2026 World Journal of Innovation and Modern Technology, Vol. 9, Issue 6 (Jun)
ISSN 2682-5910
DOI: 10.66069/ojspub.26820606

# Biometric and Biochemical Characterization of Two Cassava Varieties from Southeastern Pará, Brazil

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**Abstract:** ***This study evaluated the biometric characteristics and biochemical composition of fresh cassava roots from two varieties (Cacau and Jaibara) cultivated in southeastern Pará, Brazil. Plant biometric parameters, root yield attributes, and proximate composition (moisture, ash, protein, lipids, carbohydrates, and energy value) were determined. The Cacau variety exhibited superior vegetative vigor, a pulp yield of 77.71%, and roots with pink cortex and white pulp, whereas Jaibara showed lower vigor, a pulp yield of 73.90%, white cortex and yellow pulp. Biochemical profiles of both varieties closely matched national food composition reference values. Although Cacau proved more productive, both varieties demonstrated satisfactory nutritional quality. These findings underscore the need for further investigations into physical traits, biochemical composition, and sensory properties across a wider range of cassava cultivars, given the crop's nutritional and socioeconomic significance.***

**Keywords:** Cassava (Manihot esculenta); biometric characterization; biochemical composition; root yield; variety comparison; nutritional quality.

## 1. INTRODUCTION

Cassava (Manihot esculenta Crantz) is an important food produced by family farming, as well as a generator of employment and income in several countries around the world (OLIVEIRA et al., 2020). Cassava can be found in various parts of the globe because it is a hardy plant, easily grown in low-fertility soils, has drought tolerance, and is a root that can be harvested throughout the year. As a result, the root stands out as one of the most important foods in the world, consumed by more than 800 million families (Saravanan et al., 2016; Guimarães et al., 2022).

The characterization of cassava cultivation involves several aspects related to the environment, agricultural practices, and crop characteristics. Cassava, also known as aipim or macaxeira, is a tropical plant widely cultivated in regions with a hot and humid climate, such as Latin America, Africa, and Southeast Asia (Souza; Kalid, 2022).

Cassava is a staple food for millions of people, especially in tropical regions. It is used for human consumption (roots, flours, tapioca) and animal feed (Neves et al., 2020). Additionally, cassava is important in the industrial production of starches and ethanol. This characterization shows the importance of properly managing cultivation, from soil selection to pest and disease control, to ensure good productivity and sustainability of the crop (Maciel; Ming, 2022).

Cassava can be consumed in various forms, either raw, which refers to minimal processing, or in the form of products commonly found in the industry (PONCE et al., 2020). The root is also the third largest food source, after rice and corn. It is considered a complete food, and its roots contain between 30 and 35% energy, being consumed mainly raw, boiled, or fried (Nunes et al., 2020; Silva; Nunes, 2023).

Currently, there are several varieties on the market, each of which responds agronomically in distinct ways to the environment in which it is produced, resulting in a wide range of morphological, agronomic, biochemical, and sensory characteristics (Oliveira Junior; Wander, 2020). Therefore, further studies on their productive and sensory quality are necessary (Maniezo; Araújo, 2022).

Given the food and socioeconomic importance of cassava, studies that make greater contributions regarding the biometric characteristics of the plants, as well as the biochemical and sensory composition of the roots, are necessary, considering the several existing varieties today. The aim of this study was to characterize the cultivation, analyze the biometric and biochemical characteristics of cassava roots produced in the southeast of Pará.

## 2. MATERIALS AND METHODS

Cassava plants and roots of the Cacau and Jaibara varieties were collected from a private rural property located in Palmares Sul, rural area of Parauapebas-PA, at the geodetic coordinates: 05°58'47" S latitude and 49°51'40"W longitude. Biometric analyses of the plants and roots were performed on-site.

The cultivation area was initially subjected to conventional soil preparation, including plowing, harrowing, correction, and fertilization, in accordance with the recommendations established for cassava cultivation. Planting of the stem cuttings was mechanized, with a spacing of 1.0 m between plants and 0，090m between rows. Weed control was carried out until 90 days after planting. At the time of harvest, both varieties were 14 months old (Medeiros et al., 2023).

Minimal processing of the cassava varieties (Jaibara and Cacau) was performed, as well as biometric and physical analyses at the Federal Rural University of the Amazon, Parauapebas Pará Campus, located at the geodetic coordinates $06°12'58'' S$ latitude and $49°51'19'' W$ longitude, with an altitude of 197m.

### 2.1 Cultivation Characterization

Growth variables of 100 plants of each variety were analyzed, related to the morphology of the canopy and root system, such as: (i) relative plant height, based on the measurement from the base of the stem to the tip of the leaves, measured using a tape measure; (ii) number of leaves; (iii) number of branches; (iv) number of stems; and (v) number of roots, all determined by counting their numbers in the plant after harvest; (vi) stem diameter, measured using a 300 mm analog caliper with a precision of 0.01 mm (Moshenin, 1986) (Figure 1).

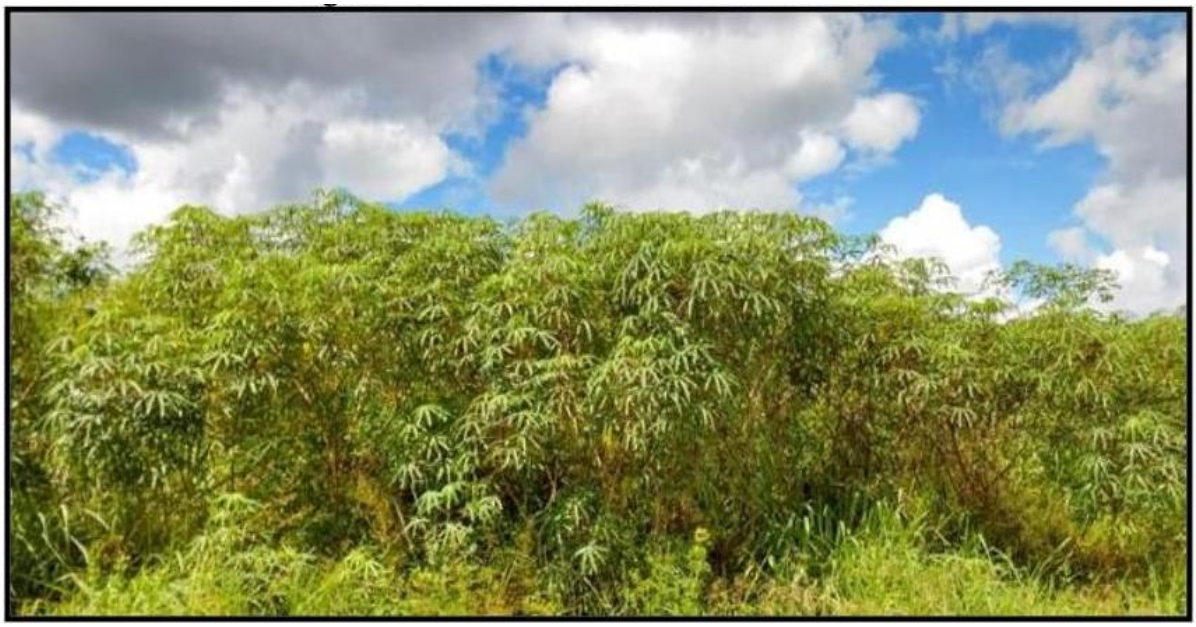

**Figure 1:** Assessed cassava plant.

### 2.2 Biometric Evaluation and Root Yield

After root collection, a random sample containing the roots of 100 plants from each cultivar was taken for physical characterization. The procedure involved determining the weights of the pulp with peel, pulp without peel, and peel weight. The yield of cassava roots was determined by manually separating the pulp and peel and measuring their respective masses using a semi-analytical balance (Moshenin, 1986).

Root length was measured using a tape measure, and the diameters of the upper, middle, and lower parts of the roots were measured using a 300 mm analog caliper with a precision of 0.01 mm, with results expressed in centimeters (Moshenin, 1986). From Figure 2a, it can be observed that the Jaibara variety root has a cylindrical shape, brown skin, white cortex, and yellow pulp. In Figure 2b, it can be seen that the Cacau variety root has a conical shape, brown skin, pink cortex, and white pulp.

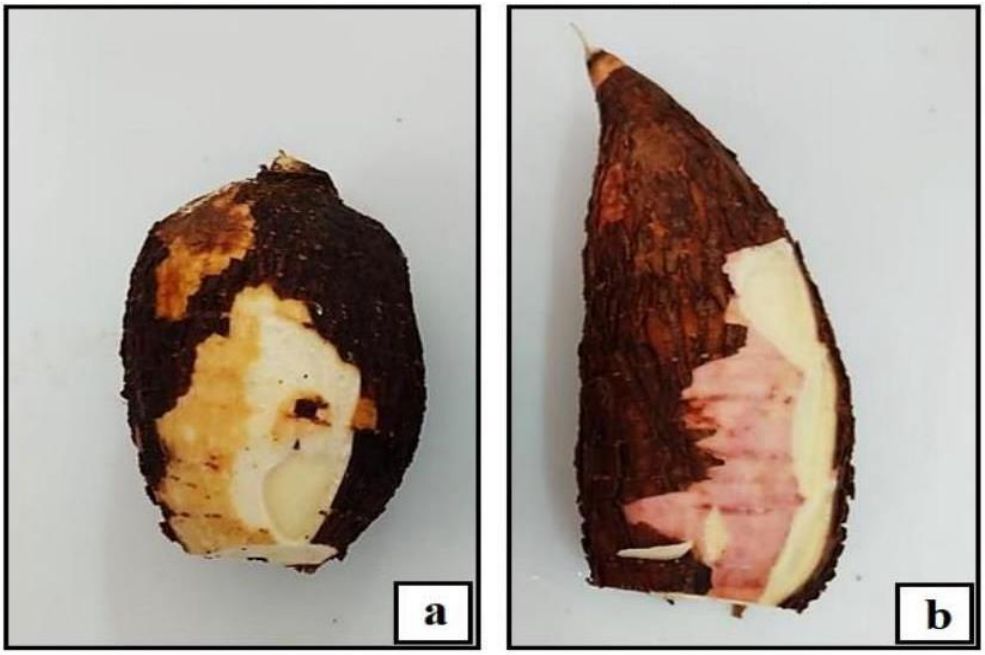


**Figure 2:** Roots of cassava Jaibara (a) and Cocoa (b).

### 2.3 Biochemical Composition of the Roots

The following analyses were performed in triplicate (n=3) on fresh cassava roots as well as minimally processed roots: pH: determined using a potentiometer previously calibrated with pH 4 and 7 buffer solutions (AOAC, 2019). Titratable total acidity (TTA): performed by titration with a citric acid conversion factor of 64.02 (AOAC, 2019). Moisture: determined gravimetrically in a Tecnal model TE - 395 oven (AOAC, 2019). Ash: samples were incinerated in a muffle furnace at 550℃ (AOAC, 2019). Proteins: determined according to the Biuret Method described by Layne (1957). Lipids: determined via cold solvent mixture extraction, using the Bligh and Dyer method (1959). Carbohydrates: calculated by difference, according to Resolution No.360 of December 23, 2003 (ANVISA, 2003). Total energy value (TEV): estimated (kcal/100g) using the Atwater conversion factors: 4 kcal/g for carbohydrates and proteins, and 9 kcal/g for lipids, according to Anderson et al. (1988) and Resolution No. 360 of December 23, 2003 (ANVISA, 2003).

The results of the biochemical analyses were analyzed using descriptive statistics, including measures of central tendency (mean), data variability (standard deviation), and coefficient of variation (Rodrigues et al., 2017). The results were also evaluated through analysis of variance, and when differences were present, they were compared using the Tukey Test at a 5% probability level, using the Sisvar software version 5.6 (Ferreira, 2019).

### 2.3 Plantation Characterization

The growth variables of the Cacau and Jaibara variety cassava plants used in the study can be observed in Table 1.

**Table 1:** Growth variables of cassava plants.

| Variables | Cocoa Variety | Jaibara Variety | DMS | F calc. | CV(% ) |
|---|---|---|---|---|---|
| Height (m) | 1,24±0,14$^{a}$ | 1,03±0,10$^{b}$ | 6,220 | 48,02* | 10,61 |
| Number of leaves (unit) | 181,09±17,62$^{a}$ | 170,73±15,63 | 8,609 | 5,80* | 9,47 |
| Number of stems (unit) | 2,43±0,29$^{a}$ | 2,47±0,31$^{a}$ | 0,161 | 148.141 ns | 10,23 |
| Number of branches (unit) | 2,23±0,35$^{b}$ | 3,28±0,25$^{a}$ | 0,158 | 143,20* | 11,11 |
| Stem diameter (cm) | 2,38±0,23$^{a}$ | 2,36±0,15$^{a}$ | 0,102 | 0.24 ns | 8,29 |
| Number of roots (unit) | 5,12±0,47$^{a}$ | 4,04±0,44$^{b}$ | 0,233 | 86,40* | 9,85 |
| Root weight (g) | 2533,33±271,21$^{a}$ | 2308,50 ± 249,01$^{b}$ | 0,134 | 13,34* | 10,66 |
| Stem weight (g) | 1506,63± 124,88$^{a}$ | 1263,67 ± 101,53 | 0,058 | 69,63* | 8,16 |
| Leaf weight (g) | 100,07±9,10$^{b}$ | 209,50 ± 19,67$^{a}$ | 0,008 | 776,49* | 9,80 |

DMS - Least significant difference; CV - experimental coefficient of variation. Means followed by the same letter in the same row do not differ statistically by the Tukey test at the 5% probability level; ns - not significant; * - significant at the 5% probability level. Values represent the

mean ± standard deviation.

There was a significant difference ($p < 0,05$) between the varieties in terms of height, number of leaves, number of branches, number of roots, and stem weight, with the Cacau variety showing higher means in the cited variables. However, for the leaf weight variable, the Jaibara variety showed a higher mean compared to Cacau. There was no significant difference ($p > 0,05$) for the number of stems and stem diameter variables.

For the height variable, mean values of 1.24 m and 1.03 m were observed for the Cacau and Jaibara varieties, respectively (Table 1). Ferreira et al. (2009), when evaluating the production and nutritional value of the aerial part of Cassava, Maniçoba, and Pornunça, found that cassava had a final mean height of 106.8 cm at 10 months; these data are consistent with those of the present study.

Albuquerque et al. (2009), when evaluating 10 sweet cassava varieties at 13 months, found that the plants reached heights between 1.33 m and 2.62 m; thus, the lower mean indicated is consistent with the mean found for the Cacau variety in the present study.

The number of leaves variable showed means of 181.09 and 170.73 units for the Cacau and Jaibara varieties, respectively (Table 1). Streck et al. (2014), evaluating the effect of planting spacing on the growth, development, and productivity of cassava, observed that the highest mean value for the number of leaves was 115 units, a number much lower than that found in the present study.

The number of stems was 2.43 and 2.47 units for the Cacau and Jaibara varieties, respectively, and the mean number of branches was 2.23 and 3.28 units, respectively (Table 1). Fagundes et al. (2010), when studying the development, growth, and productivity of cassava at different planting dates, found that the number of branches had a lower mean of 4.4 at 8 months after planting and a higher mean of 12.3 at 10 months. These values are much higher than those of the present study, especially considering the 14-month age of the plants here.

The fact that the Jaibara variety has fewer leaves and more branches compared to the Cacau variety is explained by the hypothesis of competition for photoassimilates, water, and nutrients between branches and leaves. Increased competition within the cassava plant leads to an increase in the phyllochron, i.e., a decrease in the rate of leaf emission in higher-order sympodial branches; thus, the higher the order of sympodial branches, the lower the rate of leaf emission and, therefore, the lower the number of leaves (Fagundes et al., 2009).

Still in the study by Fagundes et al. (2010), it was found that the mean stem diameter was 1.2 cm at 8 months after planting and 1.9 cm at 10 months after planting; these values are much lower than those observed in the present study, where at 14 months after planting, the Cacau variety had a diameter of 2.38 cm and the Jaibara variety 2.36 cm.

The number of verified roots for the Cacau (5.12 units) and Jaibara (4.04 units) varieties are within the expected values by Carvalho and Fukuda (2006), who state that production can range from 1 to 10 roots.

Prates et al. (2017), when evaluating and comparing morphological characteristics of different cassava genotypes under the edaphoclimatic conditions of the municipality of Cândido Sales, Southwest Bahia, found an overall average of 0.530 kg for tuberous root weight; this average is much lower than that observed in the present study, which showed 2533.33 and 2308.50 g for the Cacau and Jaibara varieties, respectively.

Plants of the Cacau variety showed a stem weight of 1506.63 g, while the Jaibara variety showed a lower value of 1263.67 g. Regarding leaf weight, the Jaibara and Cacau varieties showed values of 209.50 and 100.07 g, respectively, demonstrating that in this attribute, the Jaibara cassava, despite having fewer leaves (170.73 units) compared to Cacau (181.09 units), had heavier leaves. This is due to the size of the leaves of the studied varieties; thus, the Jaibara leaves (Figure 2a) were larger with 7 lobes, while the Cacau leaves had only 2 to 3 lobes (Figure 2b). For Tan and Cock (1979), leaf size is influenced by changes in branching pattern; thus, the lower the number of branches, the larger the leaf size.

In general, there is a sink relationship between the aerial part of the plant and the roots; when the plant "invests" in root development, the aerial part consequently will not have as much vigor, and the opposite is true. Alves (2006) agrees, stating that tuberous roots and the aerial part are two sinks that compete during the plant's cycle and life. Aguiar et al. (2011) point out that under lower planting density conditions, the root sink surpasses that of the aerial

part.

### 2.4 Biometric Evaluation and Root Yield

Table 2 shows the parameters for determining the physical characteristics and average yield of the cassava roots used in the present study.

**Table 2:** Unit biometric characterization and average yield of cassava roots.

| Physical determinations | Cacau Variety | Jaibara Variety | DMS | F calc. | CV (%) |
|---|---|---|---|---|---|
| Length (cm) | 23.18 ± 4.00° | 19,97 ± 4,19[b] | 1,522 | 17,43* | 18,99 |
| Upper diameter (cm) | 3,38±0,98[b] | 4,16 ± 0,76° | 0,326 | 22,19* | 23,27 |
| Middle diameter (cm) | 4,27±0,62[b] | 5,38 ± 0,74° | 0,255 | 74,47* | 14,21 |
| Lower diameter (cm) | 4,27±0,60[b] | 4,69±0,59[a] | 0,223 | 14,00* | 13,38 |
| Pulp weight with peel (g) | 319,75 ± 59,06 [b] | 416,90±47,01[a] | 19,816 | 94,38* | 14,49 |
| Pulp weight without peel (g) | 248,51 ± 34,09 [b] | 308,10 ± 30,42[a] | 11,990 | 97,00* | 11,60 |
| Peel weight (g) | 58,98 ± 9,746 | 112.60 ± 19.60° | 5,742 | 341,95* | 18,03 |
| Average yield Var. Cacau | Root weight (kg) | | Root weight (%) | | |
| Root with peel (kg.root z$^{?1}$ ) | 31,98 | | 100 | | |
| Root without peel (kg.root ?$^{?1}$ ) | 24,85 | | 77,71 | | |
| Peels (kg.root ?$^{?1}$ ) | 7,13 | | 22,29 | | |
| Average yield Var. Jaibara | Root weight (kg) | | Root weight (%) | | |
| Root with peel (kg.root-1) | 41,69 | | 100 | | |
| Root without peel (kg.root-1) | 30,81 | | 73,90 | | |
| Peels (kg.root-1) | 10,88 | | 26,10 | | |

DMS - Minimum significant difference; CV - Experimental coefficient of variation; Means followed by the same letter in the same line do not differ statistically by the Tukey test at the 5% probability level; ns - not significant; * - significant at the 5% probability level. Values represent the mean ± standard deviation.

There was a significant difference ($p < 0,05$) for the root length variable, where the Cacau variety showed a higher mean compared to the Jaibara variety (23.18 and 19.97 cm, respectively) (Table 2). Albuquerque et al. (2012), in a study conducted with the "cacauzinha" variety intercropped with beans, found that the root length range of this variety was between 22.10 and 23.51 cm, thus results similar to those of the present study. According to Silva et al. (2015), roots with a length much above the observed means present problems for storage, transport, and require a longer cooking time, so consumption in natura is not recommended; however, they are ideal for industrial use.

There was a significant difference ($p < 0,05$) for the upper, middle, and lower diameter variables, where the Jaibara variety showed higher means compared to the Cacau variety. The Jaibara variety stood out with 4.16, 5.38, and 4.69 cm in diameter, while the Cacau variety presented only 3.38, 4.27, and 4.27 cm in upper, middle, and lower diameter, respectively, as observed in Table 2.

The upper and middle diameter values of the Jaibara variety are close to those observed in the study by Silva (2011), who found means of 4.99, 5.76 and 4.52, 5.21 cm for the Pocu and Paulo Velho varieties, respectively. A similar result was observed in a study by Rós et al. (2011) who, when evaluating the growth, phenology, and productivity of different cassava cultivars, found that all of these presented mean values between 4.8 cm and 5.9 cm for the root diameter variable.

For the variables pulp weight with peel, pulp weight without peel, and peel weight, there was a significant difference ($p < 0.05$); thus, the Jaibara variety showed higher means (416.90; 308.10 and 112.60 g) than the Cacau variety (319.75; 248.51 and 58.98 g) for the respective variables, as shown in Table 2.

Silva (2011) found that the Pai Ambrósio, Pocu, and Paulo Velho varieties had an average root weight of 387.90 g, 353.40 g, and 341.10 g, respectively, which are lower than those obtained in the present study. Higher values were recorded in the study by Guimarães et al. (2017) who, when characterizing the morphology of 28 cassava genotypes, found an overall mean root weight of 530 g. Rós et al. (2011) also found higher values, with an average individual fresh root mass of 513 g.

The average pulp and peel yields of cassava roots were 77.71 and 22.29% and 73.90% and 26.10% for the Cacau and Jaibara varieties, respectively, as shown in (Table 2). These values are similar to those found by Lima et al.

(2015), who, when conducting a study on nine cassava varieties, observed an average value between 77.21 and 85.74% for the pulp yield variable. In a study by Carréra et al. (2013), when evaluating the roots of different cassava genotypes, they found that the fresh pulp average ranged from 62.39 to 83.95%.

In summary, the cassava roots of the Jaibara variety were short, cylindrical, more vigorous, and have a good pulp yield. The roots of the Cacau variety, on the other hand, were long, conical, and also have a good pulp yield.

### 2.5 Biochemical Composition of Fresh Roots

From Table 3, the biochemical parameters evaluated in fresh cassava roots can be viewed.

**Table 3:** Biochemical composition of fresh cassava roots.

| Fresh roots | | | | | |
|---|---|---|---|---|---|
| Determinations | Cocoa Variety | Jaibara Variety | DMS | F calc. | CV(%) |
| pH | 7.40±0.03° | 7.54±0.06° | 0,110 | 13,02* | 0,65 |
| ATT (g 100 $g^{-1}$) | 2,10±0,22 $?^{a}$ | 2,14±0,28 | 0,566 | 0.03 ns | 11,80 |
| Moisture (g 100 $g^{-1}$) | 57,20±0,54 $?^{a}$ | 57,88±0,54 | 1,230 | 2.33 ns | 0,94 |
| Ash (g 100 $g^{-1}$) | 0,69±0,03 $?^{a}$ | 0.68±0.03° | 0,077 | 0.01 ns | 4,96 |
| Proteins (g 100 $g^{-1}$) | 0,61±0,04 $?^{b}$ | 0.90±0.05° | 0,108 | 56,94* | 6,31 |
| Lipids(g 100 $g^{-1}$) | 0.28±0.02° | 0,24±0,02[a] | 0,041 | 5,00 ns | 7,02 |
| Carbohydrates(g 100 $g^{-1}$) | 41,22±0,45 | 40,29±0,54 | 1,123 | 5.29 ns | 1,21 |
| VET (kcal 100 $g^{-1}$ ) | 170,16 | 166,92 | - | - | - |

**Results on a wet basis. ATT - Titratable total acidity; VET - Total Energy Value; DMS - Minimum significant difference; CV - Experimental coefficient of variation. Means followed by the same letter in the same row do not differ statistically from each other by the Tukey test at the 5% probability level; ns - not significant; * - significant at the 5% probability level. The values represent the mean ± standard deviation of three replicates (n = 3) .

There was no significant difference $(p > 0{,}05)$ between the cassava varieties studied for the variables of titratable total acidity (ATT), moisture, ash, lipids, and carbohydrates. However, for the variables of pH and proteins, there was a significant difference $(p < 0{,}05)$ (Table 3).

The Jaibara variety showed a mean of pH higher when compared to the Cacau variety (7.54 and 7.40, respectively). These means are higher than those found by Carréra et al. (2014), who, when studying the physicochemical characteristics of sweet cassava roots, observed values ranging from 6.6 to 7.0 for the same variable.

According to Lima et al. (2013), the pH of minimally processed cassava roots stored in vacuum packaging remains practically constant, due to treatment with sanitizer and antioxidant. Very low pH values (acidic) are an indication of microbial contamination and a sign of failure during the cleaning and sanitization process. The washing and sanitization processes carried out during processing are effective in eliminating microorganisms, even if superficially. This already ensures good post-harvest quality (Abreu et al., 2021).

The titratable total acidity (ATT) observed for the studied varieties was 2.10 and 2.14 g 100 g $?^{?1}$ for Cacau and Jaibara, respectively. In the study by Oliveira et al. (2021), when evaluating the physicochemical characteristics of cassava roots of the BRS Aipim Brasil and Eucalipto varieties, they observed ATT values of 0.11 and 0.12 g $100? g^{?1}$ respectively, at 12 months after freezing the roots.

The determination of pH and acidity provides important data regarding the state of preservation of a food product (Abreu et al., 2020). The higher these levels, the greater the indicators of contamination by pathogenic agents.

The moisture observed for the Cacau variety was 57.20 g 100 , and for the Jaibara variety, 57.88 g 100 g . Carréra et al. (2014) observed moisture values between 55.3 and 64.4 g 100 g , data that corroborate with those found in the present study.

The ash content of the Cacau and Jaibara varieties was 0.69 and 0.68 g 100 g $?^{1}$ , respectively. According to the Brazilian Table of Food Composition (Taco), raw cassava roots should have around 0.60 g 10 of ash (Taco, 2011); these parameters corroborate with those found in the present study.

The amount of protein present in the roots of the Jaibara variety of cassava (0.90 g 100 ) was higher when compared to the amount present in the roots of the Cacau variety $(0{,}61g)$ . Oliveira and Moraes (2009) found that

the IAC 576-70 cassava cultivar at 12 months after planting had 1.25 g of protein, thus being higher than those observed in the present study.

The amount of lipid found was 0.28 and 0.24 g 100 for the respective Cacau and Jaibara varieties. Still according to Taco, these values should be close to 0.30 g (Taco, 2011), therefore, they are within the expected range.

The total energy value (TEV) for the Cacau variety was 170.16 kcal per 100 g ?$^{?1}$ and for the Jaibara variety was 166.92 kcal per 100 g ?$^{?1}$ . The Brazilian Table of Food Composition (Taco) establishes the amount of 151 kcal per 100 g of raw cassava (Taco, 2011); therefore, the values of the present study are close to those established.

## 3. CONCLUSION

Regarding the physical characterization of Cacau variety cassava plants, when analyzing the variables of height (1,24m) , number of leaves (181.09 units), number of roots (5.12 units), root weight (2533.33 g), stem weight (1506.63 g), and leaf weight (100.07 g), it was found that plants of this variety showed notable vegetative vigor; however, the leaves were "light" due to the fact that the leaf blade had few lobes (2 to 3 lobes), hence a smaller leaf area and lower mass. As for the Jaibara variety plants, according to the variables of height (1.03 m), number of leaves (170.73 units), number of roots (4.04 units), root weight (2308.50 g), stem weight (1263.67 g), and leaf weight (209.50 g), it was found that the plants showed lower vigor; however, the leaves were "heavier" because the leaves had 7 lobes on the leaf blade, hence a higher mass.

Regarding the physical characterization of Cacau cassava roots based on the variables of length (23.18 cm), upper diameter (3.38 cm), middle diameter (4.17 cm), and lower diameter (4.17 cm), they presented a conical shape, visually showing a pink cortex and white pulp. In this case, most of the fresh weight of the roots was from the pulp (248.51 g), accounting for a yield of 77.71%. The Jaibara cassava, according to the length data (19.97 cm), upper diameter (4.16 cm), middle diameter (5.38 cm), and lower diameter (4.69 cm), presented a cylindrical shape, visually showing a white cortex and yellow pulp. This variety had heavier roots (308.10 g) and a yield of 73.90%.

The chemical analysis of the fresh roots of both studied varieties showed values very close to those found in the literature and, therefore, the nutritional composition did not present significant deficits or excesses when compared to the TACO.

The Cacau variety of cassava was more productive; both varieties showed good nutritional quality. Knowing the food and socioeconomic importance of cassava, it is necessary to conduct studies that make greater contributions regarding the physical characteristics of the plants, as well as the biochemical composition and sensory study of the roots, considering the various existing varieties currently.

## REFERENCES

[1] ABREU, C. M.; CASTRO, M. R. A.; GATTI, V. C. M.; BARATA, H. S.; CARVALHO, F. I. M.; SILVA, P. A. Percepção sensorial de raízes de mandioca minimamente processada desenvolvida para agricultura familiar. Natural Resources, v. 11, n. 2, p. 1-6, 2021. http://doi.org/10.6008/CBPC2237-9290.2021.001.0001

[2] ABREU, C. M. de; SANTOS NETO, J. P. dos; MARTINS, L. H. S.; CRUZ, W. P. da; SILVA, J. N. da; SILVA, V. F. A.; CARVALHO, F. I. M.; SILVA, P. A. Quality of minimally processed table cassava cultivated in southeastern Pará, Brazilian Amazonian. Brazilian Journal of Development, v. 6, n. 7, p. 46365-46379, 2020. https://doi.org/10.34117/bjdv6n7- 314

[3] AGUIAR, E. B.; VALLE, T. L.; LORENZI, J. O.; KANTHACK, R. A. D.; MIRANDA FILHO, H.; GRANJA, N. P. Efeito da densidade populacional e época de colheita na produção de raízes de mandioca de mesa. Bragantia, v. 70, p. 561-569, 2011.

[4] ALBUQUERQUE, A. A. J.; SEDIYAMA, T.; SILVA, A. A.; SEDIYAMA, S. C.; ALVES, A. M. J.; NETO, A. F. Caracterização morfológica e agronômica de clones de mandioca cultivados no Estado de Roraima. Revista Brasileira de Ciências Agrárias, v. 4, n. 4, p. 388- 394, 2009.

[5] ALBUQUERQUE, A. A. J.; SEDIYAMA, T.; ALVES, A. M. J.; SILVA, A. A.; UCHÓA, P. C. S. Cultivo de mandioca e feijão em sistemas consorciados realizado em Coimbra, Minas Gerais, Brasil. Revista Ciência Agronômica, v. 43, n. 3, p. 532-538, 2012.

[6] ALVES, A. A. C. Physiology of cassava. Socioeconomic and agronomic aspects of cassava. In: Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA. Cassava and Tropical Fruit Growing. Cruz das Almas: EMBRAPA, 2006. p.138-169.
[7] ANDERSON, L.; DIBBLE, M. V.; TURKKI, P. R.; MITCHEL, H. S.; RYNBERGEN, H. J. Meeting nutritional standards. In: Nutrition. 17th ed. Rio de Janeiro: Guanabara, ch. 10, p.179-187, 1988.
[8] AOAC - Association of Official Analytical Chemists. Official Methods of Analysis of AOAC International. 21st ed. Rockville: AOAC International, 2019.
[9] ANVISA - National Health Surveillance Agency. Resolution RDC, of December 23, 2003. Approves the Technical Regulation on nutritional labeling of packaged foods. Official Gazette [of the Federative Republic of Brazil]. Brasília, p.4, Dec. 2003. Section 1.
[10] BLIGH, E. C.; DYER, W. J. A rapid method of total lipid extraction and purification. Canadian Journal of Biochemistry and Physiology, Ottawa, v. 37, p. 911-917, 1959. https://doi.org/10.1139/o59-099
[11] CARRÉRA, A. G. P.; CUNHA, R. L.; CUNHA, E. F. M.; REGO, J. Y. N. Physicochemical characteristics of sweet cassava roots (Manihot esculenta Crantz). 18th Scientific Initiation Seminar and 2nd Postgraduate Seminar of Embrapa Amazônia Oriental, Belém - PA, 2014.
[12] CARRÉRA, A. G. P.; LORENZO, N. D.; ARAUJO, F. C. B.; CUNHA, R. L.; CUNHA, E. F. M.; ROSÁRIO, S. F.; ARAÚJO, M. P. S. Evaluation of roots from different bitter cassava genotypes (Manihot esculenta, Crantz). In: 17th Scientific Initiation Seminar of Embrapa Amazônia Oriental and 1st Postgraduate Seminar of Embrapa Amazônia Oriental, 1st, 2013, Belém, PA. Proceedings. Belém, PA: Embrapa Amazônia Oriental, 2013.
[13] CARVALHO, J. E.; FUKUDA, W. M. G. Plant structure and morphology. In: Embrapa Cassava and Tropical Fruit Growing. Socioeconomic and agronomic aspects of cassava. Cruz das Almas, 2006. Ch.6, p.126-137
[14] FAGUNDES, L. K.; STRECK, N. A.; LOPES, S. J.; ROSA, H. T.; WALTER, L. C.; ZANON, A. J. Vegetative development in different cassava stems as a function of planting time. Ciência Rural, v. 39, p. 657-663, 2009.
[15] FAGUNDES, L. K.; STRECK, N. A.; ROSA, H. T.; WALTER, L. C.; ZANON, A. J.; LOPES, S. J. Development, growth and productivity of cassava at different planting dates in a subtropical region. Ciência Rural, v. 40, p. 2460-2466, 2010.
[16] FERREIRA, A. L.; SILVA, A. F.; PEREIRA, L. G. R.; BRAGA, L. G. T.; MORAES, S. A.; ARAÚJO, G. G. L. Production and nutritional value of the aerial part of cassava, maniçoba, and pornunça. Brazilian Journal of Health and Animal Production, vol. 10, no. 1, 2009.
[17] FERREIRA, D. F. Sisvar: A computer statistical analysis system to fixed effects split-plot designs: Sisvar. Brazilian Journal of Biometrics, vol. 37, p. 529-535, 2019. https://doi.org/10.28951/rbb.v37i4.450
[18] GUIMARÃES, D. L. F.; SILVA, R. N. da; ANDRADE, H. M. L. da S.; ANDRADE, L. P. de. Cassava production chain in the Brazilian territory: innovations and technologies - a systematic literature review: a systematic literature review. Diversitas Journal, vol.7, no.1, p.0017-0025, 2022 https://doi.org/10.48017/dj.v7i1.2009
[19] GUIMARÃES, G. D.; PRATES, N. J. C.; VIANA, S. E. A.; CARDOSO, D. A.; TEIXEIRA, G. R. P.; CARVALHO, D. K. Morphological characterization of cassava genotypes (Manihot esculenta Crantz). Scientia Plena, vol. 13, no. 9, 2017.
[20] LAYNE, E. Spectrophotometric and turbidimetric methods for measuring proteins. In: Colowick, P. S. and Kaplan, N. O., Eds., Method in enzymology, Academic Press, Inc., New York, p. 447-454, 1957. http://dx.doi.org/10.1016/s0076-6879(57)03413-8
[21] LIMA, A. A; BENINCA, C.; MARÇAL, I. M. Minimal processing of cassava: an alternative for family farmers in Canoinhas-SC and region. In: Research, Extension and Innovation Seminar of IFSC - SEPEI, Santa Catarina, 2013.
[22] LIMA, C. L. C.; ANJOS, U. E.; SANTIAGO, D. A. Evaluation of table-type cassava variety. In: XVI Brazilian Congress of Cassava. Latin American and Caribbean Congress of Cassava. Integration: food security and income generation: proceedings. Foz do Iguaçu: SBM, 2015.
[23] MACIEL, M. R. A.; MING, L. C. The importance of cultivation and use of cassava (Manihot esculenta Crantz) among the Paresí people, Mato Grosso, Brazil. Scientia Naturalis, vol. 4, no. 1, p. 227-254, 2022. https://doi.org/10.29327/269504.4.1-16
[24] MANIEZO, G. T.; ARAÚJO, G. C. C. de. Cassava flour: safeguarding food cultures from the descriptive treatise of Brazil to the geographical indication. Revista Extraprensa, vol. 15, p. 816-832, 2022. https://doi.org/10.11606/extraprensa2022.194191
[25] MEDEIROS, M. M. de; SANTANA, M. C. A.; LIMA, P. M. de. Documentary and heritage: the cassava flour house in the Alagoas sertão, tradition and contemporaneity. Latin American Journal of Built Environment &

Sustainability, vol. 04, no. 12, p. 43 – 53, 2023. MOSHENIN, N. N. Physical properties of plant and animal materials. Gordon and Breach Publishers. New York, 1986, 841p.

[26] NEVES, E. C. A.; NASCIMENTO, G. C.; FERREIRA, A. R.; NEVES, D. A.; FUKUSHIMA, A. R.; LEONI, L. A. B.; CLERICI, M. T. P. S. Classification, nutritional and technological characteristics of cassava flour marketed in Belém, Pará, Brazil. Brazilian Journal of Food Technology, v.23, 2020, e2019143. https://doi.org/10.1590/1981-6723.14319

[27] NUNES, E. M.; CRUZ, M. S.; SILVA, V. M. Technical Assistance and Rural Extension (ATER) in the Rural Territory of Sertão Central Cabugi and Litoral Norte (RN): the challenge of sociotechnical adaptation. Revista Extensão Rural, v. 27, n. 3, p. 40-64, 2020.

[28] OLIVEIRA, E. J.; OLIVEIRA, S. A.; OTTO, C.; ALICAI, T.; FREITAS, J. P. X.; CORTES, D. F. M.; PARIYO, A.; LIRI, C.; ADIGA, G.; BALMER, A.; KLAUSER, D.; ROBINSON, M. A new multiplication approach based on seed treatment for cassava planting material. Plos one, v.15, n.6, 2020. http://dx.doi.org/10.1371/journal.pone.0229943

[29] OLIVEIRA JUNIOR, O. P.; WANDER, A. E. Description of the cassava production chain in the Araguaia Valley Region (Goiás, Brazil). Revista GeoNordeste, n. 1, p. 73-92, 2020. https://doi.org/10.33360/RGN.2318-2695.2020.11.p.73-92

[30] OLIVEIRA, L. A.; REIS, R. C.; VIANA, E. S.; SANTOS, J. F.; SOUZA, V. S.; ASSIS, J. L. J.; SASAKI, F. F. C.; SANTOS, V. S. Effect of the storage period on physical-chemical characteristics, microbiological composition and sensory acceptance of two varieties of frozen sweet cassava. Brazilian Journal of Food Technology, v. 24, e2020215, 2021. https://doi.org/10.1590/1981-6723.21520

[31] OLIVEIRA, M. A. de, MORAES, P. S. B. Physicochemical characteristics, cooking quality and productivity of cassava cultivar IAC 576-70 at different harvest times. Ciência e Agrotecnologia, Lavras, v. 33, n. 3. 2009.

[32] PONCE, T. P.; RIBEIRO, M. R.; TELLES, T. S. Spatial dynamics of cassava production in Paraná, Brazil. Revista Franco-Brasilera de Geografia, n. 48, 2020. http://dx.doi.org/10.4000/confins.34307

[33] PRATES, C. J. N.; GUIMARÃES, D. G.; VIANA, A. E. S.; CARDOSO, A. D.; TEIXEIRA, P. R. G.; CARVALHO, K. D. Morphological characterization of cassava genotypes (Manihot esculenta Crantz). Scientia Plena, v. 13, n. 9, 2017.

[34] RÓS, A. B.; HIRATA, A. C. S.; ARAÚJO, H. S.; NARITA, N. Growth, phenology and productivity of cassava cultivars. Pesquisa Agropecuária Tropical, v. 41, n. 4, p. 552-558, 2011.

[35] RODRIGUES, C. F. S.; LIMA, F. J. C. de; BARBOSA, F. T. Importance of the proper use of basic statistics in clinical research. Revista Brasileira de Anestesiologia, v. 67, n. 6, p. 619 - 625, 2017. http://dx.doi.org/10.1016/j.bjan.2017.01.003

[36] SARAVANAN, R.; RAVI, V.; STEFHEN R.; THAJUDHIN, S. Post-harvest physiological deterioration of cassava (Manihot esculenta Crantz): A review. Indian Journal of Agricultural Sciences, v. 86, n. 11, p. 1383-1390, 2016.

[37] SILVA, J.; PESSOA, M. O.; SILVA, P. S. L.; ARRAIS, I. G.; SILVA, J. R.; TORRES, J. F. Yields of fertigated cassava cultivars in the Tabuleiro de Russas, PE. In: 16th Brazilian Congress of Cassava. Latin American and Caribbean Congress of Cassava, 2015. Foz do Iguaçu: SBM, 2015.

[38] SILVA, P. A. Study on the processing and physical, physicochemical, and sensory quality of tapioca flour. Dissertation (Master's Degree in Food Science and Technology) Federal University of Pará, Belém - PA, 2011.

[39] SILVA, R. M. A. da; NUNES, E. M. Family farming and cooperativism in Brazil: a characterization based on the 2017 Agricultural Census. Revista de Economia e Sociologia Rural, v. 61, n. 2, e252661, 2023. https://doi.org/10.1590/1806-9479.2021.252661

[40] SOUZA, E.; KALID, R. Technology transfer in cassava cultivation - the case of the Reniva Project. Interações, v.23, n.2, p. 423-439, 2022. http://dx.doi.org/10.20435/inter.v23i2.3017

[41] TACO - Brazilian Table of Food Composition. 4th ed. rev. and expanded. Campinas: SP. NEPA - UNICAMP, 2011, p.164.

[42] TAN, T. S.; COCK, J. H. Branching habit as a yield determinant in cassava. Field Crops Research, v. 2, p. 281-289, 1979.