PHYSICOCHEMICAL AND NUTRITIONAL CHARACTERISTICS OF DIFFERENT CASSAVA VARIETIES CULTIVATED IN NAMPULA PROVINCE

CARACTERÍSTICAS FÍSICO-QUÍMICAS E NUTRICIONAIS DE DIFERENTES VARIEDADES DE MANDIOCA CULTIVADAS NA PROVÍNCIA DE NAMPULA

PHYSICOCHEMICAL AND NUTRITIONAL CHARACTERISTICS OF DIFFERENT CASSAVA VARIETIES CULTIVATED IN NAMPULA PROVINCE

https://doi.org/10.56238/sevened2026.023-002

Porfírio Américo Nunes Rosa[1], Fernando João Tanleque-Alberto[2], Cristovão João Miguel[3], José Jorge da Costa[4], Maria Alice Tavares Chaves Leal[5], Amilton Martins Rúbio[6], Epifânia Sidónio Alberto Salimo[7], Renato Pedro Gemusse[8]

ABSTRACT

Cassava (*Manihot esculenta Crantz*) is one of the main staple foods in Mozambique; however, variability among varieties may affect nutritional quality, food safety, and processing potential, representing a challenge for its proper utilization. This study aimed to evaluate the physicochemical and nutritional characteristics of five cassava varieties cultivated in Nampula Province (Badje, Mokhalana, Napirithe, Nziva, and Técnico). Mature roots were collected and laboratory analyses were performed for moisture, ash, pH, titratable acidity, cyanide, β-carotene, lycopene, and total solids, with statistical treatment by ANOVA. Moisture ranged from 51.91 ± 1.54% (Badje) to 58.35 ± 0.96% (Napirithe), while ash content varied between 1.06 ± 0.08% (Mokhalana) and 5.08 ± 0.53% (Napirithe). pH ranged from 6.64 ± 0.01 (Napirithe) to 7.79 ± 0.15 (Mokhalana), and titratable acidity ranged from 3.94 ± 0.07% (Napirithe) to 7.97 ± 0.08% (Técnico). β-carotene contents were highest in Nziva (11.52 ± 0.15 µg/g) and Técnico (20.81 ± 0.27 µg/g), while lycopene ranged from 6.99 ± 0.09 µg/g (Mokhalana) to 11.18 ± 0.45 µg/g (Técnico). Cyanide levels ranged from 3.70 ± 0.48 mg/g (Nziva) to 5.09 ± 0.02 mg/g (Técnico), remaining below critical limits for safe consumption after proper processing. It is concluded that varietal selection based on physicochemical and nutritional parameters is a relevant strategy to optimize food, industrial, and nutritional use of cassava in Nampula.

Keywords: Cassava. Physicochemical Properties. Carotenoids. Nutritional Quality. Food Safety.

[1] Doctoral student in Agrochemistry. Instituto Federal Goiano. E-mail: porfirio.rosa@estudante.ifgoiano.edu.br
[2] Dr. in Food Science, Technology and Management. Universidade Rovuma. E-mail: tanleque22@gmail.com
[3] Master's Student. Universidade Rovuma. E-mail: cristovaofilo@gmail.com
[4] Master's degree in Health Sciences Education. Escola Secundaria de Rapale.
E-mail: omarjosejorge@gmail.com
[5] Dr. Escola Secundaria Marcelino dos Santos. E-mail: mariaaliceleal061@gmail.com
[6] Graduated in Food Sciences. Universidade Rovuma. E-mail: amiltonmartinsrubio19@gmail.com
[7] Graduated in Food Sciences. Universidade Rovuma. E-mail: sepifaniasidonio@gmail.com
[8] Graduated in Food Sciences. Universidade Rovuma. E-mail: renatodalucia00@gmail.com

RESUMO
A mandioca (*Manihot esculenta Crantz*) constitui um dos principais alimentos básicos em Moçambique; contudo, a variabilidade entre variedades pode afectar a qualidade nutricional, a segurança alimentar e o potencial de processamento, configurando um desafio ao seu aproveitamento adequado. Objetivou-se avaliar as características físico-químicas e nutricionais de cinco variedades de mandioca cultivadas na província de Nampula (Badje, Mokhalana, Napirithe, Nziva e Técnico). Para tanto, procedeu-se à colecta de raízes maduras e à realização de análises laboratoriais de humidade, cinzas, pH, acidez titulável, cianeto, β-caroteno, licopeno e sólidos totais, com tratamento estatístico por ANOVA. Desse modo, observou-se que a humidade variou de 51,91 ± 1,54% (Badje) a 58,35 ± 0,96% (Napirithe), enquanto o teor de cinzas oscilou entre 1,06 ± 0,08% (Mokhalana) e 5,08 ± 0,53% (Napirithe). O pH apresentou valores de 6,64 ± 0,01 (Napirithe) a 7,79 ± 0,15 (Mokhalana), e a acidez titulável variou de 3,94 ± 0,07% (Napirithe) a 7,97 ± 0,08% (Técnico). Os teores de β-caroteno destacaram Nziva (11,52 ± 0,15 μg/g) e Técnico (20,81 ± 0,27 μg/g). O licopeno variou entre 6,99 ± 0,09 μg/g (Mokhalana) e 11,18 ± 0,45 μg/g (Técnico). Quanto ao cianeto, os valores oscilaram de 3,70 ± 0,48 mg/g (Nziva) a 5,09 ± 0,02 mg/g (Técnico), permanecendo abaixo dos limites críticos recomendados. Conclui-se que as variedades apresentam perfis físico-químicos e nutricionais distintos, sendo a selecção varietal uma estratégia relevante para optimizar o uso alimentar, industrial e nutricional da mandioca em Nampula.

Palavras-chave: Mandioca. Propriedades Físico-Químicas. Carotenoides. Qualidade Nutricional. Segurança Alimentar.

RESUMEN
La mandioca (*Manihot esculenta Crantz*) constituye uno de los principales alimentos básicos en Mozambique; sin embargo, la variabilidad entre variedades puede afectar la calidad nutricional, la seguridad alimentaria y el potencial de procesamiento, representando un desafío para su aprovechamiento adecuado. El objetivo de este estudio fue evaluar las características fisicoquímicas y nutricionales de cinco variedades de mandioca cultivadas en la provincia de Nampula (Badje, Mokhalana, Napirithe, Nziva y Técnico). Se recolectaron raíces maduras y se realizaron análisis de humedad, cenizas, pH, acidez titulable, cianuro, β-caroteno, licopeno y sólidos totales, con tratamiento estadístico mediante ANOVA. La humedad varió entre 51.91 ± 1.54% (Badje) y 58.35 ± 0.96% (Napirithe), mientras que el contenido de cenizas osciló entre 1.06 ± 0.08% (Mokhalana) y 5.08 ± 0.53% (Napirithe). El pH presentó valores de 6.64 ± 0.01 (Napirithe) a 7.79 ± 0.15 (Mokhalana), y la acidez titulable varió de 3.94 ± 0.07% (Napirithe) a 7.97 ± 0.08% (Técnico). El β-caroteno fue mayor en Nziva (11.52 ± 0.15 μg/g) y Técnico (20.81 ± 0.27 μg/g), mientras que el licopeno osciló entre 6.99 ± 0.09 μg/g (Mokhalana) y 11.18 ± 0.45 μg/g (Técnico). Los niveles de cianuro variaron de 3.70 ± 0.48 mg/g (Nziva) a 5.09 ± 0.02 mg/g (Técnico), permaneciendo por debajo de los límites críticos recomendados. Se concluye que las variedades evaluadas presentan perfiles fisicoquímicos y nutricionales distintos, y que la selección varietal basada en estos parámetros constituye una estrategia relevante para optimizar el uso alimentario, industrial y nutricional de la mandioca en Nampula.

Palabras clave: Mandioca. Propiedades Fisicoquímicas. Carotenoides. Calidad Nutricional. Seguridad Alimentaria.

1 INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is one of the most important food crops in tropical and subtropical regions, playing a central role in the food and nutrition security of millions of people, especially in African countries such as Mozambique. It is a root with a high starch content, low production cost and great capacity to adapt to different edaphoclimatic conditions, constituting an important source of energy and raw material for food and industrial uses (QUIRÓS, 2023). The nutritional relevance of foods rich in β-carotene is highlighted in regional crops, such as carrots in Ribáuè, recognized as a source of vitamin A essential for eye and immune health (ROSA, MIGUEL, DA CAMARA & EUGENIO 2026). Thus, the physicochemical characterization of cassava becomes fundamental to support food security and biofortification strategies.

Cassava is one of the pillars of food security in Mozambique, playing a central role in the diet of rural and urban populations, especially in the northern and central regions of the country. In provinces such as Nampula, Zambezia and Cabo Delgado, cassava is consumed daily in various forms fresh, dried, in flour or in traditional preparations, ensuring energy supply to millions of families. In addition to its food importance, the crop has high adaptability to low fertility soils and irregular rainfall regimes, common characteristics in several Mozambican agroecological zones, which makes cassava a strategic crop in the face of climate change and the instability of cereal production.

The physicochemical variability observed in agricultural products, such as carrots, demonstrates that edaphoclimatic factors and management practices influence the essential nutritional components (ROSA et al., 2026).

Parameters such as pH, titratable acidity, moisture, ash, total solids, carotenoids and content of cyanogenic compounds allow us to understand the conservation status, post-harvest stability, nutritional value and associated toxicological risks (PEREIRA, 2020, ROSA, et al., 2026). In particular, the content of β-carotene, a precursor of vitamin A, is of great relevance in contexts where deficiencies of this micronutrient persist, while cyanide levels require attention due to their potential adverse effect on health when cassava is not properly processed. As reported in nutritional studies of staple foods marketed in Nampula, foods of high nutritional value are essential for the food security of Mozambican populations (ROSA et al., 2025a). In Nampula province, cassava is widely cultivated and consumed, but there are still few comparative studies that systematically characterize the physicochemical and nutritional differences between local varieties (MACANE, 2024).

The realization of this study is justified by the need to generate scientific information that subsidizes the choice of more appropriate varieties from the point of view of nutrition, food security and industrial use, contributing to the rational use of cassava and to the improvement of the diet of local populations.

In Nampula province, cassava is not only a food base, but also a raw material for emerging agro-industrial chains, such as the production of flour, starch and fermented beverages, including cassava beer, which reinforces its regional economic value. However, there are still few systematic studies that comparatively characterize the physicochemical and nutritional properties of locally cultivated varieties, limiting the definition of appropriate varietal selection strategies for human consumption and industrial use.

In this context, it is essential to generate scientific evidence that allows understanding the differences between cassava varieties grown in Nampula, contributing to the choice of safer, more nutritious and suitable materials for processing. Thus, the present study seeks to fill this gap by evaluating physicochemical and nutritional parameters of local varieties, with a view to strengthening food security, adding value to agricultural production and supporting sustainable rural development policies in Mozambique. Regional studies on plant resources emphasize that valuing traditional knowledge through scientific validation is fundamental, especially in contexts with limited access to technical and laboratory services (ROSA et al., 2025a). Such an approach has been successfully applied in phytochemical research of medicinal plants, which uses systematized methodologies for sample preparation and identification of bioactive compounds (ROSA et al., 2025b), and can also strengthen the understanding of the physicochemical and nutritional properties of strategic food crops such as cassava.

2 THEORETICAL FRAMEWORK

2.1 BOTANY, ORIGIN AND DISPERSION OF CASSAVA CULTURE

Cassava (*Manihot esculenta* Crantz) is a plant belonging to the Euphorbiaceae family, characterized as a perennial shrub, of variable size, with a woody stem, palmatilobed leaves, and starch-rich tuberous roots (SHILING, 2024; SILVA, 2019). The cassava can be divided into an aerial part composed of stems, petioles and leaves and an underground part, formed by tuberous roots. In mature plants, it is estimated that the biomass is distributed in approximately 50% tuberous roots, 40% stems and petioles, and 10% leaves (SILVA, 2020; ALVES & SETTER, 2004). This proportion, however, can vary according to the variety and edaphoclimatic conditions of the crop.

A fundamental aspect in the classification of varieties is the content of hydrocyanic acid (HCN), a toxic compound derived from the cyanogenic glucosides present in the plant. Cassava is traditionally classified as "tame" or "wild": the former have an HCN content of less than 50 mg per kg of fresh root, and are safe for human consumption after minimal processing; the "bravas", also called bitter or poisonous, have a content higher than 100 mg/kg, requiring rigorous detoxification techniques before consumption and are often intended for industrial use, such as in the production of starch and bioethanol (DA SILVA MARTINS, 2018; SILVA, 2018).

The dispersion of the crop occurred mainly during the period of Portuguese and Spanish navigations, from the sixteenth century onwards, when cassava was introduced in Africa and Asia as a food alternative resistant to drought and poor soils (FERRÃO, 2013; DA COSTA NUNES, 2018). In Mozambique, the crop quickly adapted to local soil and climatic conditions, becoming the food base of many rural communities. Thus, the above leads us to argue that cassava is a paradigmatic example of how a crop originating in the Americas became central to food systems outside its original cradle.

2.2 CASSAVA VARIETIES GROWN IN NAMPULA PROVINCE

The province of Nampula has a high diversity of cassava varieties, as a result of the interaction between improved materials and local varieties (landraces). Among the widely cultivated varieties are: Nikwaha (interior of Nampula), Orrera (variety recently released by IIAM), Amwaali campiinxe, Badje, Mokhalana, Napirithe, Nziva and Técnico.

In addition to these, studies carried out by IIAM and agricultural development projects identify other local and improved varieties, such as Chinhembwe, Kakala, Muchele, Muali, Xitsekele, Kalima, TMS 60444, TMS 98/0581 and Sauti, mainly used in rural areas for fresh consumption, flour processing and rale production (IIAM, 2022).

This varietal diversity suggests that farmers select cassava based on criteria such as yield, drought resistance, starch content, taste, and ripening time. In view of the above, it is concluded that the genetic variability of cassava in Nampula is high and constitutes a strategic resource for food security. In this context, the present study specifically addresses the Badje, Mokhalana, Napirithe, Nziva and Técnico varieties, due to their productive representativeness and local consumption.

2.3 PHYSICOCHEMICAL COMPOSITION OF CASSAVA

Cassava's physicochemical composition is dominated by high water content (50-70%), starch (20-45%), low protein and lipid content, as well as minerals and bioactive compounds such as carotenoids (SOUZA, 2024; DE OLIVEIRA, 2007). The total solids and starch content is decisive for the industrial yield of cassava (SOUZA, 2024).

The main physicochemical parameters evaluated include pH, titratable acidity, moisture, ash, total solids and cyanide content. pH and acidity indicate stability and susceptibility to spoilage; humidity influences texture and conservation; the ash reflects the mineral content; and cyanides determine safety for consumption (SILVA, 2009).

As for the nutritional composition, β-carotene stands out, an essential provitamin A in diets with a deficiency of this micronutrient. Studies conducted by BERNI, 2014 and FACUNDES, et al., 2021 observed that biofortified varieties may have significantly higher levels of β-carotene, contributing to the reduction of hypovitaminosis A.

2.4 INFLUENCE OF CULTIVATION CONDITIONS AND ENVIRONMENT ON PHYSICOCHEMICAL CHARACTERISTICS

The physicochemical and nutritional characteristics of cassava do not depend exclusively on the genetic material, but are strongly influenced by environmental and cultivation conditions, such as soil type, water regime, temperature, agronomic practices, harvest age and soil fertility. The cultivation environment has a direct influence on the dry matter, acidity and cyanogenic compounds content of cassava (SOUSA, 2024). As reported in nutritional studies of staple foods marketed in Nampula, foods of high nutritional value are essential for the food security of Mozambican populations (ROSA et al., 2025a).

2.5 CASSAVA QUALITY PARAMETERS

The quality of cassava is evaluated by a set of physical, chemical and nutritional parameters, which allow inferring its suitability for human consumption and industrial processing.

2.5.1 Titratable acidity and pH

Titratable acidity indicates the total amount of acids present in the root and is associated with fermentation, conservation and microbiological stability. High acidity values indicate greater metabolic activity and possible beginning of deterioration. The pH, in turn, complements the acidity, values between 6.0 and 7.5 are common in fresh cassava. Studies carried out by CHISTÉ & COHEN, 2011, affirm that cassava roots, before the fermentation stage, presented an acidity of 1.37 cmol $^{NaOH.kg-1}$ (0.0548%) $^{\text{and after 96 hours of fermentation the total acidity increased to 1.56 cmol}}$ NaOH.kg-1 (0.0624%). The analyses of cassava titrable acidity carried out by DE LUNA, et al, 2013, found a content of 1.4±0.57.

2.5.2 Total moisture and solids

It refers to the amount of water in the fresh root, usually between 50% and 70%. High humidity (>65%) is associated with shorter shelf life and a higher risk of rot, but can facilitate starch extraction. On the other hand, lower values (<55%) indicate higher dry matter content, favoring industrial yield. In the study carried out by CENI, et al., 2009, the moisture content found ranged from 64 to 70 g/100g. DE LUNA, et al, (2013), found in their research a content of 35.31±4.74% in their cassava samples.

"The total solids indicate the dry fraction of the cassava (100%-moisture) and are directly related to the starch content. High total solids (>35% on a dry basis) indicate a high starch content, essential for industry. In the research carried out by CENI, et al., 2009, in five cultivars (BRS Rosada, Casca Roxa, BRS Dourada, BRS Gema de Ovo and Saracura) of cassava (*Manihot esculenta Crantz*) *in natura*, it varied from 30 to 36 g/100g.

2.5.3 Ashes

They represent the mineral residue after incineration (550 °C), indicating the content of minerals (calcium, potassium, magnesium, iron). Typical values range from 0.5% to 6.0%. Research conducted by DE LUNA, et al (2013), found ash content of 1.35±0.29.

2.5.4 Cyanide

"The cyanide content is one of the main indicators of food security. Measured as HCN (mg/kg), cyanides are toxic antinutritional compounds. Levels < 50 mg/kg classify the variety as "tame"; >100 mg/kg, as "brava". Thus, levels above the recommended limits represent a toxicological risk if cassava is not properly processed" (BARRONCAS, 2020). Research carried out by BORGES, FUKUDA & ROSSETTI (2002) found a content ranging from 22.33 to 90.00 mg/kg in ten samples analyzed by the titration method.

2.5.5 Carotenoids

Carotenoids, especially β-carotene, are fundamental because they are precursors of vitamin A. Studies have shown that varieties with higher levels of β-carotene contribute to reducing nutritional deficits in vulnerable populations. Lycopene, although less abundant, also has antioxidant properties (GAINO, 2012). Studies carried out by DE OLIVEIRA (2009), of the 28 hybrids evaluated showed β-carotene content between 7 and 10 μg/g of fresh cassava.

In view of the above considerations, it is concluded that each physicochemical and nutritional parameter provides a specific dimension of cassava quality, and its interpretation must be contextualized as to the intended use, whether food, nutritional or industrial.

2.6 CASSAVA CULTIVATION IN AFRICA AND MOZAMBIQUE

The African continent is the world's largest producer of cassava, accounting for more than half of global production. According to FAO (2022), Nigeria and the Democratic Republic of Congo contribute about 50% of African production, while the remaining 37 producing countries account for the remaining volume (p. 23). This means that production is concentrated, but the culture is widely disseminated.

Although rice is the staple food of many African populations, cassava is cultivated as a complementary food and strategic reserve in times of scarcity. In Mozambique, "cassava is more widespread in the northern region, being consumed fresh or dried in the form of *makhaka*, as well as in the preparation of *xima* and traditional drinks".

Cassava is the main staple food in four provinces Nampula, Zambezia, Cabo Delgado and Inhambane and more than 1.2 million rural households depend on this crop, with about 43% concentrated in Nampula province. This province ranks first in national production, also standing out for the industrial use of cassava, as in the case of Impala beer (IIAM, 2022). Thus, the above leads us to argue that cassava is simultaneously a food, cultural and economic pillar in Mozambique.

3 METHODOLOGY

3.1 TYPE OF STUDY

This is an applied research, with a quantitative approach, with an experimental and descriptive design, as it seeks to characterize the physicochemical and nutritional properties of different varieties of cassava cultivated in the province of Nampula, Mozambique. The experimental part was adopted to allow the direct measurement of laboratory parameters, while the descriptive character allowed the interpretation of the variations observed among the varieties analyzed.

3.2 SAMPLE SELECTION

The study was conducted in the province of Nampula, Mozambique, a region of high productive relevance and consumption of cassava. Samples were taken from five local varieties: Badje, Mokhalana, Napirithe, Nziva and Técnico. The samples consisted of mature tuberous roots (10-12 months after planting), collected from agricultural plots of different producers in the districts of Nampula.

For each variety, 15 healthy and homogeneous roots were collected, totaling 75 samples. The selection followed criteria of physiological maturity, absence of physical damage and geographical representativeness, ensuring environmental diversity within the province. After collection, the samples were packed in thermal boxes and transported to the laboratory for immediate analysis.

In the laboratory, the roots were washed under running water to remove impurities, peeled manually with stainless steel blades and crushed in an electric processor. The homogeneous pulp obtained was packed in airtight containers and used for the physicochemical analyses.

3.3 PARAMETERS ANALYZED

The physicochemical and nutritional analyses were conducted at the Laboratory of Agri-Food Analysis of Rovuma University, following internationally recognized methodologies:

Total moisture and solids: drying in an oven at 105 °C to constant mass (AOAC, 2002).

Ash: incineration in muffle furnace at 550 °C up to constant weight (AOAC, 2002).

pH: direct reading in calibrated digital pH-meter.

Titratable acidity: acid-base titration with 0.1 N NaOH and phenolphthalein indicator

Total cyanide: argentometric titration after hydrolysis of cyanogenic glycosides

β-carotene and lycopene: acetone extraction and spectrophotometric reading at 450 nm and 472 nm, respectively.

All analyses were performed in triplicate, ensuring data reproducibility.

3.4 STATISTICAL TREATMENT AND ANALYSIS

The data obtained were organized in Excel and later submitted to statistical treatment using the Statgraphics statistical package (version 18). Then, analysis of variance (ANOVA-one-way) was applied to verify the existence of statistically significant differences between the means of the varieties studied. When significant differences were identified ($p < 0.05$), the LSD (Least Significant Difference) multiple means comparison test was performed at a 95% confidence level

3.5 ETHICAL CONSIDERATIONS

The collection of samples was carried out with the prior consent of the farmers, respecting the traditional knowledge associated with the local varieties. The study had an exclusively academic purpose, without commercial exploitation of the samples.

4 RESULTS AND DISCUSSIONS

4.1 PHYSICOCHEMICAL AND NUTRITIONAL CHARACTERIZATION OF CASSAVA

Table 1

Mean (and standard deviation), minimum and maximum moisture values, Ash, pH, Cyanide, β - Carotene, Total Solids, Lycopene and Titratable Acidity of the samples of five cassava varieties (Badje, Mokhalana, Napirithe, Nziva and Técnico) from Nampula, Mozambique. ANOVA results (F-ratio and significant differences) obtained for the "province" factor for each variable.

Parâmetros	Variedade de mandioca															
	Badje			Mokhalana			Napirithe			Nziva			Técnico			Total
	Média (Desp)	Mín	Máx	Média (Desp)	Mín	Máx	Média (Desp)	Mín	Máx	Média (Desp)	Mín	Máx	Média (Desp)	Mín	Máx	*Razão F*
Humidade (%)	51.91 (1.54) ^{A}	50.81	53.68	56.97 (6.04) ^{AB}	58,0	60,6	58.35 (0,96) ^{B}	57.78	59.46	55,48 (0,38) ^{AB}	55,04	55,7	56.78 (0,82) ^{AB}	56.20	57.36	1,99^{ns}
Cinzas %	4.91 (0,60) ^{B}	4,54	5,60	1.06 (0,08) ^{A}	0,97	1,13	5.08 (0,53) ^{B}	4,48	5,5	1.25 (0,13) ^{A}	1,17	1,4	4,36 (0,52) ^{B}	3,99	4,73	66,2***
pH	6,76 (0,01) ^{A}	6,75	6,77	7.79 (0,15) ^{B}	7,64	7,95	6.64 (0,01) ^{A}	6,63	6,64	7,78 (0,05) ^{B}	7,73	7,82	6,7 (0,0) ^{A}	6,7	6,7	174,8***
Cianeto (mg/kg)	4.65 (0,02) ^{B}	4,64	4,67	3.85 (0,12) ^{A}	3,72	3,92	4.86 (0,13) ^{B}	4,78	5,01	3.70 (0,48) ^{A}	3,19	4,15	5.09 (0,02) ^{B}	5,08	5,11	17,9***
β - Caroteno (µg/g)	8.88 (1.55) ^{AB}	7.90	10.67	7.69 (1.37) ^{A}	6,77	9,27	10.11 (0,64) ^{AC}	9.37	10.51	11.52 (0,15) ^{C}	11,35	11,64	20.81 (0,27) ^{D}	20.61	21,0	57,1***
Sólidos Totais	4.52 (0,04) ^{A}	4.47	4.55	4.53 (0,08) ^{A}	4.46	4.61	4.47 (0,01) ^{A}	4.45	4.48	4.55 (0,05) ^{A}	4.52	4.61	4.49 (0,02) ^{A}	4.48	4.51	1,15^{ns}
Licopeno (µg/g)	7.27 (0,51) ^{AB}	6.95	7.86	6.99 (0,09) ^{A}	6.89	7.07	10.69 (0,45) ^{D}	10.29	11.18	9.02 (0,12) ^{C}	8.89	9.12	7.90 (0,81) ^{B}	7.33	8.47	37,5***
Acidez titulavel	4,15 (0,17) ^{A}	3,97	4,32	7.04 (0,09) ^{C}	6,99	7,15	3.94 (0,07) ^{A}	3,88	4,02	5,5 (0,25) ^{B}	5,23	5,72	7.97 (0,08) ^{D}	7,91	8,02	329,0***

*p < 0.05; **p < 0.01; p < 0.001. For each factor, there was no statistically significant difference and different letters on the lines indicated homogeneous groups (significant differences at the 95% confidence level obtained by the LSD test).

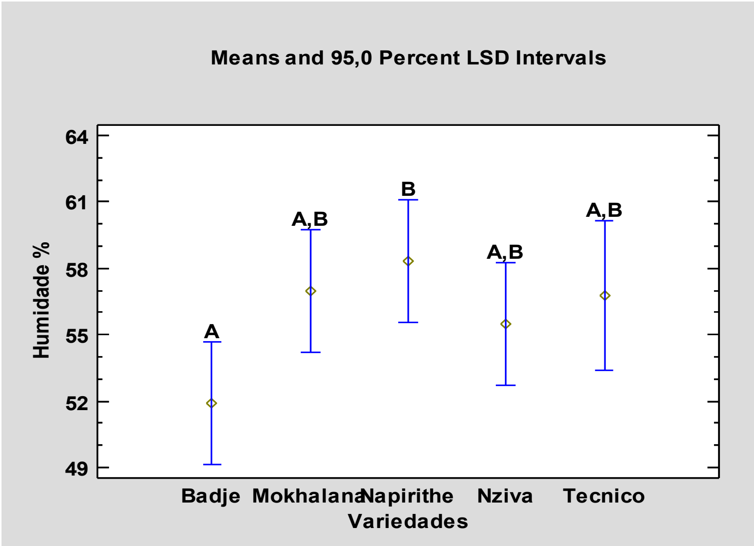
4.2 MOISTURE CONTENT

Regarding humidity, the values ranged between 51.91% (Badje) and 58.35% (Napirithe), with no statistically significant differences (ns), as shown in table 01 and graph 01. This range is compatible with the values reported for fresh cassava under different genotypes, growing conditions, where moisture is often remains close to 50-65 % and can fluctuate with ripeness, soil and management. This result suggests that Napirithe has greater water retention in the tissues, which may be associated with a less dense cell structure or a higher content of gelatinized starch, directly influencing the drying time and stability of the final product.

DE LUNA, et al. (2013) evaluated the composition of cassava and found a moisture content of 35.31±4.74%, a value much lower than that found in this research, while CENI et al. (2009) evaluated the centesimal composition of five varieties of cassava and observed moisture content from 64.0% to 70.0%, results different from those found in this study.

Figure 1

Moisture content in the cassava samples analyzed



Source: Authors, 2025

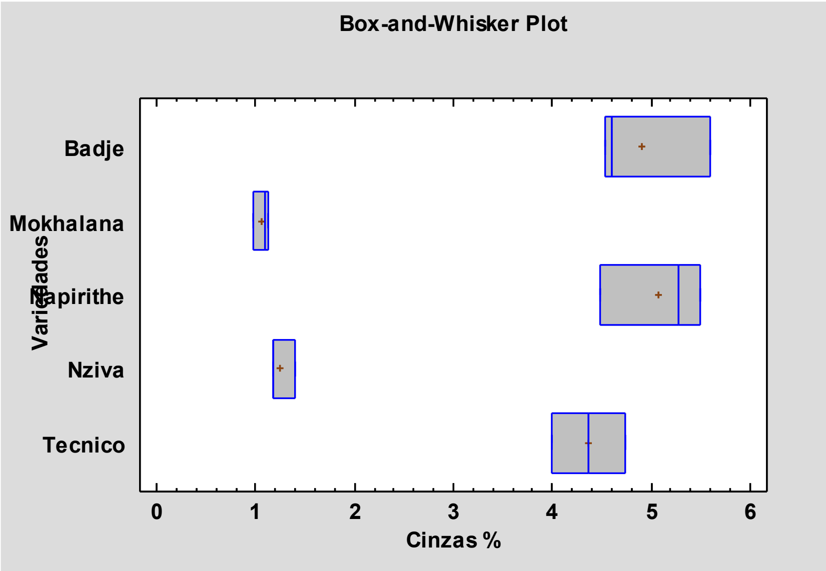
4.3 ASH CONTENT

There were highly significant differences for ash (p <0.001), where the Napirithe variety had the highest ash content (5.08%), followed by Badje (4.91%) and Técnico (4.36%) indicating the highest mineral concentration. On the other hand, Nziva (1.25 %) and Mokhalana (1.06%) showed low levels (graph 02), suggesting a lower density of micronutrients, possibly due to edaphoclimatic factors or different agricultural practices. The ash content values of Napirithe, Badje and Técnico are higher than those shown by DE OLIVEIRA (2007), studying fresh roots of table cassava varieties, cultivated in the organic system (1.67% to 1.27%) and close to those of Nziva and Mokhalana.

For DE LUNA et al. (2013), they reported ash levels of 1.35 ± 0.29% in sweet varieties of cassava acquired at two different points between street markets and markets in the city of Juazeiro do Norte. This value is very close to that found in Mokhalana (1.06 %) and N'Ziva (1.25 %), as illustrated in table 01, suggesting similarity in terms of mineral content.

Figure 1

Ash content per sample



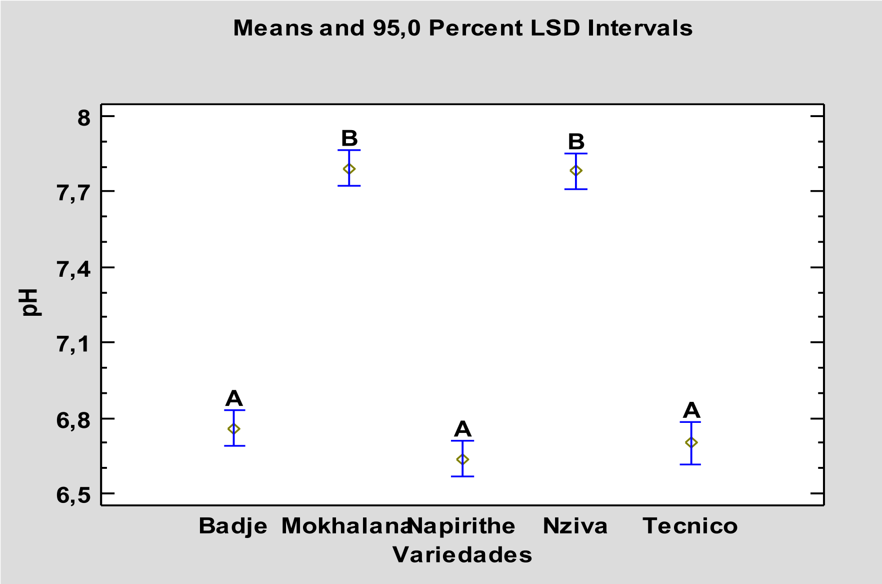
Source: Authors, 2025

4.4 PH

The pH ranged from 6.46 (Nziva) to 7.64 (Mokhalana), as shown in figure 03, revealing significant differences (F=174.88). The Mokhalana variety had the highest pH value, indicating a less acidic pulp, while Nziva had the lowest pH, denoting higher acidity. This variation may have technological implications, since the higher pH favors the stability of certain compounds, while the lower pH is related to better microbiological conservation. Similar results were found with LUNA et al. (2013), the pH of sweet cassava varieties in Brazil presented average values of 7.09±0.25. In fresh cassava, pH close to neutrality is common; in fermented products the pH tends to drop and acidity to rise due to the formation of organic acids. Therefore, pH differences between varieties may be related to tissue composition (available sugars, mineral buffer) and harvest/storage conditions, and also have implications for **microbiological stability** and behavior in fermentation processes.

Figure 2

pH levels in cassava samples



Source: Authors, 2025

4.5 CYANIDES CONTENT

The cyanide content showed significant differences between the varieties ($p < 0.001$), as shown in table 01, indicating the influence of the genotypic factor on the concentration of cyanogenic compounds. It was observed that the Técnico variety had the highest content (5.09 mg/kg), followed by Napirithe (4.86 mg/kg) and Banje (4.65 mg/kg) while Badje had the lowest value (3.70 mg/kg) and Mokhalana (3.85 mg/kg), as shown in graph 04.

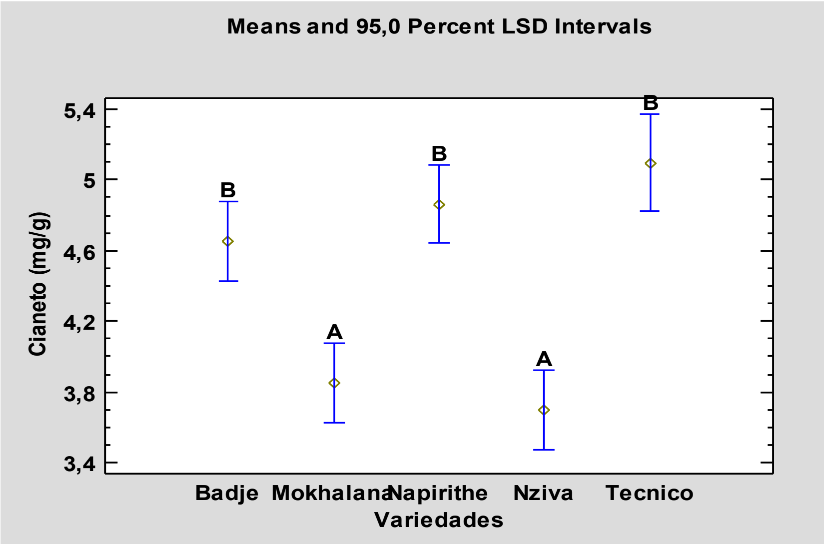
A study carried out by BORGES, FUKUDA & ROSSETTI (2002) found levels higher than those found in this research, values ranging from 22.33 to 90.00 mg/kg, in ten samples analyzed by the titrametric method.

Additionally, research carried out by CHICOVELA, et al., (2025) when evaluating the cyanide content in dried and ground cassava leaves, observed that the Fernando Boa variety had the highest content (2.253 mg/kg), followed by A. Kampwiche (1.720 mg/kg) and Nassuruma (1.473 mg/kg). The cyanide content found in cassava leaf flour ranged from 1.473 to 2.253 mg/kg, values considerably below the maximum recommended limit for food safety.

In all cases, the samples in this study are within the standards required by the WHO (2021), the cyanide content in fresh cassava intended for human consumption should not exceed 10 mg/kg, since higher concentrations can cause acute cyanide poisoning, characterized by nausea, vomiting, and weakness, and, in chronic exposures, neurological disorders such as konzo. Thus, although the values found in the present study remain below the maximum recommended limit, the variability observed between varieties reinforces the need to adopt appropriate processing practices (peeling, fermentation, drying and cooking) to ensure food safety.

Figure 3

Cyanide levels found per sample



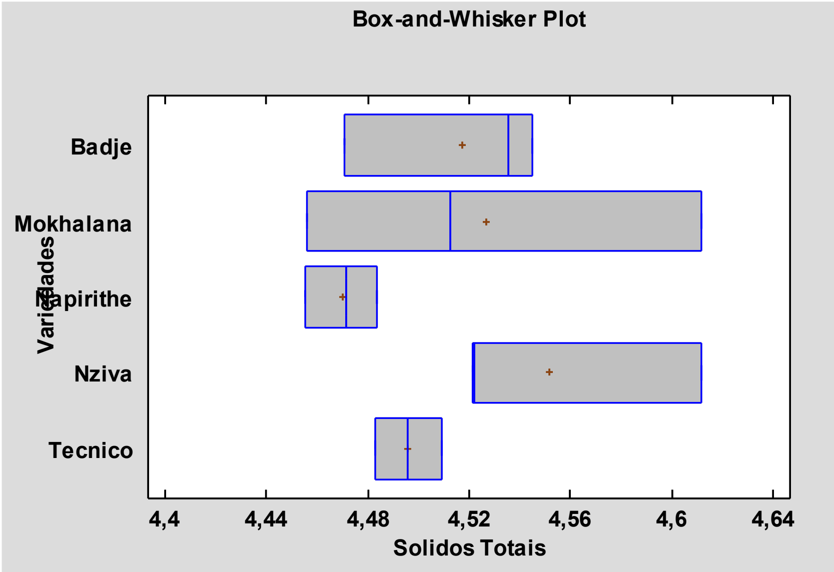
Source: Authors, 2025

4.6 TOTAL SOLIDS CONTENT

The total solids did not show significant difference (ns), indicating relative uniformity between varieties. Such homogeneity indicates that the solid content, composed mainly of starch and fibers, remained stable among the varieties, suggesting a similar structural composition. In food technology, total solids/dry matter are fundamental indicators for **flour and starch yield,** in addition to being associated with texture and culinary acceptance; recent literature widely discusses the importance of dry matter as a selection and quality criterion (BILATE DAEMO et al., 2024). The levels found in this study were lower than those found by CENI, et al., (2009), in five cultivars (BRS Rosada, Casca Roxa, BRS Dourada, BRS Gema de Ovo and Saracura) of cassava (*Manihot esculenta Crantz*) *in natura*, ranging from 30 to 36 g/100g

Figure 5

Average Findings for Total Solids



Source: Authors, 2025

4.7 B-CAROTENE CONTENT

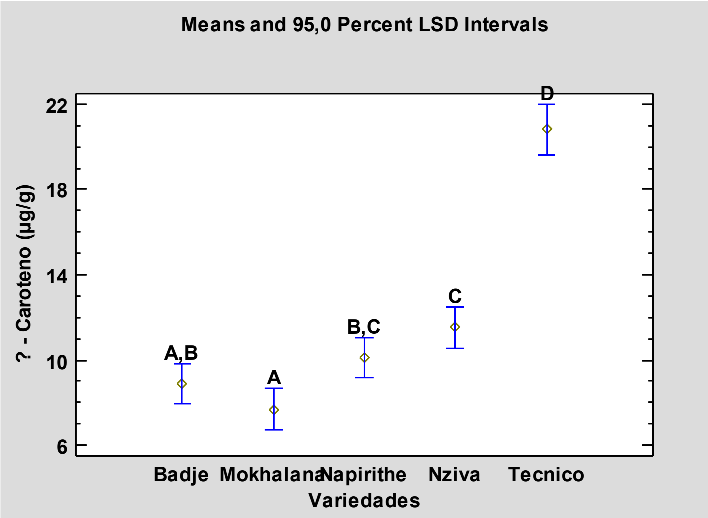
With regard to β-carotene, a precursor pigment of vitamin A, the results show substantial differences (F=57.11). The highest content was observed in the variety Técnico (20.81 μg/g), followed by Nziva (11.52 μg/g), while Mokhalana (7.69 μg/g) presented the lowest value (table 02 and graph 06).

Approximate levels were found by DE OLIVEIRA (2009) who evaluated 28 hybrids and presented β-carotene content between 7 and 10 μg/g of fresh cassava.

Similar to what was observed for carrots, where soil and management factors explained significant variations in carotenoid levels (ROSA et al., 2026), the results of this study indicate that agricultural practices can modulate the physicochemical composition of cassava.

Figure 6

β-carotene levels per sample



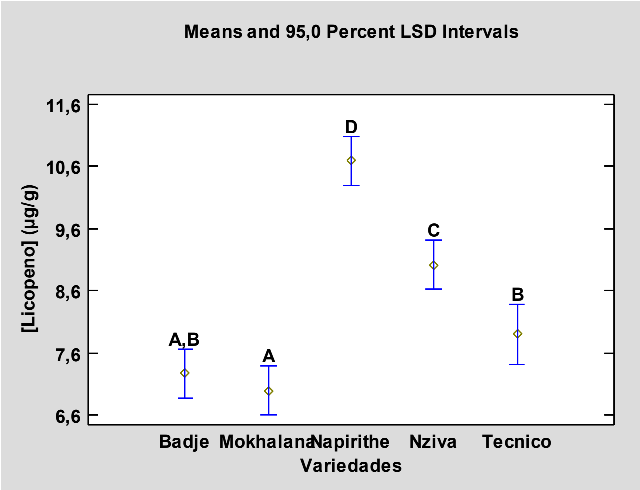
Source: Authors, 2025

4.8 LYCOPENE CONTENT

In the lycopene parameter, an antioxidant pigment of high nutritional relevance, the variety Napirithe (10.69 µg/g) presented the highest content, followed by Nziva (9.02 µg/g) while Mokhalana (6.99 µg/g) showed the lowest value (graph 07). The differences were significant (F=37.58), showing greater antioxidant capacity of the Napirithe variety (table 02), which may be related to genetic characteristics or the physiological state of the roots at the time of harvest. For Silva et al. (2014), in a study carried out on cassava in the Branca, Amarela and Rosada varieties, lycopene values ranging from 0.01 to 19.47% in the three varieties studied, these results are different from those found in this research. The need for public policies to improve the quality and preservation of staple foods has been highlighted in regional studies, highlighting the importance of interventions along the value chain (ROSA et al., 2025a).

Figure 4

Lycopene Values Findings



Source: Authors, 2025

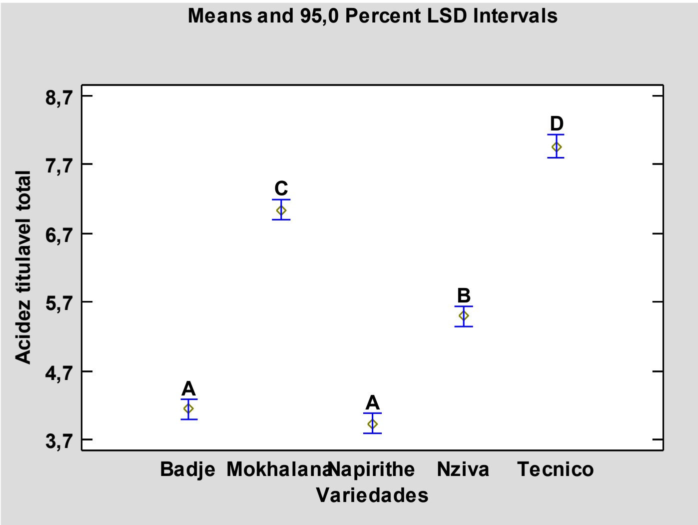
4.9 ACIDITY CONTENT

Finally, the titratable acidity showed significant variations (F=329.00), with the highest value found in the Técnico (7.97%) and Mokhalana (7.04%) varieties, the lowest was found in Napirithe (3.94%), as shown in table 02. This behavior demonstrates an inverse relationship with pH, where higher acidity corresponds to lower pH value, reflecting metabolic differences in the accumulation of organic acids.

CHISTÉ & COHEN (2011) reported mean RTA values of 0.0548%.The analyses of cassava titratable acidity made by DE LUNA, et al, (2013), found a content of 1.4±0.57, these contents are very low than that found in this study.

Figure 5

Total Titratable Acidity Content



Source: Authors, 2025

5 CONCLUSION

The present study allowed the physicochemical and nutritional characterization of five cassava varieties (Badje, Mokhalana, Napirithe, Nziva and Técnico) cultivated in the province of Nampula, Mozambique, showing significant differences between the genotypes for most of the parameters evaluated. Although the moisture and total solids did not present statistically significant variation, the contents of ash, pH, cyanide, β-carotene, lycopene and titratable acidity differed in a highly significant way, demonstrating the influence of the varietal factor on the composition of the roots.

The varieties Badje, Napirithe and Técnico stood out for their higher ash content, indicating greater mineral potential. The variety Técnico had the highest content of β-carotene, suggesting special nutritional interest as a source of provitamin A, while Napirithe and Nziva had higher levels of lycopene, reinforcing the antioxidant potential of these varieties. On the other hand, cyanide levels varied among the varieties, underscoring the importance of proper processing to ensure food safety.

In general, the results demonstrate that there is relevant physicochemical and nutritional diversity among the local varieties of cassava cultivated in Nampula, which opens perspectives for the **targeted selection of genotypes** according to the objective of use, whether for direct consumption, industrial processing or nutritional improvement. Thus, the valorization and scientific characterization of these varieties contribute to programs for improvement, food security and technological use of cassava in Mozambique.

REFERENCES

Alves, A. A. C., & Setter, T. L. (1990). Fisiologia da mandioca (2ª ed.). Embrapa.

Alves, R. M. V. (2021). Mandioca: da botânica à aplicação industrial (2ª ed.). Viçosa: UFV.

Barroncas, S. C. (2020). Quantificação de cianeto em alimentos amazônicos como ferramenta para análise de risco.

Berni, P. R. D. A. (2014). Biodisponibilidade de beta-caroteno em mandiocas e batatas-doces biofortificadas (Tese de doutorado). Universidade de São Paulo.

Bilate Daemo, B., et al. (2024). Genetic variation and determination the optimal crop age for harvest in cassava (Manihot esculenta Crantz). Cogent Food & Agriculture, 10(1), 2355991.

Borges, M. D. F., Fukuda, W. M. G., & Rossetti, A. G. (2002). Avaliação de variedades de mandioca para consumo humano. Pesquisa Agropecuária Brasileira, 37, 1559–1565.

Ceni, G. C., Colet, R., Peruzzolo, M., Witschinski, F., Tomicki, L., Barriquello, A. L., & Valduga, E. (2009). Avaliação de componentes nutricionais de cultivares de mandioca. Alimentos e Nutrição, 20(1), 107–111.

Chisté, R. C., & Cohen, K. D. O. (2011). Influência da fermentação na qualidade da farinha de mandioca. Acta Amazonica, 41, 279–284.

Codex Alimentarius Commission. (1989). Standard for edible cassava flour (Codex Stan 176-1989). FAO/WHO.

Da Costa Nunes, E., Peruch, L. A. M., Moreto, A. L., Massignan, Â. M., Pola, A. C., Marchesi, D. R., et al. (2018). Recomendações técnicas para a produção de mandioca. Sistemas de Produção, (51).

Da Silva Martins, P. (2013). Quantificação de cianeto total em farinhas de mandioca.

De Oliveira, L. A. (2007). Composição físico-química de variedades de mandioca. Revista Raízes e Amidos Tropicais, 3.

De Oliveira, L. A., Kimura, M., Pereira, M. E. C., Fukuda, W. M. G., & Da Silveira Júnior, P. B. (2009). Avaliação de carotenoides e compostos cianogênicos. Revista Raízes e Amidos Tropicais, 5, 805–809.

Fagundes, G. A., Pinto, N. S., Severo, J., Michelotti, A. A. H., & Walter, M. (2021). Batata-doce biofortificada. Revista de Ciência e Inovação, 7, 1–21.

FAO. (2022). Panorama da produção de mandioca em África. Roma.

FAO/OMS. (2021). Joint FAO/WHO expert consultation on cyanogenic glycosides in cassava. Roma.

Feldsine, P., Abeyta, C., & Andrews, W. H. (2002). AOAC guidelines. Journal of AOAC International, 85(5), 1187–1200.

Ferrão, J. E. M. (2013). Intercâmbio de plantas entre África e América. Revista de Ciências Agrárias, 36(2), 250–269.

Gaino, N. M. (2012). Estado nutricional e disponibilidade de nutrientes (Tese de doutorado). Universidade de São Paulo.

Instituto de Investigação Agronómica de Moçambique. (2022). Catálogo de variedades melhoradas de mandioca. Maputo.

Luna, A. T., Rodrigues, F. F. G., Costa, J. G. M., & Pereira, A. O. B. (2013). Estudo físico-químico de Manihot esculenta. Revista Interfaces, 1(2).

Mucane, A. M. (2024). Avaliação nutricional da farinha de mandioca.

Nassar, N. M. A., & Hashimoto, D. Y. (2020). Origem e evolução da mandioca (2ª ed.). Brasília: UnB.

Oliveira, E. J., & Pinto, L. R. (2022). Biofortificação da mandioca com pró-vitamina A. Embrapa.

Penteado, M. D. V. C. (2008). Ocorrência de isômeros do beta-caroteno em raízes de mandioca.

Pereira, G. D. C. (2020). Estudo de parâmetros da mandioca no pós-colheita.

Queirós, L. S. S. D. (2023). Aspectos biométricos da planta e produção de mandioca com inoculantes biológicos.

Rosa, P. A. N., Martinho, O. I., Daniel, J., Chale, A., Buma, E. L. L., Jossamo, G. M. C. G., & Lantaruva, G. B. O. (2025a). Avaliação da qualidade do feijão vulgar. Revista Científica ACERTTE, 5(8).

Rosa, P. A. N., Miguel, C. J., Câmara, D. P. D., & Eugénio, B. A. (2026). Avaliação pós-colheita da cenoura. Revista Multidisciplinar do Nordeste Mineiro, 1(1), 1–19.

Rosa, P. A. N., Paulo, M. S., Ernesto, J. T., & Mário, T. A. (2025b). Caracterização fitoquímica e atividade antifúngica. Revista Multidisciplinar do Nordeste Mineiro, 18(2), 1–21.

Shiling, B. B. R. (2024). Ocorrência de plantas daninhas em cultivos de mandioca.

Silva, J. A. D. (2009). Conservação de mandioca minimamente processada.

Silva, R. B. (2020). Crescimento e produtividade da mandioca sob níveis de irrigação.

Silva, R. D. C. C. D. (2018). Subprodutos da mandioca na alimentação de codornas.

Silva, R. M. D. (2019). Componentes da produção e produtividade da mandioca.

Silva, R. M. G., et al. (2014). Atividade antioxidante e compostos bioativos. Bioscience Journal, 556–564.

Souza, A. P. S. D. (2024). Produção e características físico-químicas de raízes e amidos de mandioca.

Chicovela, A. F., et al. (2025). Avaliação das folhas secas de mandioca como suplemento nutricional. Cognitus Interdisciplinary Journal, 2(3), 608–618.