Nutritional characterization and productivity evaluation of landrace maize cultivars

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ABSTRACT
The objective of this work was to identify landrace maize cultivars with high nutritional contents and productivity. Biometric parameters, dry matter, ash, protein, and lipid contents, as well as fatty acid and mineral profiles of 15 landrace maize cultivars, and two improved controls (‘BRS 1002’ and ‘BRS Missões’) were determined. The maize cultivars were cultivated in the 2010/2011 growing season, in Ibarama, RS, Brazil. The improved maize controls showed similar performance to most landrace cultivars for the biometric parameters; however, ‘BRS 1002’ had the highest productivity. The landrace maize cultivars ‘Cateto Amarelo’, ‘Ferro’, ‘Mato Grosso’, and ‘Cinquentinha’ were more nutritious than the other cultivars. The measuring of the genetic values was effective for the analyzed characteristics in the cultivar grains. The studied cultivars, mainly those with higher-nutrient content, can be used in the food industry for food fortification and oil production.

Index terms: Zea mays, agrobiodiversity, grain productivity, landrace, nutritional quality.

Caracterização nutricional e avaliação da produtividade de cultivares crioulas de milho

RESUMO
O objetivo deste trabalho foi identificar cultivares crioulas de milho com altos teores nutricionais e produtividade. Determinaram-se os parâmetros biométricos, os teores de matéria seca, cinzas, proteínas e lipídios e o perfil de ácidos graxos e minerais dos grãos de 15 cultivares crioulas de milho e duas testemunhas melhoradas (‘BRS 1002’ e ‘BRS Missões’). As cultivares de milho foram cultivadas na safra 2010/2011, em Ibarama, RS, Brasil. As testemunhas melhoradas de milho apresentaram desempenho semelhante ao...
da maioria das cultivares crioulas quanto aos parâmetros biométricos; no entanto, a ‘BRS 1002’ mostrou a maior produtividade. As cultivares crioulas ‘Cateto Amarelo’, ‘Ferro’, ‘Mato Grosso’ e ‘Cinquentinha’ mostraram-se mais nutritivas do que as demais cultivares analisadas. A mensuração do valor genético foi eficiente para as características analisadas nos grãos das cultivares. As cultivares estudadas, em especial as crioulas que apresentam maiores quantidades de nutrientes, podem ser empregadas na indústria alimentícia para a fortificação de alimentos e a produção de óleos.

**Termos para indexação:** Zea mays, agrobiodiversidade, produtividade de grãos, cultivar crioula, qualidade nutricional.

**INTRODUCTION**

Maize (Zea mays) is a cereal member of the Gramineae family, whose origin is believed to be in the agriculture of the Aztec, Mayan, and Inca people (Araújo et al., 2015). From Mexico, cradle of maize, it spread throughout America (Cruz & Koblitz, 2011). In Europe, maize came to be known after Christopher Columbus returned to the continent, in 1492 (Cruz & Koblitz, 2011). After spreading around the world, maize began to be widely produced, significantly contributing to world economic development (Mussolini, 2009).

In Brazil, the estimated production of maize in the 2017/2018 harvest was 80,786,000 tonnes (Acompanhamento..., 2018). The continuous and high productivity of maize allowed of its insertion among the four main harvests produced in Brazil (Acompanhamento..., 2018), and gave the country the title of third largest producer of the cereal, behind the United States and China (Cruz & Koblitz, 2011). Paraná, Minas Gerais, and Rio Grande do Sul are the Brazilian states that stand out for maize harvest (Cruz & Koblitz, 2011).

Brazilian maize production has been used for diverse purposes. Maize is used for both animal feed and human consumption (Mussolini, 2009; Araújo et al., 2015), as well as raw material in high-technology industries (Paes, 2006). Because it is a source of energy attributed to the presence of carbohydrates (Araújo et al., 2015) and lipids (Paes, 2006), approximately 500 of the more than 600 existing maize products are part of human food (Araújo et al., 2015). Despite their significant amount, maize proteins are of poor quality (Paes, 2006) due to the small amount of the essential amino acids lysine and tryptophan (Cruz & Koblitz, 2011). The composition of maize micronutrients consists of vitamins A, B complex (Mussolini, 2009) and E, and the minerals phosphorus, sulfur, calcium (Paes, 2006), potassium, and magnesium (Cruz & Koblitz 2011).

There are several existing maize cultivars from which landrace ones are an important example. Preserved for generations by indigenous people and small farmers, landrace maize can also be called landraces (Coimbra et al., 2010). Although rustic (Araujo et al., 2013) and low yielding (Sandri & Tofanelli, 2008), landrace maize seed have several advantages for the farmer, such as: adaptation to the conditions of the cultivation place (Araujo et al., 2013), resistance, genetic variation (Sandri & Tofanelli, 2008), and use of seed in subsequent plantings, which results in lower costs. However, it has been observed that farmers have replaced the cultivation of landrace seed by genetically improved ones (Araujo et al., 2013), which is associated with the modernization suffered by agriculture in recent years. Although contributing to high productivity, hybrid cultivars require the heating of seeds for planting (Cruz & Koblitz, 2011), which entails high costs for the farmer, as well as high technological level to express their productive potential (Emygdio & Pereira, 2006). These facts show the need to rescue and preserve landrace maize seed, which play an important role in the conservation of species variability (Coimbra et al., 2010), providing information that can aid in the development of new genotypes and products. Landrace maize preserving could also increase the economic viability of domestic, commercial, and industrial areas (Sandri & Tofanelli, 2008; Araujo et al., 2013), as well as guarantee the food security and sovereignty, preventing and recovering cases of nutritional deficiencies.

The objective of this work was to identify the landrace maize cultivars with higher nutritional contents and productivity.
MATERIALS AND METHODS

Fifteen landrace maize cultivars (‘Brancão’, ‘Cunha’, ‘Cinquentinha’, ‘Pintado’, ‘Sertanejo’, ‘Oito Carreiras’, ‘Cateto Amarelo’, ‘Bico de Ouro’, ‘Cabo Roxo’, ‘Colorido’, ‘Amarelão’, ‘Mato Grosso’, ‘Ferro’, ‘Lombo Baio’ and ‘Palha Roxa’) and two control – one simple hybrid (‘BRS 1002’) and one open-pollinated variety (‘BRS Missões’) – were grown in a field experiment in Ibarama (29° 25’10” S, 53° 08’ 05” W, at 317 m altitude), in Rio Grande do Sul state, Brazil.

Maize sowing was performed with manual machines. For each cultivar, 50 maize seedlings were planted. The plots consisted of two 5 m rows, with 0.90 m row spacing, and 5 plants per linear meter were grown. Each plot corresponded to one cultivar.

Soil sampling for analysis, and fertilization and liming needs followed the guidelines of the Sociedade Brasileira de Ciência do Solo (Tedesco et al., 2004).

The experimental area was monitored for weeds and pests. Weeding was done by hand. For the biological control of caterpillars (Spodoptera frugiperda), 1% neem oil and 133 kg N ha⁻¹ were applied to the hole in the form of urea, and wasps (Trichogramma spp.) were distributed in all experimental plots.

Harvesting was carried out manually in March 2011. Maize grains were dried to a 13% moisture content, cleaned and classified, to remove impurities and scraps. In a micromill MA-630, the grains were ground to obtain particles smaller than 1 mm. The cornmeal was stored in plastic bags and kept refrigerated until the beginning of the analyses.

The biometric parameters, thickness, length, and width of the grains were measured with a caliper. For this, in each performed analysis, 15 seed of each replicate were evaluated, totaling 45 grains of each cultivar.

To calculate the productivity of each cultivar, the maize grain weight in grams per plot was transformed to kilogram per hectare.

Dry matter, crude protein, and ash were evaluated by AOAC methodologies (Cunniff, 1995). Lipid extraction was performed according to the method of Bligh & Dyer (1959).

For the determination of fatty acids, lipids were methylated after extraction, using the procedures suggested by Hartman & Lago (1973). Lipids were derivatized using methanolic solutions of KOH (0.4 mol L⁻¹) and H₂SO₄ (1 mol L⁻¹) and heating for 10 min in water bath at 100°C for each solution. Fatty acid methyl esters were dissolved with hexane, and determined using Varian gas chromatography (Star 3400 cx, Walnut Creek, California, USA), equipped with a flame ionization detector (GC-FID). The fatty acid methyl esters were injected manually (1 µL) and separated in a ZB Wax capillary column (Phenomenex, Torrance, California, USA) (30 m x 0.25 mm i.d. x 0.25 µm film thickness). Hydrogen was used as carrier gas at 10342 x 10⁵ Pa constant pressure. The injector remained in separation mode with 1:50 ratio at 230°C. The column heating program began at 50°C with 2 min stop and then increased to 180°C with the heating rate of 20°C min⁻¹. Subsequently, 3°C min⁻¹ rate was applied to reach 230°C and was maintained under isothermal conditions for 8 min. Ionization flame detector temperature was 230°C.

Fatty acids were identified by comparing the retention times of the analyses with the standard (FAME Mix-37, Sigma Aldrich). The quantification was performed by the normalization of fatty acid areas.

Maize samples were decomposed by wet digestion assisted by closed-range microwave radiation, using a commercial Multiwave microwave oven 3000 (Microwave Sample Preparation System, Anton Paar GmbH, Graz, Austria). The system was equipped with 8 quartz flasks with 80 mL
maximum capacity each. The maximum operating conditions for power, temperature, and pressure were 1400 W, 280°C and 80 bar respectively.

Samples of 500 mg of dried, homogenized ground maize kernels were mixed with 6 mL concentrated HNO₃ at 65% (Merck KGaA, Darmstadt, Hessen, Germany) in a decomposition flask. Subsequently, the flasks were closed and brought into the microwave oven cavity, following the microwave manufacturer’s recommendation for the heating program. At the end of the digestion procedure, the resulting solutions were transferred to a polypropylene flask and checked to 30 mL with purified water (Millipore, with final resistivity of 18.2 MΩ cm).

Minerals were determined by inductively coupled plasma optical emission spectrometry (ICP OES) with axial view (Spectro Ciros CCD, Spectro Analytical Instruments GmbH, Kleve, North Rhine-Westphalia, Germany).

The results were subjected to the analysis of variance, at 5% probability. When the F value was significant, the cultivar means were compared to each other by the Scott-Knott test, at 5% probability, for which the statistical program SISVAR 5.3 was used (Ferreira, 2000).

The accuracy of the experiments was measured by selective accuracy (SA), considered as SA=(1-1/F)½ and corresponding to the linear correlation between genotypic and phenotypic values (Resende & Duarte, 2007).

RESULTS AND DISCUSSION

The biometric parameters, thickness, length, width, and yield of the landrace cultivar grains showed significant difference due to the wide variability of the results (Table 1). The grains of the cultivar ‘Cateto Amarelo’ stood out, in relation to the others analyzed, for having the greatest thickness. As well the cultivar ‘Oito Carreiras’, it was observed that the ‘Cateto Amarelo’ had the greatest width. ‘Bico de Ouro,’ ‘Amarelão’, and ‘Mato Grosso’ produced longer grains than the other cultivars. When comparing the biometric parameters of the landrace cultivars and controls, it was found that controls do not differ significantly from most landrace maize.

The only cultivar that differed significantly from the others was the control cultivar ‘BRS 1002’ for to its high productivity. The landrace cultivars and ‘BRS Missões’ had a productivity less than 50% than that observed for ‘BRS 1002’. However, despite being superior to the other cultivars for productivity, “BRS 1002” did not reach its maximum, which is approximately, 9,100 kg ha⁻¹ (Emygdio et al., 2008). The same fact was observed for ‘BRS Missões’, which productivity much less than 6,262 kg ha⁻¹ obtained by Emygdio & Pereira (2006) in Rio Grande do Sul, Brazil. Our result corroborates the widely accepted idea that the use of hybrid cultivars by low-technology farmers is not recommended due to the impossibility of expressing their productive potential (Emygdio & Pereira 2006). In addition to genetic factors, environmental factors may have interfered with the productivity obtained (Miranda et al., 2005).

The experimental precision through selective accuracy showed that the biometric parameters were between 0.93 and 0.97, proving to be very high according to the classification proposed by Resende & Duarte (2007). This result allowed of the inference on the efficiency of measuring the true genetic value of the characteristics of maize cultivars. The selective accuracy is considered adequate to classify the accuracy of experiments in general, as it depends on the magnitude of the experimental error, the number of repetitions and the proportion between variations of genetic and residual nature, associated with the character under evaluation (Cargnelutti Filho & Storck, 2007). The validity has been confirmed in the evaluation of experimental precision of competition tests for maize cultivars (Cargnelutti Filho & Storck, 2009).
The evaluated cultivars showed significant differences for the contents of dry matter, crude protein, ash, and lipid (Table 2). However, the improved control did not differ from most landrace cultivars for chemical composition. The selective accuracy obtained for dry matter, crude protein, and ash was high and very high for lipids.

The mean dry matter content in the analysed cultivars was 86.74% (Table 2), which agrees with the Instrução Normativa 60 of December 23, 2011, of the Ministério da Agricultura, Pecuária e Abastecimento (MAPA) (Brasil, 2011). The maximum moisture content in maize should be 14%, therefore the minimum dry matter content of this cereal should be 86%. Approximately 76.47% of the samples were in accordance with the MAPA recommendation (Brasil, 2011). The dry matter, identified in maize grains of the present study was higher than that observed by Sandri & Tofanelli (2008) in landrace maize (78.90%), and within the range identified by Santos et al. (2018) (86.25% and 88.47%).

The landrace cultivars ‘Ferro’, ‘Cinquentinha’, ‘Mato Grosso’, ‘Bico de Ouro’, and ‘Cateto Amarelado’ had the largest protein content, which makes them promising for commercial exploitation and direct insertion in alimentation (Table 2). However, maize has approximately 10% protein that is of low biological value (Cruz & Koblitz, 2011; Santos et al., 2018), due to the small amount of the essential amino acids lysine and tryptophan (Cruz & Koblitz, 2011). This fact was confirmed in this study, as the amount of crude protein present in maize grains ranged from 6.20% (‘BRS 1002’) to 8.75% (‘Ferro’). Studies on landrace maize reported crude protein levels of approximately 7%, greater than 14% (Santos et al., 2018), and between 10.26% and 12.41% (Pinto et al., 2009), which are higher than those evidenced in the present study. The possible causes that led to low-protein levels identified in maize grains are the genetic variation among cultivars and the efficiency of soil-nitrogen utilization (Santos et al., 1998).

‘Brancão’, ‘Sertanejo’, ‘Cateto Amarelo’, ‘Bico de Ouro’, ‘Amarelão’, ‘Mato Grosso’, and ‘Ferro’ showed the higher ash contents among the cultivars (Table 2). Nevertheless, all maize cultivars in the present work had higher mineral contents than those described in the study by Mussolini (2009).
and Santos et al. (2018). Variations in the maize mineral composition may be influenced by soil nutrients and the type of management employed, according to Santos et al. (2018).

The highest values for lipids were observed for the ‘Ferro’ (6.53%) and ‘Cateto Amarelo’ (6.52%), which makes them important raw materials for the oil industry (Table 2). The average lipid contents in all cultivars were higher than those evidenced in other studies on landrace maize (Pinto et al., 2009; Santos et al., 2018), on hybrid (Mussolini, 2009), and on produced in agroecological system for maize (Kokuszka & Murate, 2007).

### Table 2. Dry matter, crude protein, ash, and lipids (% dry matter) content of grains of different landrace maize cultivars and controls.$^{(1)}$

| Cultivar            | Dry matter | Crude protein | Ash     | Lipids |
|---------------------|------------|---------------|---------|--------|
| Brancão             | 85.82b     | 6.64b         | 1.43a   | 5.79c  |
| Cunha               | 86.83a     | 7.13b         | 1.32b   | 6.12b  |
| Cinquentinha        | 87.04a     | 8.18a         | 1.37b   | 5.95b  |
| Pittado             | 86.95a     | 6.99b         | 1.37b   | 4.93d  |
| Sertanejo           | 85.04b     | 6.73b         | 1.44a   | 5.28d  |
| Otto Carreiras      | 85.54b     | 6.73b         | 1.33b   | 5.59c  |
| Cateto Amarelo      | 86.47a     | 7.66a         | 1.55a   | 6.52a  |
| Bico de Ouro        | 85.42b     | 7.73a         | 1.38a   | 5.09d  |
| Cabo Roxo           | 87.61a     | 7.31b         | 1.37b   | 5.61c  |
| Colorido            | 87.14a     | 6.96b         | 1.33b   | 5.19d  |
| Amarelo             | 87.75a     | 7.31b         | 1.38a   | 5.36d  |
| Mato Grosso         | 87.09a     | 8.12a         | 1.52a   | 5.59c  |
| Ferro               | 86.52a     | 8.75a         | 1.52a   | 6.53a  |
| Lombo Baio          | 86.69a     | 6.92b         | 1.35b   | 5.19d  |
| Palha Roxa          | 88.08a     | 6.24b         | 1.37b   | 5.02d  |
| BRS 1002            | 87.40a     | 6.20b         | 1.29b   | 5.63c  |
| BRS Missões         | 87.19a     | 6.55b         | 1.30b   | 5.64c  |
| Mean                | 86.74      | 7.19          | 1.39    | 5.59   |
| Maximum value       | 88.08      | 8.75          | 1.55    | 6.53   |
| Minimum value       | 85.04      | 6.20          | 1.29    | 4.93   |
| Selective accuracy$^{(2)}$ | 0.83     | 0.82          | 0.88    | 0.93   |

$^{(1)}$Means with different letters, in the same column, are statistically different, according to the Scott-Knott’s test, at 5% probability. $^{(2)}$Selective accuracy: very high, \(\geq 0.90\); high, \(0.70 \text{ to } 0.90\); moderate, \(< 0.70 \text{ to } 0.50\); low, \(< 0.50\).

Grains of the analysed maize cultivars have a fatty acid profile composed of 12 types, from which the main ones are unsaturated (81.22%) (Table 3); out of these, the polyunsaturated ones represent 47.43% of the total fatty acids. Among the polyunsaturated fatty acids, linoleic acid showed the highest quantification in maize grains (46.44%). Linoleic acid is not synthesized by the human organism, requiring a diet to be obtained, therefore, the high content of this fatty acid shows maize as an important source of it.

Monounsaturated fatty acids correspond to 33.79% of the total fatty acids of maize grains. The monounsaturated fatty acid that stands out in the studied maize cultivars was oleic fatty acid (33.32%).
Table 3. Identification and quantification of unsaturated fatty acids from grains of different landrace maize cultivars and controls.\(^{(1)}\)

| Cultivar     | 16:1 | 18:1n9c | 18:2n6c | 18:3n3c | 20:1 | ΣMUFAs | ΣPUFAs |
|--------------|------|---------|---------|---------|------|--------|--------|
| Brancão      | 0.18b| 31.92c  | 48.40a  | 1.06a   | 0.32a| 32.41  | 49.45  |
| Cunha        | 0.16b| 35.64a  | 43.64c  | 0.91b   | 0.30a| 36.09  | 44.55  |
| Cinquentinha | 0.14b| 37.76a  | 42.52c  | 0.75c   | 0.30a| 38.19  | 43.27  |
| Pintado      | 0.14b| 33.49b  | 45.94b  | 0.93b   | 0.36a| 33.98  | 46.27  |
| Sertanejo    | 0.15b| 33.59b  | 46.72a  | 0.96b   | 0.31a| 34.05  | 47.69  |
| Oito Carreiras| 0.14b| 32.32c  | 47.72a  | 1.14a   | 0.32a| 32.78  | 48.86  |
| Cateto Amarelo| 0.16b| 35.90a  | 44.35c  | 1.05a   | 0.30a| 36.36  | 45.40  |
| Bico de Ouro | 0.14b| 32.91b  | 47.69a  | 1.02a   | 0.32a| 33.37  | 48.71  |
| Cabo Roxo    | 0.15b| 34.13b  | 45.35b  | 0.94b   | 0.32a| 34.60  | 46.28  |
| Colorido     | 0.15b| 31.15c  | 47.45a  | 0.99b   | 0.29a| 31.59  | 48.44  |
| Amarelão     | 0.15b| 35.70a  | 43.71c  | 0.97b   | 0.31a| 36.15  | 44.68  |
| Mato Grosso  | 0.15b| 31.71c  | 48.56a  | 1.06a   | 0.31a| 32.16  | 49.62  |
| Ferro        | 0.16b| 32.09c  | 48.12a  | 1.06a   | 0.30a| 32.55  | 49.18  |
| Lombo Baio   | 0.15b| 31.95c  | 47.62a  | 1.06a   | 0.30a| 32.41  | 48.68  |
| Palha Roxa   | 0.18b| 31.87c  | 46.89a  | 0.98b   | 0.31a| 32.35  | 47.88  |
| BRS 1002     | 0.14b| 31.24c  | 48.99a  | 0.98b   | 0.31a| 31.69  | 49.97  |
| BRS Missões  | 0.25a| 33.07b  | 45.74b  | 1.08a   | 0.29a| 33.61  | 46.82  |
| Mean         | 0.16 | 33.32   | 46.44   | 1.00    | 0.31 | 33.79  | 47.43  |
| Maximum value| 0.25 | 37.76   | 48.99   | 1.14    | 0.36 | 38.19  | 49.97  |
| Minimum value| 0.14 | 31.15   | 42.52   | 0.75    | 0.29 | 31.59  | 43.27  |
| Selective accuracy\(^{(3)}\) | 0.75 | 0.93   | 0.91    | 0.94    | 0.30 | -      | -      |

\(^{(1)}\)Means with different letters, in the same column, are statistically different, according to the Scott-Knott’s test, at 5% probability. \(^{(2)}\)Unsaturated fatty acids: 16:1, palmitoleic acid; 18:1n9c, oleic acid; 18:2n6c linoleic acid; 18:3n3c, linolenic acid; 20:1, elaidic acid; ΣMUFAs, sum of monounsaturated fatty acids; ΣPUFAs, sum of polyunsaturated fatty acids. \(^{(3)}\)Selective accuracy: very high, ≥0.90; high, ≥0.70 and <0.90; moderate, <0.70 and ≥0.50; low, <0.50.

Saturated fatty acids were in small proportion in the maize cultivars (17.87%) (Table 4). Despite the low percentage of saturated fatty acids in maize grains, palmitic acid (C16: 0) showed a significant amount (13.83%). The variation of oleic acid, the variation was between 31.15% in ‘Colorido’, and 37.76% in ‘Cinquentinha’; for linoleic acid contents was between 42.52 in ‘Cinquentinha’ and 48.99% in ‘BRS 1002’; and for linolenic acid, the variation corresponded to 0.75 in ‘Cinquentinha’ and 1.14% in ‘Oito Carreiras’.

Table 4. Identification and quantification of saturated fatty acids from grains of different landrace maize cultivars and controls.\(^{(1)}\)

| Cultivar     | 14:0 | 16:0 | 17:0 | 18:0 | 20:0 | 22:0 | 24:0 | ΣSFA |
|--------------|------|------|------|------|------|------|------|------|
| Brancão      | 0.04a| 13.36a| 0.11b| 2.55c| 0.66b| 0.25a| 0.36a| 17.34|
| Cunha        | 0.04a| 13.97a| 0.11b| 3.00a| 0.78a| 0.28a| 0.39a| 18.56|
| Cinquentinha | 0.03a| 14.14a| 0.09b| 2.40c| 0.65b| 0.21a| 0.27a| 17.78|
| Pintado      | 0.04a| 14.01a| 0.12b| 2.65b| 0.78a| 0.33a| 0.47a| 18.39|
| Sertanejo    | 0.04a| 13.74a| 0.10b| 2.26c| 0.65b| 0.27a| 0.37a| 17.42|
| Oito Carreiras| 0.04a| 13.42a| 0.12b| 2.55c| 0.73a| 0.30a| 0.43a| 17.59|
| Cateto Amarelo| 0.04a| 13.67a| 0.10b| 2.33c| 0.63b| 0.25a| 0.31a| 17.33|
| Bico de Ouro | 0.04a| 13.03a| 0.12b| 2.51c| 0.66b| 0.26a| 0.42a| 17.04|

Continua...
Continuação da Tabela 4

| Cultivar  | Saturated fatty acids(2) |         |         |         |         |         |         |
|-----------|--------------------------|---------|---------|---------|---------|---------|---------|
|           |                          | Min     | Mean    | Max     | Selective accuracy(3) |         |         |
|           |                          |         |         |         | Mean     | Maximum value | Minimum value |
|           |                          | 0.04a   | 13.98a  | 0.13b   | 2.61b    | 0.72a    | 0.27a    | 0.38a    | 18.14 |
| P.M.G. Londero et al. | Cadernos de Ciência & Tecnologia, Brasília, v. 37, n. 3, e26644, 2020 | DOI: 10.35977/0104-1096.cct2020.v37.26644 | | | | | | |
|           |                          |         |         |         | 0.04     | 13.83    | 0.12     | 2.53     | 0.70     | 0.27     | 0.38     | 17.87 |
|           |                          | 0.03a   | 13.51a  | 0.13b   | 2.31c    | 0.69b    | 0.28a    | 0.34a    | 17.32 |
|           |                          | 0.04a   | 14.14a  | 0.13b   | 2.27c    | 0.72a    | 0.26a    | 0.34a    | 18.62 |
|           |                          | 0.06a   | 14.49a  | 0.13b   | 2.63b    | 0.72a    | 0.26a    | 0.34a    | 18.62 |

(1)Means with different letters, in the same column, are statistically different, according to the Scott-Knott’s test, at 5% probability. (2)Saturated fatty acids: 14:0, myristic acid; 16:0, palmitic acid; 17:0, heptadecanoic acid; 18:0, stearic acid; 20:0, arachidic acid; 22:0, behenic acid; 24:0, lignoceric acid. \( \sum \text{SFA} \), sum of saturated fatty acids. (3)Selectivity accuracy: very high, ≥0.90; high, ≥0.70 and <0.90; moderate, <0.70 and ≥0.50; low, <0.50.

Selective accuracy showed very high values for oleic (0.93), linolenic (0.94) and linoleic (0.91) acids, and high values for heptadecanoic and stearic (0.88), arachidic (0.78), palmitic (0.76), palmitoleic acids (0.75) (Table 3).

Maize has approximately 3 to 6% minerals in its composition, which are mainly concentrated in the germ (Paes, 2006). Although considered the most abundant mineral in maize grains (Paes, 2006), phosphorus (282.75 to 355.80 mg 100 g\(^{-1}\)), after potassium (344.20 to 411.70 mg 100 g\(^{-1}\)), was the mineral present in higher amounts in the studied cultivars. The grain mineral profile of the analyzed maize cultivars was composed by potassium, phosphorus, magnesium (104.10 to 131.85 mg 100 g\(^{-1}\)), sulfur (103.30 to 120.50 mg 100 g\(^{-1}\)), calcium (2.79 to 3.95 mg 100 g\(^{-1}\)), zinc (1.78 to 2.24 mg 100 g\(^{-1}\)) and iron (1.63 to 2.18 mg 100 g\(^{-1}\)). The maize cultivars showed significant differences for calcium, potassium, and iron contents (Table 5).

Table 5. Characterization of mineral profile in grains of different landrace maize cultivars and controls (mg 100 g\(^{-1}\) dry matter). (4)

| Cultivar         | Mg     | Ca     | K      | P      | S      | Fe     | Zn     | \( \sum \) minerals |
|------------------|--------|--------|--------|--------|--------|--------|--------|---------------------|
| Brancão          | 111.85 | 3.12   | 344.20 | 329.05 | 110.20 | 2.03   | 1.84   | 902.29              |
| Cunha            | 104.20 | 3.87   | 350.65 | 282.75 | 103.30 | 1.63   | 1.79   | 848.19              |
| Cinquentinha     | 112.80 | 3.80   | 391.60 | 355.80 | 120.50 | 1.99   | 2.19   | 988.68              |
| Pintado          | 105.10 | 3.95   | 376.45 | 320.75 | 108.90 | 1.73   | 1.99   | 918.87              |
| Sertanejo        | 109.10 | 3.56   | 371.35 | 301.35 | 106.10 | 1.66   | 1.91   | 895.03              |
| Otão Carreiras   | 104.10 | 3.46   | 348.00 | 301.15 | 104.80 | 1.91   | 1.91   | 865.33              |
| Cateto Amarelho  | 118.00 | 3.17   | 382.50 | 334.50 | 112.45 | 1.81   | 2.18   | 954.61              |
| Bico de Ouro     | 112.25 | 2.80   | 380.05 | 319.80 | 115.25 | 1.94   | 1.87   | 933.96              |
| Cabo Roxo        | 112.50 | 3.88   | 390.20 | 351.25 | 116.35 | 1.89   | 1.97   | 978.04              |
| Colorido         | 114.40 | 3.69   | 367.45 | 338.95 | 114.30 | 1.77   | 1.94   | 942.50              |
| Amarelão         | 108.05 | 2.83   | 391.25 | 323.45 | 113.30 | 2.13   | 2.12   | 943.13              |
| Mato Grosso      | 120.85 | 3.24   | 394.75 | 350.00 | 106.20 | 1.79   | 1.88   | 978.71              |
| Ferro            | 116.20 | 3.42   | 351.35 | 317.90 | 114.80 | 2.11   | 2.17   | 907.95              |

(4)Means with different letters, in the same column, are statistically different, according to the Scott-Knott’s test, at 5% probability.
The selective accuracy obtained for calcium (0.82) and potassium (0.83) was high, while for iron (0.91) it was very high. Given these results, it can be considered that there was a high precision in the measurement of the true genetic value of the studied characteristics.

All maize cultivars showed satisfactory total mineral concentrations. However, ‘Lombo Baio’ (994.66 mg 100 g⁻¹), ‘Cinquentinha’ (988.68 mg 100 g⁻¹), ‘Mato Grosso’ (978.71 mg 100 g⁻¹), ‘Cabo Roxo’ (978.04 mg 100 g⁻¹), and ‘BRS Missões’ (975.69 mg 100 g⁻¹) showed higher total mineral contents than the other cultivars. These results show that the studied cultivars, especially those with higher amounts of minerals, can be used in the food industry, aiming to fortify foods, mainly those intended for children.

It should be noted that mineral accumulation in maize may vary depending on the maturity stage, soil quality, cropping system, genetic diversity and nutrient interactions (Feil et al., 2005).

CONCLUSIONS

The improved maize controls show biometric parameters similar to that of most maize cultivars.

The landrace maize cultivars proved to be more nutritious than the improved controls.

‘Cateto Amarelo’, ‘Ferro’, ‘Mato Grosso’, and ‘Cinquentinha’ show significant contents for ash, proteins, lipids, mono- and polyunsaturated fatty acids, and minerals.

The landrace maize cultivars, especially those with higher-nutrient contents, can be used in the food industry for food fortification and oil production.

The measuring of true genetic value is effective in relation to biometric parameters, chemical composition, and fatty acids and mineral profiles of the studied maize cultivars.

‘BRS 1002’ is the control cultivar with the highest productivity.

There is no significant differences between several landrace maize cultivars and the controls ‘BRS 1002’ and ‘BRS Missões’.

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