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Nutritional and Mineral Variability in 52 Accessions of Common Bean Varieties (*Phaseolus vulgaris* L.) from Madeira Island

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Abstract

The *Phaseolus vulgaris* L. is one of the traditional and most important leguminous crops in the Island of Madeira. The island's bioclimatic tiers, agro-ecological environment and traditional farming practices had a great influence on the evolution of regional bean landraces. The variability of the nutritional and mineral seeds composition of 59 accessions of the Madeiran landraces, standard and commercial varieties was evaluated. Wide ranges of variability in biochemical parameters were reported among the Madeiran landraces, being the best sources of protein and mineral nutrition, according to the statistical results and literature comparative evaluation. Specifically, the content (g per 100 g DW) of ash ranged from 3.64 - 5.67, lipids from 0.57 - 2.86, protein from 18.55 - 29.69, starch from 23.40 - 52.65, soluble sugars from 2.97 - 6.84, while content of dry matter was from 83.35 - 93.55. The seeds also contained (per 100 g DW) between 2.55 - 4.83 g N, 0.30 - 7.50 g P, 1.30 - 2.49 g K, 0.10 - 0.18 g Mg, 4.10 - 10.00 mg Fe, 50.0 - 1.40 mg Cu, 2.20 - 5.00 mg Zn, 0.90 - 3.80 µg Mn and 0.20 - 2.40 µg B. This variability implies that the screened germplasm could serve as a source for breeding new varieties with improved biochemical and nutritional traits or could be highly recommended to meet specific dietary requirements. The cultivar *Vaginha Grossa* (ISOP 713) revealed low carbohydrate content that could be a good food choice for diabetics, while cultivar *Vermelho* (ISOP 724) bean should be offered as a valuable alternative source of protein and minerals in the local diet.

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Keywords

***Phaseolus vulgaris* L.; Beans; Genetic Resources; Proximal Analysis; Nutritional Value; Mineral Composition; Variability; Food Quality**

1. Introduction

The Archipelago of Madeira is a group of Portuguese islands with a territory of about 800 square km, localized on the Africa's continental shelf, 900 km southwest of Portugal and about 630 km west of North Africa. Madeira Island has a rugged landscape, altitude variation from sea level to 1860 m, deep and isolated valleys, and fields in terraces mitigating slopes greater than 25% in 65% of the territory. Four bioclimatic tiers, e.g. subtropical, temperate, mountain and alpine, and five soil complexes: vertisoils, cambiosoils, phaeozems, leptosoils and andosoils create a great diversity of edaphic and agro-ecological conditions [1] [2]. Agricultural activities are conducted on small plots (terraces or *poios*) located at elevations ranging from the sea level up to 800 meters asl, and are mostly restricted to isolated valleys and steep slopes, primarily under low input conditions or organic farming [3].

The common bean (*Phaseolus vulgaris* L.) is the most produced legume crop in Madeira and plays an important role in agricultural economy, with an average production of 2811 tons on approximately 170 hectares [4].

Common bean is known for its morphological variability and adaptability to different environments, creating a wide range of local varieties. At the same time, its nutritional composition is conditioned by factors such as genotype, origin, environmental and growing conditions, influencing the quality of the bean seeds [5]. Historical records [6] corroborated by the analysis of phytogeographic origin [7] indicate that common bean has been introduced into Madeira in the beginning of sixteenth century, probably from Brazil, South America, represented almost exclusively by the Andean gene pool, C (Contender) and T (Tendergreen) genotypes. For centuries the farmers maintained under cultivation a wide diversity of common bean landraces, both with indeterminate and determinate growth, divided into green or seed bean. A morphological and agronomic evaluation of germplasm accessions from the ISOPlexis Genebank[1] collection representing the Madeiran crop diversity was performed [8]. Fifteen landrace groups have been detected, of which genetic diversity results from successive germplasm introductions, geographical isolation, even within the archipelago, acclimatization and adaptation to agro-ecological conditions, and the traditional practices based on the simultaneous use of several cultivated forms of crops [2] [3]. However, to date the Madeiran common beans have been never evaluated in relation to the composition of their nutritional and mineral traits.

Common bean is often a main source of protein, dietary fiber and minerals in diet, occupying a very important worldwide place in human alimentation, offering benefits for human health [9]. Nowadays, loss of crop diversity and extinction of genetic resources lead to a simultaneous deterioration of nutritional quality, with the majority of the crop genetic diversity and desirable traits remaining underutilized in elite varieties [10] [11]. Kigel [12] reviewed available information on biochemical composition of bean seeds and documented that their nutritional and culinary quality depends of genetic, environmental and origin (location) factors.

There is a discernible lack of information about the Madeiran Island beans genetic resources. However, some data on nutritional quality of the common bean from the Iberian Peninsula [13] and Portugal [14] [15] have been reported, as example. The main goal of this study was to perform nutritional and mineral analyses of fifty-two accessions representing Madeiran bean diversity by determining their total ash, protein, starch, total soluble sugar, fat and minerals content. Additionally, we intended to compare the nutritional and mineral composition of the Madeiran bean landraces with the Portuguese mainland accessions and to identify the genetic material that could be a source of the desirable traits for bean breeding programs aimed at improvement of nutritional characteristic of the crop.

[1]The ISOPlexis Germplasm Bank, University of Madeira, Funchal, Portugal, is a research unit, partner of the FAO genebank network (since 2001) and Germobanco, Macaronesian Agriculture Genebank (since 2003). ISOPlexis has seventeen years of experience in prospection, survey, conservation, evaluation and valorization of the Madeiran genetic resources.

2. Material and Methods

2.1. Seed Material

Fifty-nine accessions of common bean, including fifty-two accessions from the germplasm collection of the ISOPlexis Genebank, five standard cultivars and two commercial varieties were submitted to the analysis of their nutritional traits, presented in **Table 1**.

All samples were simultaneously multiplied in randomly designed trials established at the experimental field (32˚39'52"N 16˚55'44"W, 159 m of altitude, Funchal, Madeira) in 2008. They were grown under the same environmental conditions, in soil free of chemical contaminants and without addition of any fertilizers or phytopharmaceutical products.

After the harvest, seeds were dehydrated and stored in the ISOPlexis Genebank at −20˚C under controlled relative humidity. In 2010, mineral and nutritional properties were evaluated as an additional quality control of the germplasm storage process in our genebank.

2.2. Sample Preparation

Fifty dry seeds per accession were selected and their tegument and embryo were removed with a scalpel. The cotyledons were milled using a grinder, followed by manual mortar grinding to obtain fine flour (200 meshes - 74 μm). The flour was packed in hermetically sealed tubes and stored at room temperature until the compositional analyses were conducted.

2.3. Nutritional and Mineral Analysis

Nutritional (total protein, starch, soluble sugar and fat) and mineral (Cu, Fe, K, Mg, Mn and Zn) parameters of seeds of dry beans accessions were analyzed. Dry matter was determined by dehydration at 105˚C using a Kern moisture balance model MRS 120-3 according to the method AOAC 925.10:2005 [16]. Total protein content was determined by the Kjeldahl method with the quantification of total nitrogen, according to AOAC 945.18-B: 2005, using a Distillation and Titration Unit, model Velp Scientifica UDK 152. The factor Nx6.25 was applied to convert the total nitrogen to protein content [17]. Starch was extracted according to Hodge and Hofreiter (1962) and its content determined at 630 nm, using the spectrophotometer UV/Vis, model Shimadzu, 2401 PC with the UVProbe software [18]. The soluble sugars were determined according to McCready [19], with new adaptations proposed by Bailey [20], crafting the sugars react with 0.02% anthrone solution (P/V), dissolved in 70% sulfuric acid (V/V). Extraction of lipid fraction was held after the breakdown of starch present in the bean flour, according to Humphreys & Kelly [21], using 7 M perchloric acid. Fat content in bean flour was determined by the Bligh & Dyer [22] gravimetric method. Bean flour was ashed using the AOAC [23] method. Mineral content was determined according to Temminghoff & Houba [24], digesting the bean flour ash with hydrochloric acid for P, Cu, Fe, K, Mg, Mn and Zn, and with sulfuric acid for B determination. While the P and B content were determined by colorimetric quantification using a Skalar Sanplus System, the Cu, Fe, K, Mg, Mn and Zn were quantified by atomic absorption spectroscopy by Perkin Elmer Instruments (AAnalyst 800). The analyses of the proximate composition were performed in triplicates for all the analyzed parameters. The values were expressed in g per 100 grams on a dry weight basis (DW).

2.4. Statistical Analysis

Data treatment was performed using the software SPSS (Statistical Package for the Social Science) version 20.0 for Windows and MVSP (Multivariate Statistical Package) version 3.1 for Windows. A descriptive statistical analysis was made for each parameter. The Kolmogorov-Smirnov non-parametric test was applied to test the data normal distribution. One-way ANOVA was applied to evaluate the variance of nutritional and mineral parameters. The Pearson coefficient was used to verify the existence of statistically significant correlations among the variables. The multivariate analysis of main PCA components was performed, with the aim to detect the existence of clusters grouping bean accessions according to their nutritional and mineral composition.

3. Results and Discussion

Fifty-two bean accessions from the ISOPlexis Genebank were selected based on their representativeness of crop

Table 1. Source information, proximate composition and mineral content for each variety of common bean (*Phaseolus vulgaris* L.) flours (g/100g DW[b])[a].

ISOP[c]	Vernacular name	Collection site	DM	Lp	CP	St	SS	As	Macronutrients content (g/100g DW)				Micronutrients content (mg/100g DW) (µg/100g DW)				
									N	P	K	Mg	Fe	Cu	Zn	Mn	B
459	Canadiano	Santana	89.47	1.37	21.63	33.07	4.91	4.21	3.58	0.55	2.28	0.13	6.00	1.10	2.60	1.30	0.60
460	Vergalheiro	Santana	90.84	2.32	27.21	37.22	3.73	4.74	3.83	0.42	1.70	**0.18****	7.00	1.00	3.40	1.30	1.70
463	Corno de Carneiro	Santana	87.55	1.40	25.65	36.09	6.38	4.44	4.17	0.70	2.17	0.13	5.00	0.80	2.80	2.10	**0.20***
478	Filipe	Santana	90.13	2.07	24.41	42.71	3.11	4.61	3.67	0.41	1.55	0.17	6.00	1.00	2.70	1.20	1.60
480	Preto	Santana	91.68	**2.86****	20.13	37.83	4.02	5.32	3.00	0.35	1.70	0.17	6.00	1.20	3.00	1.60	1.80
489	Rasteiro	Santana	89.23	1.57	22.97	38.65	5.36	4.10	3.92	0.55	2.28	0.15	6.00	1.00	3.20	1.10	0.50
492	Fava	Santana	87.25	1.68	23.12	35.62	4.75	4.38	3.53	0.73	1.86	0.15	4.30	0.70	2.20	1.30	0.30
497	Touquinho	Santana	86.96	1.75	24.76	33.31	5.21	4.11	4.41	0.44	2.14	0.14	5.00	**0.50***	2.60	1.50	0.50
505	Corno de Carneiro	Santana	91.55	2.34	24.02	37.39	4.45	5.36	3.67	0.50	1.55	0.17	6.20	1.30	3.30	1.40	1.80
508	Milheiro	Santana	89.19	2.42	21.57	39.95	3.82	4.65	3.33	0.51	1.50	**0.18****	6.50	1.30	3.50	1.50	2.00
514	Algarve	Santana	87.82	1.80	23.20	34.19	5.52	4.28	3.92	0.52	2.42	0.12	6.00	1.00	3.00	1.50	0.50
519	Touquinho	Santana	87.22	1.90	27.65	34.55	4.35	4.58	3.15	0.56	1.53	0.14	7.00	1.10	3.10	1.80	2.10
521	Faial	Santana	85.06	1.79	21.41	44.33	5.30	4.34	3.43	0.42	2.28	0.12	6.50	0.80	2.70	1.40	0.70
528	Faial	Santana	87.97	1.54	25.94	34.08	6.05	4.87	4.17	**0.75****	2.49	0.13	5.00	0.70	3.00	1.80	0.30
534	Vaginha	Santana	89.60	1.61	20.04	42.67	3.59	4.61	3.17	0.44	1.60	0.14	6.80	1.30	2.80	1.60	1.70
541	Manteiga	Santana	88.36	1.66	21.88	39.32	5.83	3.92	3.43	0.44	2.14	0.12	**4.10***	**0.50***	**2.20***	1.30	0.60
668	Preto	S. Vicente	85.99	1.51	27.26	31.67	5.19	4.60	4.41	0.62	2.21	0.14	6.00	1.20	3.10	1.20	0.70
670	Branco Rasteiro	S. Vicente	92.63	1.64	19.30	49.06	4.73	4.07	3.00	0.43	**1.30***	**0.18****	5.50	**1.40****	2.90	1.10	1.90
679	Vassoura Rasteiro	P. Moniz	90.13	1.46	25.59	35.18	6.53	4.12	4.17	0.38	2.21	0.12	5.80	1.00	2.70	1.00	1.00
712	Vaginha	S. Vicente	92.74	2.09	**18.55***	**52.65****	5.35	4.54	3.00	0.35	1.40	0.17	6.40	1.30	2.50	1.50	1.70
713	Vaginha Grossa	S. Vicente	91.35	1.60	23.33	36.01	**2.97***	4.97	3.83	0.41	1.55	0.17	5.50	1.20	3.10	1.40	1.40
719	Feijão	S. Vicente	**83.35****	1.51	23.83	37.33	5.65	4.36	3.75	0.55	2.07	0.13	5.50	1.00	3.10	1.80	0.60
722	Açores	S. Vicente	91.07	1.57	20.02	40.42	3.27	4.40	3.17	**0.30***	1.45	0.15	5.00	1.00	2.80	1.30	1.50
724	Vermelho	S. Vicente	**93.55***	1.44	**29.69****	42.36	3.99	5.55	**4.83****	0.41	1.65	0.17	8.50	**1.40****	**5.00****	1.50	1.40
726	Vassoura Rasteiro	S. Vicente	90.90	1.80	21.51	41.99	4.44	4.82	3.50	0.37	1.55	0.17	6.50	0.90	2.80	**0.90***	1.70
730	Boneco	R. Brava	87.03	2.00	24.69	38.80	5.64	4.16	3.97	0.52	2.03	0.14	6.50	0.80	2.70	1.40	0.50
731	Rasteiro Vassoura	R. Brava	92.20	1.97	20.87	35.34	4.31	4.86	3.50	0.37	1.55	0.17	6.50	1.10	3.00	1.00	1.80
732	Vaginha	R. Brava	83.89	1.16	20.57	37.78	6.54	4.11	3.09	0.53	1.96	0.12	4.80	1.00	2.70	1.00	0.40
743	Feijão	R. Brava	92.64	2.40	21.67	26.91	4.30	3.82	4.33	0.43	1.60	0.15	6.00	1.00	2.70	1.50	1.20
744	Feijão	R. Brava	90.35	1.59	23.27	37.44	6.59	4.18	3.36	0.57	2.14	0.14	6.50	1.10	3.50	1.20	0.60
748	Rajado	R. Brava	88.05	1.28	20.64	39.65	6.59	4.04	3.31	0.39	1.93	0.13	5.50	1.10	2.40	1.30	0.70
749	Vaginha	R. Brava	90.07	1.60	23.71	37.54	**6.84****	4.60	3.82	0.47	2.35	0.14	4.90	0.90	2.50	1.60	0.70
755	Valinho	R. Brava	92.42	2.06	25.76	45.51	3.44	4.36	4.17	0.44	1.55	0.15	**10.00****	1.00	2.60	1.50	1.40

Continued

757	Feijão	R. Brava	91.94	2.03	22.49	29.33	3.79	4.43	3.67	0.44	1.65	0.14	6.50	1.20	2.90	1.00	1.80
760	Vaginha	P. Moniz	85.64	1.48	20.60	35.17	6.21	4.14	**2.55**[*]	0.42	1.45	0.14	6.80	1.00	3.00	1.50	**2.40**[**]
761	Alfarroba	P. Moniz	87.75	0.82	19.17	40.47	6.79	4.69	3.14	0.48	2.31	0.13	4.90	0.90	2.50	1.30	0.60
764	Rasteiro	P. Moniz	86.96	**0.57**[*]	27.12	30.34	5.19	4.64	4.61	0.58	2.35	**0.10**[*]	6.20	1.20	3.60	1.00	0.60
770	Vermelho	P. Moniz	88.31	1.11	24.90	37.93	5.37	3.97	4.21	0.53	2,21	0.12	5.00	1.10	2.80	1.20	0.50
773	Gordo	P. Moniz	85.47	1.18	23.44	38.68	5.69	4.57	3.90	0.54	2.17	0.11	6.50	1.00	3.30	1.40	0.80
777	Catarino	P. Moniz	86.01	1.44	21.52	44.92	5.26	4.28	3.48	0.55	2.07	0.14	4.80	0.90	3.10	1.40	0.30
778	Vagem Vermelha	P. Moniz	85.85	1.31	24.07	39.09	5.62	4.60	3.87	0.47	2.24	0.12	5.00	1.10	2.70	1.40	0.40
798	Riscado de Vara	Calheta	89.50	1.48	27.13	33.66	5.18	4.88	4.39	0.60	1.71	0.15	7.30	0.70	3.60	1.70	1.50
800	Vara	Calheta	88.64	1.32	23.14	41.91	4.43	4.58	3.70	0.54	2.28	0.12	5.50	0.90	2.90	1.30	0.60
806	Corno de Carneiro	S. Vicente	89.22	1.61	23.10	39.63	4.92	3.87	3.63	0.41	1.96	0.11	5.00	0.80	2.50	1.20	0.60
809	Vagem Vermelha	S. Vicente	85.61	1.37	22.63	39.30	5.44	4.77	3.55	0.64	2.38	0.15	5.50	1.00	2.80	1.40	0.40
822	De Pé	S. Vicente	88.24	1.32	27.09	39.97	3.91	4.87	4.31	0.62	2.19	0.17	6.00	1.20	3.80	1.10	0.50
824	Rajado	S. Vicente	85.80	1.36	20.85	37.67	3.92	**3.64**[*]	3.14	0.42	1.65	0.11	5.50	0.80	2.60	1.10	0.40
828	Amarelo	S. Vicente	91.61	1.48	23.47	35.73	4.81	4.54	3.83	0.35	1.65	0.17	6.00	1.10	2.30	1.30	1.50
829	De Pé	S. Vicente	89.17	1.43	25.69	39.70	4.20	4.96	4.02	0.60	**2.49**[**]	0.15	6.00	1.00	3.50	1.20	0.50
849	Corno de Carneiro	S. Vicente	84.87	1.28	27.17	31.46	5.38	5.29	4.31	0.70	2.45	0.17	6.20	1.20	3.50	1.30	**0.20**[*]
876	[1]Contender	Galicia	92.65	1.90	19.24	46.98	4.13	4.10	3.17	0.43	1.40	0.15	5.50	0.90	3.30	1.60	1.60
877	[2]Sanilac	Galicia	92.87	2.10	22.30	45.14	3.57	4.66	3.67	0.52	1.50	0.12	6.50	1.10	3.80	**3.80**[**]	1.60
878	[3]Tendergreen	Galicia	91.02	2.12	23.33	**23.40**[*]	3.70	4.79	3.67	0.46	1.50	0.17	4.50	1.00	3.60	1.90	1.30
879	[4]Pampa	Galicia	90.05	1.57	24.95	46.33	3.29	5.43	4.17	0.58	1.80	**0.18**[**]	6.00	1.10	4.00	2.20	1.70
880	[5]Boyaca	Galicia	89.81	2.22	20.49	47.10	4.63	4.96	3.33	0.43	1.60	0.17	4.50	1.20	3.10	1.80	1.80
980	Barbinha	Santa Cruz	89.26	1.26	24.24	28.27	5.51	5.24	3.60	0.52	1.75	0.15	8.00	1.10	3.10	1.90	1.30
1944	Manteiga	Santana	89.36	0.95	24.73	29.83	4.12	5.19	3.82	0.62	1.85	0.14	8.00	**0.50**[*]	3.10	1.60	1.20
-	[6]Catarino	-	92.75	1.69	20.58	30.08	4.19	4.89	3.50	0.52	1.75	**0.18**[**]	6.00	1.10	2.90	1.90	1.80
-	[7]Preto	-	92.07	2.06	23.93	38.30	3.82	**5.67**[**]	3.00	0.42	1.55	0.15	8.00	1.00	2.90	1.20	1.60

[a]Values are means of triplicate determinations. [b]DW, each values are expressed on dry weight basis. [c]ISOP Number–Identification code used in germplasm accesses in the ISOPlexis Germplasm Bank. DM—Dry Matter; Lp—Lipids; CP—Crude Protein; St—Starch; SS—Soluble Sugar; As—Ash; N—Nitrogen; P—Phosphorous; K—Potassium; Mg—Magnesium; Fe—Iron; Cu—Copper; Zn—Zinc; B—Boron. [1]Contender MBG CODE: PHA-0947, [2]Sanilac MBG CODE: PHA-0948, [3]Tendergreen MBG CODE: PHA-0949, [4]Pampa MBG CODE: PHA-0950, [5]Boyaca MBG CODE: PHA-0951 are International Bean Standards from Galicia, Spain, [6,7]Commercial bean varieties from a local supermarket. [*]Lowest value registered. [**]Highest value registered.

resources and evaluated to identify local landraces using morphological and agronomic traits [8]. Seeds samples of the selected accessions were analyzed for their nutritional and mineral traits, identifying them as ISOP Numbers used as identification code in the germplasm common bean accesses from the ISOPlexis Germplasm Bank. Five standard beans cultivars obtained from Galicia (Consejo Superior de Investigaciones Cientificas—CSIC) and two commercial varieties were included as the out-groups.

The main objective of this study was to perform nutritional and mineral evaluation of the Madeira beans. Nutritional composition of common beans can vary as a result of the influence of genetic diversity as well as environmental conditions including temperature, soil and fertilization (nutrients) [11] [12] [25]. The goal of our study was to evaluate if crop diversity [8] influences the variability of nutritional and mineral composition among common beans from Madeira. Therefore, to avoid the influence of the environmental factors, the accessions collected from different locations on Madeira were multiplied under the same experimental field conditions. Any differences in nutritional and mineral composition of plant material grown under identical environmental conditions are deemed to be due to inherent genetic properties of a given accession [11] [25].

3.1. Nutritional Analysis

The mean values of proximate nutritional and mineral composition performed on 59 bean accessions are presented in **Table 1**. The accessions originated from locations representing different soil and climatic conditions found on the island. All parameters showed a normal distribution with significance level (p-value) greater than 0.05 by the nonparametric Kolmogorov-Smirnov test (data not shown). The ANOVA analysis for the 59 bean accessions revealed highly significant differences for all parameters, ($p \leq 0.01$), with ash and protein content having the highest variance (data not shown). The major features of nutritional and mineral composition are discussed below.

3.1.1. Dry Matter

The average value for bean seeds dry weight was 89.13 g (**Table 2**). The variation ranged between 83.35 and 93.55 g for the accessions ISOP 719 and ISOP 724, respectively (**Table 1**). Since the presence of water affects its conservation, the rate of deterioration and preservation of these propagation materials in the gene bank is controlled, accordingly to Rao [26]. This parameter exhibited the following mean values or variation: 86.00 g for a Portuguese bean [15], 90.00 g for common bean from the core collection of the Iberian Peninsula [13], 91.75 g for bean samples used in the common bean supplementation study [27], between 88.99 g and 91.00 g for improved dry common bean varieties of Ethiopia [28].

3.1.2. Total Protein

The total protein mean content was 23.27 g with minimal value of 18.55 g for ISOP 712 and maximal of 29.69 g for ISOP 724 (**Tables 1** and **2**). These results are consistent with the 20.43 to 23.62 g range of protein content

Table 2. Common bean proximate composition and mineral content, expressed on a dry weight basis.

Traits	Overall			Regional			Outgroup		
	n	Content[a]	Range	n	Content[a]	Range	n	Content[a]	Range
Dry matter (g/100g)	59	89.13 ± 2.57	83.35 - 93.55	52	88.80 ± 2.52	83.35 - 93.55	7	91.60 ± 1.31	89.81 - 92.87
Protein content (g/100g)	59	23.27 ± 2.52	18.55 - 29.69	52	23.43 ± 2.55	18.55 - 29.69	7	22.11 ± 2.09	19.24 - 24.95
Starch content (g/100g)	59	37.92 ± 5.60	23.40 - 52.65	52	37.69 ± 4.96	26.91 - 52.65	7	39.62 ± 9.50	23.40 - 47.10
Soluble sugar content (g/100g)	59	4.84 ± 1.02	2.97 - 6.84	52	4.97 ± 1.02	2.97 - 6.84	7	3.90 ± 0.45	3.29 - 4.63
Lipid content (g/100g)	59	1.65 ± 0.41	0.57 - 2.86	52	1.61 ± 0.42	0.57 - 2.86	7	1.95 ± 0.24	1.57 - 2.22
Ash content (g/100g)	59	4.57 ± 0.45	3.64 - 5.67	52	4.52 ± 0.43	3.64 - 5.55	7	4.93 ± 0.51	4.10 - 5.67
N (g/100g)	59	3.69 ± 0.47	2.55 - 4.83	52	3.72 ± 0.48	2.55 - 4.83	7	3.50 ± 0.39	3.00 - 4.17
P (g/100g)	59	0.50 ± 0.10	0.30 - 0.75	52	0.50 ± 0.11	0.30 - 0.75	7	0.48 ± 0.06	0.42 - 0.58
K (g/100g)	59	1.89 ± 0.35	1.30 - 2.49	52	1.93 ± 0.35	1.30 - 2.49	7	1.59 ± 0.14	1.40 - 1.80
Mg (g/100g)	59	0.15 ± 0.02	0.10 - 0.18	52	0.14 ± 0.02	0.10 - 0.18	7	0.16 ± 0.02	0.12 - 0.18
Fe (mg/100g)	59	6.01 ± 0.00	4.10 - 10.00	52	6.03 ± 0.00	4.10 - 10.00	7	5.86 ± 0.00	4.50 - 8.00
Cu (mg/100g)	59	1.01 ± 0.00	0.50 - 1.40	52	1.01 ± 0.00	0.50 - 1.40	7	1.06 ± 0.00	0.90 - 1.20
Zn (mg/100g)	59	3.01 ± 0.00	2.20 - 5.00	52	2.96 ± 0.00	2.20 - 5.00	7	3.37 ± 0.00	2.90 - 4.00
Mn (µg/100g)	59	1.45 ± 0.00	0.90 - 2.10	52	1.37 ± 0.00	0.90 - 2.10	7	2.06 ± 0.00	1.20 - 3.80
B (µg/100g)	59	1.08 ± 0.00	0.20 - 2.40	52	1.00 ± 0.00	0.20 - 2.40	7	1.63 ± 0.00	1.30 - 1.80

[n]Represent the number of beans access analyzed; [a]Values are means of triplicate determinations ± SD.

obtained by Bhatty [27] and Siddiq [29], but shown a higher protein variation in bean seeds. The protein variation in the Madeiran bean seeds was greater than 17.96 to 27.45 g for the Northern Portuguese bean [14] and 17.96 and 22.07 g for the improved Ethiopian beans [28]. Still, protein content of the Madeiran beans was lower than obtained from the Portuguese [15] with 30.7 g and the Iberian Peninsula [13] with 31.4 g bean collections. Kozlowska [25] and Kigel [12] reported that addition nutrients such as nitrogen and sulfur can directly stimulate synthesis of bean seed storage proteins. However, the total protein content and its variation in the Madeiran bean accessions were not affected by this factor since all accessions were grown under identical field conditions, without receiving any supplemental nutrients.

3.1.3. Starch

The average starch amount was 37.92 g, ranging from 26.91 g in ISOP 743 to 52.65 g in ISOP 712 (**Tables 1** and **2**), showing a good energetic supply for the viability of the seeds during storage. The variation of starch content among the Madeiran beans was higher than 37.6 to 45.9 g detected by Rodiño [15], 40.1 to 49.5 g [13] or 23.4 and 32.0 g [9], while it was lower than 51.0 to 59.0 g of starch in common black bean seeds reported by Kozlowska [25].

3.1.4. Soluble Sugar

The average soluble sugar content was 4.84 g/100g, with the lowest value of 2.97 g and the highest of 6.84 g (**Table 2**) for ISOP 713 and ISOP 749, respectively (**Table 1**). Soluble sugar variation in regional beans was larger than in the Northern Portuguese and the Iberian Peninsula beans with content between 3.80 and 6.50 g [13] [15]. The content of soluble sugars in the bean seeds is usually reduced, varying between the 2.0 and 9.6 g [25].

3.1.5. Lipids

Total lipid mean values stood at 1.65 g, ranging from 0.57 g to 2.86 g (**Table 2**) for the ISOP 764 and ISOP 480, respectively (**Table 1**). Lipid content of the Madeiran beans was lower than 2.45 to 3.62 g range reported by Bhatty [27] and Siddiq [29]. Moreover, the Madeiran accessions shown relatively high fat content when compared with 0.60 to 2.38 g reported by several other laboratories [13] [15] [28] [30]. Pomeranz and Meloan [31] found that proteins and carbohydrates, including starch, might interfere with lipid extraction, because they are generally bound to these compounds. To obtain reliable results we performed a prior starch extraction of all the samples before analyses to the lipid fraction.

3.1.6. Ash

Ash represents total inorganic matter of the seed sample and is related to mineral residue. The mean ash content of bean samples in this study was 4.57 g, ranging between 3.64 g of ISOP 824 and 5.55 g of ISOP 724 (**Tables 1** and **2**). The Madeiran beans showed a relatively high ash content. While trait variation was greater than 2.86 and 4.26 g reported by Shimelis and Rakshit [28], or than 4.60 and 5.00 g [27] [29], it was narrower and lower than 3.00 and 6.00 g as demonstrated by Kaur [30].

3.1.7. Mineral Analysis

The analysis of nine mineral elements classified as macro- and micronutrients according to their role-played in human daily dietary intake was performed. The average minimum and maximum values for regional, standards and commercial varieties are given in **Table 2**.

1) Macronutrients content

Macronutrients analyzed in this study are the most important minerals from the dietary perspective as they play vital functions in the organism [32]. The average values for N, K, P and Mg in local bean accessions were 3.69 g, 1.89 g, 0.50 g and 0.15 g, respectively (**Table 2**). These results are consistent with the Oomah [33] and Shimelis and Rakshit [28] reports. ISOP 724, which is also the accession with highest protein content had also the highest N content (4.83 g), while ISOP 760 was characterized by the lowest content (2.55 g) (**Table 1**). Concerning P, ISOP 528 detained the highest content (0.75 g) of this element among local beans that was higher than the 0.66 g in the Canadian beans [33], and ISOP 722 the lowest (0.30 g), however higher than 0.02 g of the Ethiopian bean [28]. The maximum K content was 2.49 g in ISOP 829, and the minimal, 1.30 g in ISOP 670 (**Table 1**). This variation range covers 1.95 g of K for the Canadian bean registered by Oomah [33]. The highest Mg value was 0.18 g obtained for the accessions, ISOPs 460, 508 and 670, and the lowest (0.10 g) for ISOP 764

(**Tables 1** and **2**). This variation was slightly lower than 0.21 g in the Canadian bean reported by Oomah [33]. Our data (**Tables 1** and **2**) suggest that the variation in N, P, K and Mg traits among the Madeiran bean accessions covers up these values for the out-group composed by the standard and commercial varieties.

2) Micronutrients content

Among micronutrients playing important functions in the organism [32], Fe, Cu, Zn, Mn and B were analyzed in this study. The Madeiran bean accessions had the uppermost average content of Fe (6.01 mg), followed by Zn and Cu, 3.01 mg and 1.01 mg, respectively (**Table 2**). The variation in the content of these microelements among bean accessions is given in **Table 1**. The ISOP 755 has the highest Fe value of 10.00 mg, whereas ISOP 541 was characterized by the lowest content (4.10 mg) among the local accessions (**Table 1**). According to literature, Fe content in bean seeds varies between 2.83 mg [33] and 8.40 mg [28]. The highest Cu content registered was 1.40 mg for ISOP 670 and ISOP 724 while the lowest was 0.50 mg for ISOP 492 (**Table 1**). This Cu range covers 0.88 mg detected in the Canadian bean [33]. Finally, ISOP 724, with 5.0 mg, and ISOP ISOP 541, with 2.20 mg of Zn had 1.7 and 0.8 folds the content of this microelement (2.89 mg) of the Ethiopian bean [28] (**Table 1**).

The average content of two ultra-micronutrients, Mn and B, was 1.45 µg and 1.08 µg, respectively (**Table 2**). The highest (2.10 µg) and lowest (0.90 µg) values of Mn content were detected in ISOP 463 and ISOP 731, respectively (**Table 1**). This range covers 1.94 µg of Mn in common bean detected by Shimelis and Rakhit [28]. B is a nonmetallic trace element, which upper quantity (2.40 µg) was detected in ISOP 760 and the lowest quantity (0.20 µg) in ISOPs 463 and 849 (**Table 1**).

3.2. Nutritional and Mineral Traits Variability

The **Table 2** presents the mean values and range of variation for 15 of nutritional and mineral parameters, covering all 59 accessions, organized into 2 groups: local bean accessions (52 samples) and the out-group composed by 7 accessions, 5 standard and 2 commercial varieties. Data contained in **Table 2** point to the existence of a great variability in nutritional and mineral traits among the local Madeiran beans. The variability range covers the values of the parameters noted for improved bean varieties including dry matter, total protein, soluble sugars, and lipids. Moreover, it significantly covered the variation of starch and ash of the out-group, whereas lower limits (minimal values) of the Madeiran beans were higher than their equivalents for analyzed standard and commercial varieties. Individually, the mineral traits had shown the same behavior in their variability, with the exception of Mn, while the upper limit was lower than the equivalent for analyzed standard and commercial varieties. The variance test for regional beans versus the out group revealed significant differences between the groups in several quality parameters, including soluble sugar, lipids, dry matter, manganese and boron, ($p \leq 0.01$), and ash, lipids, zinc and potassium ($p \leq 0.05$).

The origin of the accession apparently had an influence on seed composition. Therefore, the existence of this range of variability could be used to select appropriated sources of material for breeding proposes. To better understand the importance of this variation in nutritional and mineral traits, the accessions were classified according to their growth behavior and landrace, according to Freitas [8]. The 52 Madeiran bean accessions belong to the climbing (40 accessions) and dwarf (12 accessions) beans. The group of climbing beans showed larger traits variation in relation to dwarf group for the majority of the analyzed parameters, excluding starch, lipids, ashes, K and Mg contents. However, the variance test did not identify significant differences between these groups for any parameter, with the exception of Mn ($p \leq 0.01$). **Table 3** presents the local accessions classified according to 15 bean landraces and the mean values obtained for the nutritional and mineral composition traits. The observed trait variation is split among these landraces groups, which differ between them at least by one or more parameters. However, the ANOVA tests did not show significant differences between the nutritional and mineral parameters. The exceptions were Cu and Mn traits, with a $p \leq 0.05$ and $p \leq 0.01$, respectively.

An important subject of the present work was to understand the relation between nutritional and mineral traits and to detect the existence of any pattern in their joint inheritance. To assess this hypothesis a statistical analysis, exploring correlations between studied parameters, was performed (**Table 4**). A total of 53 statistically significant correlations have been detected between 15 nutritional and mineral parameters, among them 39 correlations with $p < 0.01$ and 14 with $p < 0.05$ (**Table 4**). The majority of significant correlations involved a relation between mineral and nutritional traits (28 correlations) or among mineral traits (17 correlations). Only 8 correla-

Table 3. Proximate and mineral composition of the 52 regional common bean distributed in the 15 morpho-agronomic groups determined by Freitas [8], in g/100g DW^{a,b}.

Landrace Groups	n	Dry matter	Lipids	Protein	Starch	Soluble sugar	Ash	Macronutrients content (g/100g DW)			Micronutrients content (mg/100g DW)				(µg/100g DW)	
								N	P	K	Mg	Fe	Cu	Zn	Mn	B
I	2	90.43 ± 3.10	1.48 ± 0.23	23.19 ± 5.50	44.51 ± 6.43	4.32 ± 0.58	4.47 ± 0.56	3.66 ± 0.93	0.53 ± 0.13	1.75 ± 0.63	0.18 ± 0.01	5.75 ± 0.00	1.30 ± 0.00	3.35 ± 0.00	1.10 ± 0.00	1.20 ± 0.00
II	2	91.16 ± 1.46	1.71 ± 0.36	23.23 ± 3.34	35.26 ± 0.12	5.42 ± 1.57	4.49 ± 0.53	3.84 ± 0.47	0.38 ± 0.01	1.88 ± 0.47	0.15 ± 0.04	6.15 ± 0.00	1.05 ± 0.00	2.85 ± 0.00	1.00 ± 0.00	1.40 ± 0.00
III	3	87.56 ± 2.89	1.56 ± 0.22	23.21 ± 3.52	37.11 ± 5.18	4.52 ± 0.64	4.35 ± 0.63	3.68 ± 0.65	0.47 ± 0.13	1.80 ± 0.36	0.14 ± 0.03	6.00 ± 0.00	0.97 ± 0.00	2.83 ± 0.00	1.07 ± 0.00	0.93 ± 0.00
IV	5	89.67 ± 2.06	1.51 ± 0.65	24.14 ± 2.21	34.61 ± 5.65	5.13 ± 0.97	4.34 ± 0.46	4.05 ± 0.47	0.55 ± 0.07	2.17 ± 0.14	0.14 ± 0.00	6.14 ± 0.00	1.06 ± 0.00	3.30 ± 0.00	1.20 ± 0.00	0.68 ± 0.00
V	4	88.68 ± 2.57	1.94 ± 0.63	20.99 ± 1.49	37.47 ± 3.80	4.83 ± 1.23	4.59 ± 0.53	3.16 ± 0.57	0.43 ± 0.07	1.79 ± 0.43	0.14 ± 0.02	6.40 ± 0.00	1.13 ± 0.00	2.95 ± 0.00	1.55 ± 0.00	1.60 ± 0.00
VI	5	88.81 ± 1.21	1.54 ± 0.44	24.00 ± 1.21	34.69 ± 6.18	4.75 ± 1.12	4.61 ± 0.60	3.79 ± 0.38	0.49 ± 0.09	1.89 ± 0.26	0.14 ± 0.02	6.22 ± 0.00	0.72 ± 0.00	2.74 ± 0.00	1.50 ± 0.00	1.04 ± 0.00
VII	2	88.21 ± 1.39	2.16 ± 0.37	24.61 ± 4.29	37.25 ± 3.82	4.09 ± 0.37	4.61 ± 0.05	3.24 ± 0.13	0.54 ± 0.04	1.52 ± 0.02	0.16 ± 0.03	6.75 ± 0.00	1.20 ± 0.00	3.30 ± 0.00	1.65 ± 0.00	2.05 ± 0.00
VIII	3	87.60 ± 4.56	1.86 ± 0.30	24.76 ± 0.97	40.54 ± 4.36	4.91 ± 1.21	4.29 ± 0.11	3.96 ± 0.21	0.50 ± 0.06	1.88 ± 0.29	0.14 ± 0.01	7.33 ± 0.00	0.93 ± 0.00	2.80 ± 0.00	1.57 ± 0.00	0.83 ± 0.00
IX	5	89.20 ± 2.09	1,42 ± 0.46	21.18 ± 2.92	39.99 ± 7.80	5.94 ± 0.80	4.47 ± 0.34	3.44 ± 0.46	0.50 ± 0.16	2.08 ± 0.43	0.14 ± 0.02	5.56 ± 0.00	1.02 ± 0.00	2.60 ± 0.00	1.44 ± 0.00	0.78 ± 0.00
X	2	88.54 ± 3.57	1.51 ± 0.09	20.77 ± 1.06	42.67 ± 3.18	4.26 ± 1.41	4.34 ± 0.09	3.33 ± 0.22	0.43 ± 0.18	1.76 ± 0.44	0.15 ± 0.01	4.90 ± 0.00	0.95 ± 0.00	2.95 ± 0.00	1.35 ± 0.00	0.90 ± 0.00
XI	5	87.39 ± 2.91	1.53 ± 0.37	22.91 ± 1.01	38.67 ± 5.70	4.97 ± 0.83	4.50 ± 0.11	3.71 ± 0,19	0.48 ± 0.06	2.12 ± 0.27	0.12 ± 0.01	6.00 ± 0.00	1.00 ± 0.00	2.90 ± 0.00	1.30 ± 0.00	0.86 ± 0.00
XII	5	89.02 ± 1.34	1.64 ± 0.44	25.09 ± 2.04	36.81 ± 2.28	4.79 ± 0.64	4.37 ± 0.45	3.92 ± 0.37	0.54 ± 0.13	1.89 ± 0.21	0.14 ± 0.03	5.72 ± 0.00	0.86 ± 0.00	2.90 ± 0.00	1.34 ± 0.00	0.92 ± 0.00
XIII	3	89.74 ± 2.05	1.49 ± 0.10	24.28 ± 1.19	36.45 ± 0.96	6.01 ± 1.07	4.53 ± 0.08	3.94 ± 0.20	0.51 ± 0.18	2.06 ± 0.36	0.15 ± 0.02	5.30 ± 0.00	0.93 ± 0.00	2.53 ± 0.00	1.67 ± 0.00	0.80 ± 0.00
XIV	2	88.48 ± 4.05	1.49 ± 0.17	22.98 ± 0.50	37.65 ± 2.33	4.20 ± 1.75	4.87 ± 0.14	3.69 ± 0.20	0.53 ± 0.16	1.97 ± 0.59	0.16 ± 0.01	5.50 ± 0.00	1.10 ± 0.00	2.95 ± 0.00	1.40 ± 0.00	0.90 ± 0.00
XV	4	88.46 ± 4.80	1.56 ± 0.54	25.36 ± 3.95	37.25 ± 4.47	5.09 ± 1.13	5.08 ± 0.66	3.98 ± 0.76	0.54 ± 0.12	1.90 ± 0.40	0.16 ± 0.03	6.43 ± 0.00	1.23 ± 0.00	3.63 ± 0.00	1.30 ± 0.00	0.95 ± 0.00

[a]DW, each values are expressed on dry weight basis; [b]Values are means of triplicate determinations ± SD; [n]Represent the number of beans access analyzed.

Table 4. Pearson correlation coefficients between the proximal composition and mineral content in 59 common bean accessions.

Traits	Soluble Sugar	Starch	Ash	Lipids	Protein	Dry Matter	N	P	K	Mg	Fe	Cu	Zn	Mn	B
Soluble Sugar	1	−0.11	−0.35**	−0.45**	−0.04	−0.53**	−0.01	0.25	0.59**	−0.50**	−0.32*	−0.26*	−0.32*	−0.15	−0.54**
Starch		1	−0.06	0.14	−0.33**	0.15	−0.31*	−0.28*	−0.21	0.12	−0.01	0.18	−0.00	0.08	0.15
Ash			1	0.11	0.34**	0.27*	0.16	0.16	−0.11	0.52**	0.39**	0.31*	0.54**	0.23	0.33*
Lipids				1	−0.2	0.51**	−0.24	−0.39**	−0.55**	0.51**	0.13	0.18	0.00	0.22	0.55**
Protein					1	−0.14	0.79**	0.47**	0.33**	−0.02	0.34**	−0.05	0.48**	0.02	−0.23
Dry Matter						1	−0.04	−0.47**	−0.60**	0.54**	0.32*	0.32*	0.18	0.16	0.63**
N							1	0.39**	0.44**	−0.07	0.14	−0.07	0.39**	0.03	−0.39**
P								1	0.57**	−0.17	−0.1	−0.21	0.23	0.19	−0.53**
K									1	−0.53**	−0.31*	−0.30*	−0.08	−0.19	−0.85**
Mg										1	0.2	0.42**	0.30*	0.02	0.58**
Fe											1	0.23	0.36**	0.07	0.43**
Cu												1	0.40**	−0.02	0.42**
Zn													1	0.30*	0.21
Mn														1	0.21
B															1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

tions were connecting nutritional traits among themselves. The traits showing the major number of significant correlations are B with 10, soluble sugars with 9, ashes and Zn with 7 each, and dry matter and K with 6 each. The B has 6 negative and 4 positive correlations, while soluble sugars formed 8 negative and 1 positive correlation. The strongest trait associations were observed between B and K (−0.85), protein and N (0.79), dry matter and B (0.63) and dry matter and K (−0.60). These features may indicate that mineral traits are more specific and conservative in their variation and could play an important role in the characterization of local bean accessions and landraces. At the same time, soluble sugars and dry matter seemed to be the most perspective nutritional traits in this exercise. In general, these conclusions remain in agreement with vector representations of the Euclidean biplot (**Figure 1**), whereas 8 traits with more weight in the cases separation were soluble sugars, starch, lipids, crude protein and N, K and P, excluding B. This variability could be explained by the quality variables of lipids and K, which contributed exclusively to separation along the axis 1. Meanwhile, starch, soluble sugars, ashes, protein P and N were contributing to the variability of the axis 2.

The multivariate analyses using the principal components (PCA) generated a spatial distribution of all accessions based on the average values of nutritional and mineral analysis (**Figure 2**). The results indicated that the

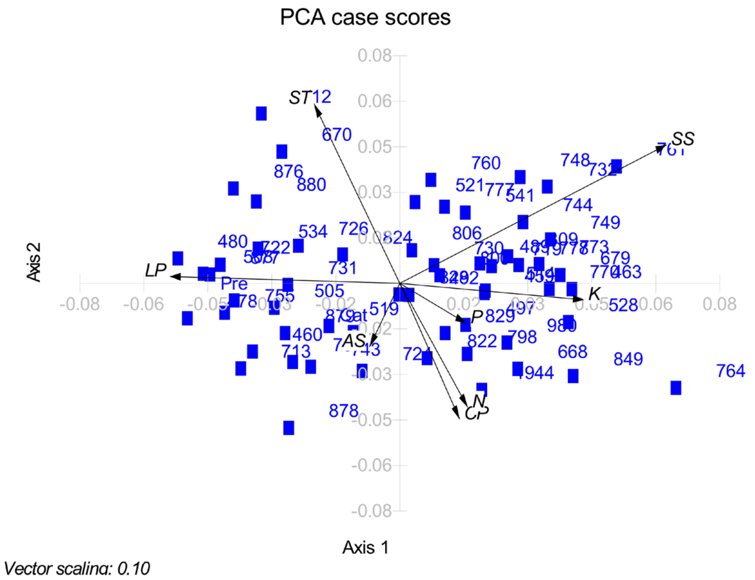

Figure 1. Representation of the Euclidean biplot by principal component analysis (PCA), with data *loge* transformation of all the parameters (variables) in analysis. Legend: AS—ash; CP—crude protein; K—potassium; LP—lipids; N—nitrogen; P—phosphorous; SS—soluble sugar; ST—starch.

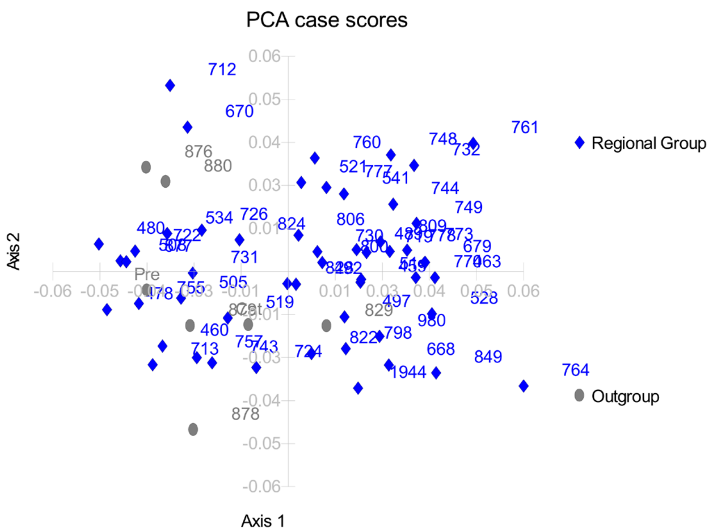

Figure 2. Representation of the case scores by principal component analysis (PCA), with spatial distribution of the common bean in two distinct groups: regional common bean as the regional group, and the commercial and standard common bean as the outgroup. Data *loge* transformation was applied to all the parameters (variables) in analysis.

nutritional and mineral variability was explained between 4 axes, but only the first two had a significant contribution to the accessions spatial distribution explaining 64.53% of the total variability. The first axis explained 42.12% and the second 22.41% of the total variability, with eigenvalues of 0.05 and 0.03, respectively. The cases dispersion in the PCA plot (**Figure 2**) supported our initial hypothesis that bean accessions exhibit a wide range of nutritional and mineral variability. This variability maintained in a field trial under the same growth conditions revealed the existence of genetic materials that could be selected by their traits desired for crop improvement proposes.

The values of nutritional and mineral traits also pointed out the existence of local accessions with high quality parameters. Daily protein intake in female and male adults is between 46 and 56 g of protein, respectively [34]. ISOP 724 is an excellent source of protein, because 100 grams grain of this accession can supply between 65% and 53% of high quality protein rich in essential amino acids (*i.e.* lysine), hence it should be considered as an important source of protein in the Madeiran diet. ISOP 712 is rich in starch contributing with 41% in the daily intake, being a good energy source for human metabolism. ISOP 743 is an accession with lower starch value, which predestinates it as a suitable component for diets requiring low glycemic index. The same feature, low starch content shown in ISOPs 713 and 980 (**Table 1**) can also have an important contribution to diabetes control. ISOP 480 has potential for future studies in oil extraction and analysis for therapeutic proposes. Seed bean oil becomes popular in the prevention and therapy of coronary diseases [35]. Several local bean accessions have abundant amounts of minerals (ashes), having potential as a source of minerals to the human diet. The role of K and Mg in proper functioning of muscles and central nervous system is well known [32]. ISOP 829 is an excellent source of K, which can contribute 125% of daily requirement. Meanwhile, ISOPs 460, 508 and 670 are a worthy source of Mg, with 48% of the daily dietary intake. P is a major component of bone and teeth composition [32] hence ISOP 528 can supply 107% of daily requirement. Fe is actively involved in the oxygen transport to the tissues, being both Cu and Fe necessary to the formation of human hemoglobin [32]. The accessions ISOP 755 and 724 are a good source of Fe, helping supplying respectively with 71% and 61% of the daily dietary intake, preventing the anemia caused by the mineral deficiency in the diet. An excellent source of Cu is ISOP 670, which can contribute with 140% of daily dietary allowance. The Zn is a component of several antioxidant vitamins [32] and ISOP 724 can supply 50% of daily dietary intake of this element. Mn and B are needed in small quantities in a healthy diet. Mn is essential in the synthesis of some enzymes [32], as well as B is a nonmetallic trace element, whose function in the human diet is not well known [32], although its deficiency in diet was linked to osteoporosis risk. As there are no officially recommended doses, ISOPs 463 and 760 are the best contributors to the daily dietary intake of these ultra-micronutrients.

4. Conclusions

In the present study, 59 accessions of common bean were grown under the same field conditions, minimizing interference of the environmental factors. The evaluation of nutritional and mineral composition of the regional beans revealed a great variability, which maintained their quality characteristics during the seed storage process. This variability did not appear linked with accessions origin and collection sites as demonstrated by One-Way ANOVA. The experimental approach used to obtain the bean samples eliminated the possibility of influence by environmental factors and thus the trait variability was determined by samples' inherent genetic properties. These nutritional and mineral traits were insufficient to discriminate the bean landraces morphological groups identified by Freitas [8], but they point out to several accessions that could be used as a source of genetic material for crop improvement, based on the criteria of high food or dietetic quality of the parameters. Our work also corroborates the Rodiño [15] and Coelho [14] conclusions that small-scale crop cultivation practiced by the Madeiran farmers minimizes the risk of loss of genetic diversity and reduction of nutritional quality.

Regional beans presented a better nutritional performance by having the highest proximate and mineral composition in their constitution, comparatively with standard and commercial varieties (**Table 2**). All accessions showed good nutritional and mineral characteristics, but protein and ash content showed significantly greater variance, distinguishing these two parameters as a presupposed key indicator of nutritional quality. According to the statistical of the 52 local common beans and literature comparative analyses, the accessions ISOPs 724 (*Vermelho*) and ISOP 713 (*Vaginha Grossa*) offer the greatest nutritional properties (**Table 1**), being the main suggested for the specific dietary requests.

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