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Chemical Quality of Landrace Varieties Cultivated in Traditional Communities in the State of Maranhão, Brazil

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Abstract: The aim of this study was to analyze the chemical composition of landrace seeds of rice, maize and cassava grown in traditional communities in the state of Maranhão. The sample collection was based on the description of the farmers for identification of varieties of plants, based on protein content, lipids, carbohydrates and mineral through Association of Official Analytical Chemists (AOAC) methods. Landrace seeds of nine maize cultivars, 13 rice and 40 cassava, with differences in centesimal composition in all varieties were analyzed. For maize landrace seeds the lipid values, carbohydrates and ash are in the average for the species. The protein contents and ash to the surveyed rice varieties were high, while the levels of lipids and carbohydrates are within average in relation to conventional varieties. The results obtained for cassava showed high percentages of protein, with a significant level for the feeding of the people of the community who consume their byproducts. Thus, differences in the chemical composition of the varieties studied showed the interference of genotype, management and environmental factors in their chemical and physiological quality, reinforcing the importance of the study of creole varieties for the development of new germplasm and for the guarantee of food sovereignty of traditional communities.

Key words: Nutrition, seeds, sustainability.

1. Introduction

The landrace seeds are those that have not undergone genetic modifications with industrial techniques, yet carried out by traditional communities as food supply depicts the culture of each community [1]. Landrace seeds are categorized as genetic and cultural patrimony by several traditional communities and as fundamental mechanisms for *in situ* conservation of natural resources and agrobiodiversity by family farmers, as they represent the basic resources for autonomy, food and nutritional security, guaranteeing the permanence of the man in the countryside with productive diversification [2]. According to Coelho *et al.* [3], the landrace seeds can provide superior nutritional quality to improved seeds of conventional crops and contribute to reduction of the environmental impacts of food production. Seeds of local varieties play a key role in the development of agroecological systems, since even in adverse environmental conditions, such as those often found in family farms, local varieties are capable of

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maintaining satisfactory yields [4].

The nutritional composition of maize grain and rice is important because of its role in food supply, especially in Brazilian population. Maize is a major source of food to supply carbohydrates and proteins for millions of people, especially in Latin America and Africa [5]. Rice is characterized as major food for over half the world's population, being excellent source of energy, due to the high concentration of starch, quality of protein, vitamins and minerals, and low in lipids [6]. The roots of the cassava are rich in energy, in which their intake can be complemented with protein sources, with use of the leaves cassava that is rich in proteins, sugars, vitamins and minerals, besides being a product with excellent palatability [7].

In Brazil through Federal Law No. 9456 of April 25, 1997, the Law of Protection of Cultivars prevented the commercialization of local seeds known as landrace. However, in 2001 the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) recognized rural men and indigenous peoples as subjects of innovation and genetic improving of resources as of their traditional practices. In 2003, the Law of Seeds and Hybrids (Law 10.711/03), has allowed farmers to produce, exchange or sell seeds and seedlings among themselves, reinforcing attempts to legitimize creole seeds by scientists and organic farmers [8].

According to Marques *et al.* [9] studies are needed to demonstrate the efficiency of landraces in relation to commercial cultivars in order to strengthen the peasant family agriculture, with its cultural, economic and social characteristics. Evaluation of the chemical composition becomes essential information for the guarantee of food sovereignty and for the development of new germplasm. The chemical composition of the seeds interferes in the physical and physiological quality of the seeds according to the cultivar used [10, 11]. The determination of the chemical composition has implications in terms of multiplication of plants or consumption as food source, being that the nutrient content in seeds may vary in relation to genotype, and according to the cultivation form [3]. Therefore, this study aimed to chemically characterize the seeds of landraces of rice (*Oriza sativa* L.), maize (*Zea mays* L.) and cassava (*Manihot esculenta* Crantz), in order to recognize the chemical and physiological quality of landrace seeds.

2. Materials and Methods

In this study, the authors used landraces seeds of rice, maize and cassava grown in the 2015 crop in traditional communities in the municipalities of Morros, Cachoeira Grande and Rosário located in the state of Maranhão, Brazil. The climate is tropical, with total rainfall varying between 1,600 mm/year and 2,000 mm/year, presenting a pluviometric regime with predominance of two well defined seasons, rainy period from the months of December to July and drought from the months of August to November. The average temperature is 26.9 °C, with small seasonal thermal variations. Relative air humidity presents high values, mainly in the rainy season, with an average of 73% per year.

Field visits were conducted to collect samples of landrace seeds, identifying them according to the description of the farmers. Nine landrace maize seeds, 13 landrace rice seeds and 40 landrace cassava seeds were collected. The samples were analyzed in technical triplicates in the Food Laboratory of Institute Federal of Education, Science and Technology of Maranhão (IFMA), campus Monte Castelo, determining the content of protein, lipids, carbohydrates and ashes for maize and rice seeds, whereas for cassava only proteins and mineral residues were determined. The samples contained about 1 kg of crushed seeds and were freeze dried until a humidity of 10%.

Parameters, such as lipids, mineral residue and proteins (expressed in g/kg) were set according to the methodology by Association of Official Analytical Chemists (AOAC) [12]. Protein determination was performed using the Kjeldahl total protein method. The determination of ethereal extract was carried out in direct extraction with Soxlet apparatus, using hexane, with reflux of 6 h. The determination of the ashes or mineral material was carried out in a Mufla oven at 550 °C. The carbohydrate content (g/kg) was estimated by subtracting the sum of moisture, lipids, protein and mineral residue from 1,000 [13].

The data were subjected to analysis of variance using GraphPad Prism system 5, and the means of the variables were determined by mean comparison test at 5% Tukey test.

3. Results and Discussion

3.1 Chemical Composition of Landrace Varieties of Rice and Maize in Traditional Communities, Maranhão-Brazil

The results showed quantitative differences in the chemical content of the parameters analyzed for both maize and rice seeds in the native varieties, when they had equal denominations (Figs. 1 and 2).

The quantification of the constituents of corn grains had an important nutritional role for the better exploitation of the different genotypes. In this context, traditional germplasm represents a good source of genetic variability to be explored and may help identify the most suitable materials for the development of more nutritious food [14].

Considering the protein content of the maize varieties Miudo 2, Miudo 3 and Natural were the only low values. For lipid values, carbohydrates and ashes values are found in the average for the species [15, 16]. Noteworthy is the content of protein found in the maize Miudo 1, Tardão 1 and Crioulo that have similar values compared to maize quality protein maize (QPM) and common maize that has undergone industrial process of genetic improvement [17]. Therefore, the high value of protein in the native seeds analyzed demonstrates the nutritional potential of the genotypes that can influence the intake of nutrients by feeding humans and animals.

The protein and ash contents to the surveyed rice varieties are high, while the levels of lipids and carbohydrates are within the average over conventional varieties [18, 8]. Ten varieties were classified as high protein content [19].

One of the reasons for differences in chemical composition of maize and rice seeds could be related to genotypic differences between varieties, mainly for protein content. Walter *et al.* [6] found that the concentration of nutrients in the rice grains are directly linked to their genotypic characteristics, nitrogen

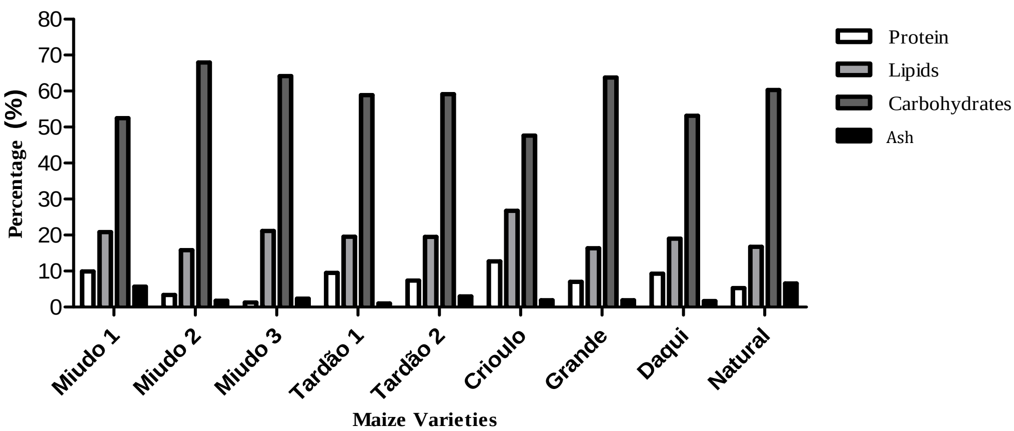

Fig. 1 Chemical analysis of maize landrace seeds collected in traditional communities of the municipalities of Morros, Rosário and Cachoeira Grande, Maranhão, Brazil.

Miudo 1 and Crioulo: village Água Azul, Cachoeira Grande; Daqui and Tardão 1: village Três Antas, Cachoeira Grande; Miudo 2 and Miudo 3: municipality of Cajazal, Rosário; Tardão 2: village Cachoerinha, Cachoeira Grande; Grande: village Campinho, Cachoeira Grande; Natural: village Patizal, Morros.

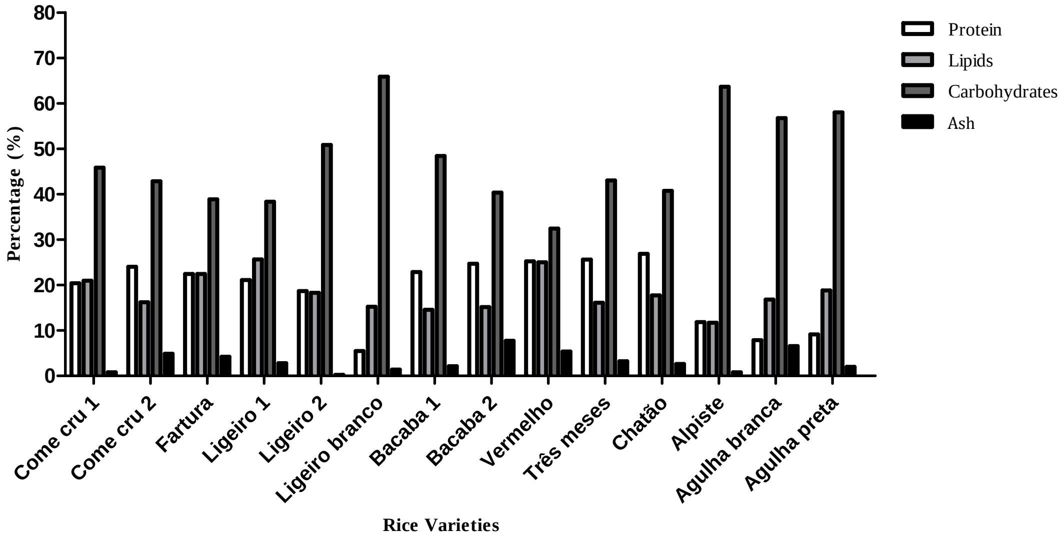

Fig. 2 Centesimal composition of rice landrace seeds collected in traditional communities of the municipalities of Morros, Rosário and Cachoeira, Maranhão, Brazil.

Come cru 1, Ligeiro 2: village Água Azul, Cachoeira Grande; Fartura, Alpiste: village Cajazal, Rosário; Ligeiro 1: village Patizal, Morros; Come cru 2, Três meses, Chatão: village Tingidor, Rosário; Ligeiro branco, Vermelho: village Três Antas, Cachoeira Grande; Bacaba 1: village Cachoeirinha, Cachoeira Grande; Bacaba 2: village Capim Açu, Cachoeira Grande; Agulha branca and Agulha preta: village Igarapé Grande, Rosário.

fertilization, solar radiation and temperature during grain development. Thus, to both the native seeds of maize and rice, the chemical components analyzed showed a nutritional value that should be considered to motivate conservation of varieties processes and its continued use as food for rural communities and other populations.

In Brazilian reality, the mineral content depends on a large share of the availability of soil nutrients, agricultural practices, varietal differences and processing conditions [20].

3.2 Crude Protein and Length/Width Ratio in Landrace Seeds of Maize and Rice

The phenotypic change in maize and rice varieties was a significant positive relation between crude protein content and the length and width of seed for maize varieties (p = 0.0609, r = 0.644). Already for the rice varieties the correlation is not significant following a negative relation (p = 0.1542, r = -0.4189) demonstrated in Table 1 and Fig. 3.

According to Araújo and Nazz [19] and Farias and Ferraz [21], the morphological characteristics of upland rice in different regions in Maranhão have no correlation with the crude protein content. Thus, regardless of their size or shape, the nutritional characteristics of rice remains, verifying high crude protein levels for most of the landrace varieties.

According to the length/width ratio, all rice landraces are classified as fine long [22, 23], affirming the characteristics described by farmers as shown in Table 1. So, the surveyed landraces are within the appropriate standards and prioritized for processing and consumption of the Brazilian population.

The maize landrace seeds correlation between length/width and crude protein is indicative that grain stores a variable protein content in accordance with the grain size. Crude protein content was higher for most varieties.

Therefore, the identification of favorable chemical and physiological characteristics in the creole varieties may be useful for the exploration of these traditional genotypes, for example, to introduce the desired traits into improved germplasm [14].

Table 1 Content of crude protein and relation between length and width to the maize and rice landraces varieties collected in the municipalities of Morros, Cachoeira Grande and Rosário, MA.

Variety/municipality	Crude protein (%)	Length/width ratio
Maize		
Miúdo/Cachoeira Grande	9.92	1.26
Miúdo/Rosário	3.38	1.22
Miúdo/Rosário	1.28	0.01
Tardão/Cachoeira Grande	9.51	1.07
Tardão/Cachoeira Grande	7.35	1.27
Crioulo/Cachoeira Grande	12.71	1.34
Grande/Cachoeira Grande	7.00	1.26
Daqui/Cachoeira Grande	9.27	1.2
Natural/Morros	5.31	1.26
Rice		
Come Cru/Cachoeira Grande	20.42	4.36
Come Cru/Rosário	24.03	2.99
Ligeiro/Morros	22.45	2.84
Ligeiro/Cachoeira Grande	21.12	3.64
Ligeiro Branco/Cachoeira Grande	18.67	2.92
Bacaba/Cachoeira Grande	5.48	3.52
Bacaba/Cachoeira Grande	22.87	3.52
Vermelho/Cachoeira Grande	24.73	4.24
Três meses/Rosário	25.20	3.08
Chatão/Rosário	25.61	2.88
Alpiste/Rosário	26.89	5.44
Agulha branca/Rosário	11.84	6.82
Agulha preta/Rosário	7.87	5.8

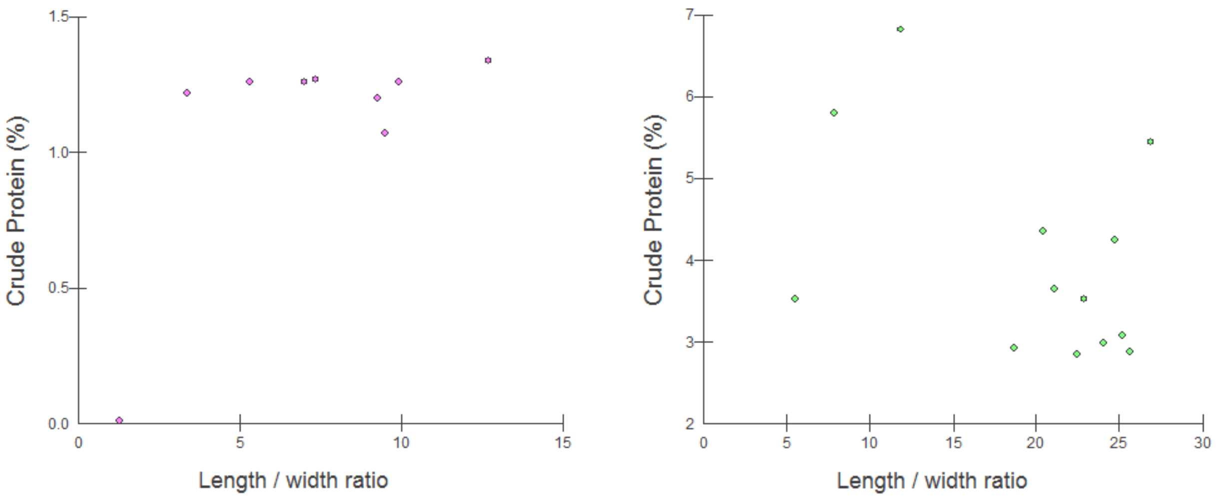

Fig. 3 Correlation between crude protein and relation Length/width ratio for maize seed (length) and rice (width) collected in the municipalities of Morros, Cachoeira Grande and Rosário, MA.

3.3 Chemical Characterization of the Varieties of Cassava, MA, Brazil

The analyzed cultivars of the cassava are: Pitanga (A-1), Macaxeira Piabinha (A-2), Macaxeira (A-3), Branquinha (A-4), Ouro do Brasil (A-5), Macaxeira Água Morna (A-6), Sodré (A-7), João Velho (A-8), Macaxeira Piabinha (A-9), João Velho (A-10), Prainha (A-11), Itajubá (A-12), Branquinha (A-13), Tomazinha (A-14), Sodré (A-15), Marelona (A-16), Josimar (A-17), Tatajuba (A-18), Amarelinha (A-19), João Velho (A-20), Bolora (A-21), Florzinha (A-22), Anajá (A-23), Cargo de Burro (A-24), Pintô (A-25), Folha Fina (A-26), Coquilha (A-27), Pingo de Ouro (A-28), Praiana (A-29), Verdinha (A-30), Semente da Ilha (A-31), Mucurana (A-32), Branquinha (A-33), Macaxeira (A-34), Prainha (A-35), Macaxeira (A-36), Cabeça Curta (A-37), Pingo de Ouro (A-38), Caverna (A-39), Leoa (A-40).

The varieties of cassava have been grouped according to the nomenclature described by the farmers, so there was no division by municipality studied. Many varieties of cassava to be found in all municipalities were analyzed. The results of protein content and mineral residues evaluated for cassava cultivars showed higher variations for the mineral residue content (Table 2).

The crude protein concentration for most of the cultivars was above 5%, and the highest value found was 23.85% in A-8 and the lowest concentration was 0.7% in A-18, with an average of 5.71%. In relation to the protein content, the yield being rated as classified as average with contents within the limits established among 5%-15% [7]. According to Chavez *et al.* [24], who analyzed 600 cassava genotypes in Latin America, the average protein found was 3.063%, showing that this variation was concerning to its genetic nature. This hypothesis is reinforced by the work of Ceballos *et al.* [25], analyzing 148 genotypes that showed the variation in the protein content found between 0.95% and 6.42% is related to its genetic origin.

This level of protein may have a desirable effect on

Table 2 Physico-chemical characterization of roots of cassava cultivated in the traditional communities of Morros, Cachoeira Grande and Morros, Maranhão, Brazil.

Samples	Protein (%)	Ash (%)	Samples	Protein (%)	Ash (%)
A-1	2.85	4.15	A-21	2.68	1.76
A-2	5.54	1.66	A-22	2.62	2.89
A-3	1.57	1.70	A-23	1.10	3.67
A-4	1.57	4.14	A-24	0.99	1.96
A-5	20.18	0.97	A-25	2.33	2.05
A-6	22.51	5.89	A-26	2.80	0.79
A-7	10.85	6.83	A-27	2.21	1.24
A-8	23.85	2.95	A-28	3.85	5.34
A-9	20.59	6.94	A-29	3.85	2.49
A-10	21.70	4.75	A-30	3.96	0.93
A-11	22.34	2.96	A-31	5.25	2.43
A-12	3.79	6.03	A-32	1.75	1.87
A-13	2.74	4.97	A-33	5.77	5.90
A-14	2.62	4.69	A-34	1.40	1.13
A-15	2.15	1.29	A-35	6.12	6.99
A-16	2.04	5.46	A-36	12.77	1.96
A-17	2.21	2.05	A-37	4.66	7.97
A-18	0.70	3.83	A-38	4.66	1.86
A-19	1.69	5.83	A-39	4.72	2.15
A-20	2.91	2.35	A-40	4.55	1.69

the subsistence of people from traditional communities in Maranhão, as they depend on cassava as a major food source, therefore their intake should be encouraged to ensure the minimum recommended protein for human consumption. Bokanga [26] argues that cassava is an important energy source for millions of people and animals in the tropics, and its roots and leaves could be used because of the richness of vitamins, proteins and minerals.

The concentration of mineral residues for most cultivars was above 3%, the highest value found was 7.97% in A-37 and the lowest concentration was 0.79% for A-5, with the general average of 3.41%. For Carvalho and Cereda [7], the mineral residues can vary between 5% and 9%, corresponding to a desirable mineral content that will be used in the metabolism of human organisms.

According to Burnst *et al.* [27], cassava will continue to be an important staple food crop due to its production of starch storage roots and its ability to grow in marginal agroecosystems. However, it is necessary to develop new cassava cultivars adapted to changes in environmental conditions, particularly as global climate patterns change and their growing areas.

4. Conclusions

Rice and maize seeds showed differences in their chemical composition, where such changes may be the result of interference from genes to environmental factors. In cassava, the protein contents were similar to the different varieties analyzed. In addition, the protein content resembles commercial seeds, a positive factor for the continuity of their storage and consumption by traditional communities. In relation to the interference of morphology in the protein content, there were several forms of seeds that resulted in different protein contents. Therefore, the study of the chemical composition of creole seeds was important to elucidate their nutritional richness, contributing to their conservation and ingestion by traditional communities.

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