cultivars.

Cultivar	Commercial classification	Mean mass (g/ 100 beans)
BRS Ametista	Carioca	32 ± 0 ^c
BRS Notável	Carioca	26 ± 0 ^d
Pérola	Carioca	23 ± 0 ^e
BRS Esplendor	Black	17 ± 0 ^g
BRS Executivo	Special	65 ± 1 ^a
BRS Pitanga	Special	20 ± 0 ^f
Jalo Precoce	Special	36 ± 0 ^b

Results are the average of three independent experiments ± SEM. Different letters among samples indicate significant differences by Tukey's test ($p < 0.05$).

Table 2. Chemical composition of Brazilian bean cultivars of improved genotypes.

Cultivar	Chemical composition (g.100 g ⁻¹ sample)				
	Protein	Lipid	Ash	Carbohydrate*	Moisture
1-AM	20 ± 0 ^d	2 ± 0 ^a	4 ± 0 ^a	64 ± 1 ^a	12 ± 0 ^a
2-NO	22 ± 1 ^{bc}	2 ± 0 ^a	4 ± 0 ^a	65 ± 0 ^a	12 ± 0 ^a
3-PE	21 ± 0 ^{cd}	2 ± 0 ^a	4 ± 0 ^a	66 ± 1 ^a	10 ± 0 ^c
4-ES	19 ± 0 ^e	2 ± 0 ^a	4 ± 0 ^a	65 ± 1 ^a	10 ± 0 ^c
5-PI	19 ± 0 ^e	2 ± 0 ^a	4 ± 0 ^a	65 ± 0 ^a	10 ± 0 ^c
6-EX	23 ± 0 ^a	2 ± 0 ^a	4 ± 0 ^a	64 ± 0 ^a	12 ± 0 ^a
7-JP	22 ± 0 ^b	2 ± 0 ^a	3 ± 0 ^b	64 ± 1 ^a	11 ± 0 ^b
	Carbohydrates total (g.100 g ⁻¹ sample)				
	Starch	Oligosaccharides	Dietary fibre		
1-BRS Ametista	36 ± 1 ^d	4 ± 0 ^a	24 ± 0 ^a		
2-BRS Notável	38 ± 0 ^{cd}	4 ± 0 ^a	23 ± 0 ^{ab}		
3-Pérola	42 ± 1 ^a	3 ± 0 ^b	21 ± 0 ^d		
4-BRS Esplendor	40 ± 0 ^{ab}	3 ± 0 ^b	22 ± 0 ^{cd}		
5-BRS Executivo	39 ± 0 ^{bc}	3 ± 0 ^b	23 ± 0 ^{ab}		
6-BRS Pitanga	39 ± 0 ^{bc}	4 ± 0 ^a	21 ± 0 ^d		
7-Jalo Precoce	36 ± 0 ^d	4 ± 0 ^a	23 ± 0 ^{ab}		

Results are the average of three independent experiments ± SEM. AM = BRS Ametista, NO = BRS Notável, PE = Pérola, ES = BRS Esplendor, PI = BRS Pitanga, EX = BRS Executivo, JP = Jalo Precoce. Different letters among samples indicate significant differences by Tukey's test ($p < 0.05$); *Determined as the total starch + oligosaccharide + dietary fibre. Nitrogen to protein conversion factor: 6.25.

Table 3. Total phenolic compounds (mg GAE* g⁻¹) and antioxidant activity measured by DPPH (µmol Trolox g⁻¹) of Brazilian bean cultivars of improved genotypes.

Cultivar	Total phenolic compounds (mg GAE* g ⁻¹)	Antioxidant activity (µmol Trolox g ⁻¹)
1-BRS Ametista	8 ± 0 ^b	59 ± 0 ^{bc}
2-BRS Notável	8 ± 0 ^b	58 ± 2 ^c
3-Pérola	5 ± 0 ^c	35 ± 1 ^e
4-BRS Esplendor	4 ± 0 ^{cd}	38 ± 0 ^d
5-BRS Executivo	8 ± 0 ^b	61 ± 0 ^{ab}
6-BRS Pitanga	4 ± 0 ^d	35 ± 2 ^e
7-Jalo Precoce	9 ± 0 ^a	63 ± 2 ^a

Results are the average of three independent experiments ± SEM. Different letters among samples indicate significant differences by Tukey's test ($p < 0.05$); *Gallic acid equivalent.

Table 4. Essential and non-essential amino acid composition of Brazilian bean cultivars of improved genotypes.

	1-BRS Ametista	2-BRS Notável	Cultivar		5-BRS Pitanga	6-Executivo	7-Jalo Precoce
			3-Pérola	4-BRS Esplendor			
EAA (mg.g ⁻¹ protein)							
Lysine	104 ± 0 ^a	95 ± 0 ^c	99 ± 0 ^d	93 ± 1 ^c	94 ± 0 ^{cd}	99 ± 0 ^b	99 ± 0 ^b
Leucine	73 ± 0 ^{cd}	76 ± 1 ^a	73 ± 0 ^{cd}	72 ± 0 ^d	74 ± 0 ^{bc}	78 ± 0 ^a	73 ± 0 ^{cd}
Isoleucine	61 ± 0 ^a	62 ± 0 ^a	60 ± 0 ^a	61 ± 1 ^a	60 ± 0 ^a	62 ± 2 ^a	60 ± 0 ^a
Threonine	61 ± 1 ^a	58 ± 0 ^{bc}	55 ± 0 ^c	57 ± 1 ^{bc}	59 ± 0 ^{ab}	58 ± 0 ^{bc}	56 ± 0 ^c
Valine	60 ± 0 ^a	59 ± 0 ^{ab}	59 ± 0 ^{ab}	59 ± 0 ^{ab}	59 ± 0 ^{ab}	58 ± 0 ^b	56 ± 0 ^c
Phe + Tyr	103 ± 0 ^{cd}	105 ± 1 ^a	103 ± 0 ^{bc}	101 ± 1 ^{cd}	97 ± 1 ^e	105 ± 0 ^a	100 ± 0 ^d
Histidine	25 ± 0 ^a	24 ± 0 ^a	25 ± 1 ^a	21 ± 4 ^a	23 ± 0 ^a	24 ± 1 ^a	25 ± 0 ^a
Met + Cys	20 ± 0 ^a	19 ± 0 ^a	20 ± 1 ^a	19 ± 0 ^a	20 ± 0 ^a	19 ± 1 ^a	20 ± 0 ^a
NEAA (mg.g ⁻¹ protein)							
Glutamic acid	173 ± 0 ^{de}	181 ± 1 ^{bc}	177 ± 0 ^{cd}	170 ± 1 ^e	167 ± 0 ^e	186 ± 3 ^{ab}	189 ± 3 ^a
Aspartic acid	146 ± 1 ^{ab}	147 ± 1 ^{ab}	143 ± 2 ^b	135 ± 2 ^c	148 ± 1 ^a	142 ± 1 ^b	146 ± 1 ^{ab}
Arginine	103 ± 0 ^a	100 ± 0 ^a	104 ± 0 ^a	94 ± 1 ^b	103 ± 2 ^a	101 ± 0 ^a	101 ± 1 ^a
Serine	74 ± 0 ^a	74 ± 2 ^a	70 ± 4 ^a	72 ± 1 ^a	71 ± 1 ^a	72 ± 1 ^a	71 ± 0 ^a
Glycine	45 ± 0 ^a	44 ± 0 ^{ab}	43 ± 1 ^b	44 ± 0 ^{ab}	45 ± 0 ^a	44 ± 1 ^{ab}	43 ± 0 ^b
Proline	41 ± 0 ^c	45 ± 1 ^{ab}	43 ± 0 ^{bc}	42 ± 0 ^{bc}	45 ± 1 ^{ab}	47 ± 1 ^a	40 ± 1 ^c
Alanine	41 ± 1 ^c	42.76±0.74 ^{ab}	39.40±0.37 ^{cd}	39.69±0.00 ^{bcd}	42.03±0.82 ^{abc}	43.01±1.03 ^a	39.02±1.43 ^{cd}

Results are the average of three independent experiments ± SEM. Different letters among samples indicate significant differences by Tukey's test ($p \leq 0.05$). Phe + Tyr = Phenylalanine + Tyrosine. Met + Cys = Methionine + Cysteine. Tryptophan = Not determined.

Table 5. Amino acids score for the proteins of Brazilian bean cultivars of improved genotypes.

Amino acid	BRS Ametista	BRS Notável	Pérola	Cultivar		BRS Pitanga	Executivo	Jalo Precoce
				BRS Esplendor				
Lys	2.2	2	2.1	1.9		2	2.1	2.1
Met + Cys	0.8	0.8	0.8	0.8		0.8	0.8	0.8
Thr	2.4	2.3	2.2	2.3		2.3	2.3	2.2
Ile	2	2.0	1.9	2		1.9	2	2
Leu	1.2	1.2	1.2	1.2		1.2	1.2	1.2
Val	1.5	1.5	1.5	1.5		1.5	1.4	1.4
Phe + Tyr	2.5	2.6	2.5	2.5		2.4	2.6	2.4
His	1.5	1.5	1.5	1.3		1.5	1.5	1.6

Lys= Lysine, Met + Cys = Methionine + Cysteine. The = Threonine, Ile= Isoleucine, Leu= Leucine, Val= Valine, Phe + Tyr= Phenylalanine + Tyrosine, His = Histidine. Based on FAO/WHO reference of 3-10-year-old children (World Health Organization, 2007). The limited amino acids are in bold.

Table 6. Protein digestibility by *in vitro* enzymatic digestion, and trypsin inhibitory activity in Brazilian bean cultivars of improved genotypes.

Cultivar	In vitro protein digestibility (%)	Trypsin inhibitory units (TIU/gprotein)
1-BRS Ametista	54 ± 2 ^{cd}	33 ± 0 ^b
2-BRS Notável	50 ± 4 ^d	29 ± 0 ^c
3-Pérola	56 ± 1 ^{bc}	45 ± 1 ^a
4-BRS Esplendor	54 ± 2 ^{bcd}	33 ± 0 ^b
5-BRS Executivo	60 ± 2 ^b	27 ± 0 ^d
6-BRS Pitanga	50 ± 2 ^{cd}	21 ± 1 ^f
7-Jalo Precoce	67 ± 0 ^a	25 ± 0 ^e

Results are the average of three independent experiments ± SEM. Different letters among samples indicate significant differences by Tukey's test ($p < 0.05$). TIU: Trypsin units inhibited, where 1 TU is defined as 0.01 absorbance at 410 nm, under the assay conditions of the method (pH 8.2 at 37 °C with 10 mL assay volume and bovine trypsin).

4.2 Nutritional quality

The cvs. studied were from a Brazilian breeding program aimed to favour the aspects of agriculture, productivity and nutritional value. The chemical and nutritional composition of the dry beans were different among the cvs. A similar phenomenon was also observed in the beans reported by Costa et al. (2006) and Shimelis & Rakshit (2005). This difference could be solely due to genotypic differences among the cvs, once because the crops were from the same agronomic region and period (Costa et al., 2006; Ribeiro et al., 2007).

Among the total carbohydrates, this study discriminated the starches (reducing and non-reducing), oligosaccharides and dietary fibre. The carbohydrate and the total oligosaccharide contents found were equal among the cvs. and similar to previously

studied improved genotype Brazilian bean cvs. (Pontal and IAC Eté) (60 to 66 g.100 g⁻¹) (Costa et al., 2006; López et al., 2013) and white Canadian beans (Linsberger-Martin et al., 2013).

In recent years, coloured beans have attracted much attention due to the various health benefits associated with their consumption. Many studies showed their beneficial effects on blood cholesterol, glucose and insulin levels, in addition to prevention of various cancers, such as gastrointestinal, breast and prostate. These properties have been attributed to the unique nutritional composition of the bean that is rich in fibre and phenolic compounds, and low in total fat and saturated fat (Boateng et al., 2008; Karababa, 2006; Marathe et al., 2011; Ranilla et al., 2010; Sievenpiper et al., 2009; Thompson et al., 2008; Wu et al., 2004; Xu & Chang, 2009). The Chinese and Brazilian beans have a similarly high content of dietary fibre (Wu et al., 2004; Costa et al., 2006).

All the bean cvs. studied revealed a high TPC. Similar TPC values were reported in a study of 10 classes and 15 varieties of beans commonly consumed in the USA (Luthria & Pastor-Corrales, 2006). Other studies on Brazilian and Italian beans cvs. also observed high TPC and antioxidant capacities (Estrada-Girón et al., 2005; Han et al., 2007).

4.3 Protein quality

All the bean cvs. in this research presented high protein contents. Legumes, which are rich in lysine but poor in sulphur amino acids, like methionine and cysteine, can be mixed with cereals to improve the amino acid pattern of both raw materials (Sarwar, 1997; Toledo et al., 2013). For instance, beans and rice are a typical combination consumed in Brazil.

Protein digestibility varies with the cv. The literature reports that light-coloured grains have higher digestibility than colourful ones, which is associated with the content and nature of the tannins in the peel of coloured varieties (Linsberger-Martin et al., 2013; Sarwar, 1997).

According to Sarwar (1997), to validate the nutritional value of protein it is necessary to take into account the digestibility associated with the same amino acid profile as close as possible to the needs established for humans (World Health Organization, 2007). Nineteen Brazilian bean cvs. from the south of the country showed higher levels of leucine than lysine (Ribeiro et al., 2007). However, as observed in various legume crops (Lisiewska et al., 2007; Pedrosa et al., 2015; Slupski, 2010), they contained the eight essential amino acids but were deficient in methionine and cysteine (Ribeiro et al., 2007).

The current study found the Jalo Precoce cv. (67%), a yellow bean, had the highest _{IV}PD. Comparatively higher _{IV}PD values, up to 81%, were observed in eight African bean cvs. (Shimelis & Rakshit, 2007).

The trypsin inhibitor is considered an anti-nutritional factor present in various leguminous plants, including dry beans (Park et al., 2010). Studies show that this inhibitor adversely affects the digestibility of protein and amino acids, and hence, the protein quality (Drewnowski, 2010; Park et al., 2010; Shimelis & Rakshit, 2005). In this study, the BRS Pitanga cv. showed

the lowest trypsin inhibitor content, and also had a low _{IV}PD. However, there was no correlation between the TIA and _{IV}PD ($r = -0.2533$, $p < 0.05$). Probably other matrix components, such as phytate-protein complexes and high dietary fibre levels, or the chemical structure of the protein interfered more directly with this parameter.

5 Conclusions

Among the cvs. studied, BRS Ametista, BRS Notável and Jalo Precoce showed the highest levels of dietary fibre, while Executive cv. revealed the highest protein content. All the cvs. studied serve as an excellent dietary source of natural antioxidants and the Jalo Precoce cv. had the highest antioxidant activity. The minimal amino acids score was about 0,8 and related to the methionine and cysteine amino acids. From a nutritional perspective, the results presented will help researchers and consumers to select the best coloured Brazilian dry bean cvs. regarding their nutritive and bioactive properties. Combining bean cvs. that are characterised by a high protein quality, high dietary fibre content and antioxidant capacity, and low presence of anti-nutritional components, including oligosaccharides and trypsin inhibitor, with a food processing technique that complements their health benefits is important to improve their final quality.

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