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# QUALITY OF TABLE CASSAVA ROOTS FERTILIZED WITH PHOSPHORUS[1]

FLÁVIO PEREIRA DA MOTA SILVEIRA[2]*, WELDER DE ARAÚJO RANGEL LOPES[3], PEDRO RAMON HOLANDA DE OLIVEIRA[4], FERNANDA LARISSE DOS SANTOS LIMA[5], LINDOMAR MARIA DA SILVEIRA[3], AURÉLIO PAES BARROS JÚNIOR[3]

**ABSTRACT** - The quality parameters of cassava roots vary between cultivars and depend on abiotic factors, such as plant nutrition. However, the magnitude of how these factors interfere is not yet well defined, especially for phosphorus (P), which is a nutrient directly linked to the synthesis of sugars and starches in plants. Thus, the objective of the research was to evaluate the quality of roots of table cassava cultivars fertilized with doses of P in the Brazilian semiarid. The research was carried out at the Rafael Fernandes experimental farm, Mossoró, RN, Brazil, from June 2018 to April 2019. The experimental design used was in randomized blocks, arranged in subdivided plots and with four replications. Doses of P (0, 60, 120, 180 and 240 kg ha$^{-1}$ of $P_2O_5$) were applied in the plots, and in the subplots, the table cassava cultivars (Água Morna, BRS Gema de Ovo, Recife and Venâncio). Firmness, elasticity, titratable acidity, soluble solids, total soluble sugars, starch and cooking were all evaluated. The quality of table cassava roots varied depending on the cultivar and the dose of P. Doses of P between 120 and 240 kg ha$^{-1}$ of $P_2O_5$ increase the starch content and reduce the cooking time of table cassava roots.

**Keywords**: *Manihot esculenta*. Phosphate fertilization. Post-harvest. Physicochemical.

## QUALIDADE DE RAÍZES DE MANDIOCA DE MESA ADUBADAS COM FÓSFORO

**RESUMO** - Os parâmetros de qualidade de raízes de mandioca variam entre cultivares e em função de fatores abióticos, como a nutrição das plantas. Porém, a magnitude com a qual esses fatores interferem ainda não está bem definida, especialmente para o fósforo (P), que é um nutriente diretamente ligado à síntese de açúcares e amido nas plantas. Assim, o objetivo da pesquisa foi avaliar a qualidade de raízes de cultivares de mandioca de mesa adubadas com doses de P no Semiárido brasileiro. A pesquisa foi realizada na Fazenda Experimental Rafael Fernandes, Mossoró, RN, Brasil, no período de junho/2018 a abril/2019. O delineamento experimental utilizado foi em blocos casualizados, arranjados em parcelas subdivididas, com quatro repetições. Nas parcelas, foram aplicadas as doses de P (0, 60, 120, 180 e 240 kg ha$^{-1}$ de $P_2O_5$), e nas subparcelas, as cultivares de mandioca de mesa (Água Morna, BRS Gema de Ovo, Recife e Venâncio). Foram avaliadas: firmeza, elasticidade, acidez titulável, sólidos solúveis, açúcares solúveis totais, amido e tempo de cocção. A qualidade das raízes de mandioca de mesa variou em função da cultivar e da dose de P. Doses de P entre 120 e 240 kg ha$^{-1}$ de $P_2O_5$ proporcionam aumento no teor de amido e redução do tempo de cocção de raízes de mandioca de mesa.

**Palavras-chave**: *Manihot esculenta*. Adubação fosfatada. Pós-colheita. Físico-química.

[*]Corresponding author
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[2]Specialized Academic Unit in Agricultural Sciences, Universidade Federal do Rio Grande do Norte, Macaíba, RN, Brazil; flaviopms@hotmail.com – ORCID: 0000-0001-6324-1053.
[3]Department of Agronomic and Forest Sciences, Universidade Federal Rural do Semi-Árido, Mossoró, RN, Brazil; welder.lopes@hotmail.com – ORCID: 0000-0002-9380-6710, lindomarmaria@ufersa.edu.br – ORCID: 0000-0001-9719-7417, aurelio.barros@ufersa.edu.br – ORCID: 0000-0002-6983-8245.
[4]Zootechnics Department, Universidade Federal do Ceará, Fortaleza, CE, Brazil; ramon.holanda96@gmail.com - ORCID: 0000-0001-5807-9610.
[5]Department of Agronomy, Universidade Federal Rural de Pernambuco, Recife, PE, Brazil fernandalarisse17@gmail.com – ORCID: 0000-0002-6989-2671.

# INTRODUCTION

Cassava is a perennial vegetable species that belongs to the Euforbiáceas family and is native to South America (LI et al., 2010). Grown as an annual in tropical and subtropical regions, its main product is tuberous roots, which are among the seven most cultivated agricultural crops in the world (FAOSTAT, 2017).

Cassava has a diversified purpose but it is customary to segment its use into table manioc and manioc for industry (CARDOSO; GAMEIRO, 2006). Table manioc is commercialized in natura, minimally processed or processed as precooked, frozen or in the form of pasta (AGUIAR et al., 2011). Therefore, it is necessary to improve not only the productive performance, but also to associate it with gains in quality to meet the sensory and technological requirements of the consumer (MENEZES et al., 2019).

The quality parameters of cassava roots vary depending on the genotypes, the time of harvest, the type and fertility of the soil and meteorological variations (LORENZI, 1994; BORGES; FUKUDA; ROSSETTI, 2002; OLIVEIRA; MORAES, 2009; SILVA et al., 2014; PEDRI et al., 2018).

Table cassava cultivars must have a low content of hydrocyanic acid (<50 mg kg$^{-1}$ of root), reduced cooking time, flavor, plasticity, viscosity, an absence of fibers, good peelablity and the size and shape of the roots in the molds required by the consumer market (FUKUDA; SILVA; IGLESIAS, 2002). The selection and improvement in the management of cultivars with these attributes are necessary to expand the offer of products with better characteristics of root quality (BORGES; FUKUDA; ROSSETTI, 2002).

Research has shown the effect of plant nutrition on cassava productivity (MUNYAHALI et al., 2017; MACALOU; MUSANDU; MWONGA, 2018; MUOJIAMA et al., 2018), but these effects have not been evaluated for root quality. This is particularly true for phosphorus (P), which is a nutrient that provides an increase in the biomass production of the aerial part and in the yield of the roots (OMONDIA et al., 2019). As reported by Baset Mia (2015), in general, the most important function of P for plants is the transfer or storage of energy. Phosphate-containing compounds are the energy deposits required for the synthesis of simple sugar, as well as for the synthesis of starch. In contrast, the issues involving the sorption of P in tropical soils are well documented (VINHA et al., 2021) and it is necessary to increase these doses in order to make P available for use by plants.

Some studies have limited the relationship between P and the increase in starch content; for example, Burgos and Cenóz (2012), who found an increase in the content of cassava starch with P doses of 23.19 and 46.40 kg ha$^{-1}$ in soil with 2.27 mg dm$^{-3}$ of P. However, these results are limited and require better verification and reproduction with a greater number of cultivars to guarantee more reliable signaling of the effect of the nutrient on these characteristics of the cassava roots.

Thus, the indication of the cultivar with the best quality characteristics associated with a dose of P that, in addition to a satisfactory yield, promotes an improvement in these characteristics, will serve as a subsidy for cassava producers to choose a genotype that offers food with better culinary qualities for consumers. In this sense, the objective of this study is to evaluate the quality of the roots of table cassava cultivars fertilized with doses of P in the Brazilian semiarid.

# MATERIAL AND METHODS

The field experiment was carried out at the Rafael Fernandes experimental farm (5° 03'31.00 "S, 37° 23'47.57" W at an 80 m altitude), belonging to the Federal Rural University of the Semi-Arid (UFERSA), located in the district of Alagoinha, a rural area of the municipality of Mossoró, State of Rio Grande do Norte, Brazil.

The local climatic classification is of the BSh type, according to Köppen (ALVARES et al., 2013), typified as dry and very hot, with a rainy period between the months of February and May, and a dry period that runs from June to January. Meteorological variables of the station present at the experimental farm were collected and the data are shown in Figure 1.

The local soil is classified as typical Dystrophic Red Argisol (RÊGO et al., 2016). For chemical (SILVA, 2009) and physical (DONAGEMA et al., 2011) characterization of the experimental area, soil samples were collected at depths of 0–0.20 and 0.20–0.40 m (Table 1).

The cultivation was carried out in the agricultural year 2018–2019, conducted in a randomized block design, in subdivided plots and with four replications. In the plots, five doses of P (0, 60, 120, 180 and 240 kg ha$^{-1}$ of $P_2O_5$) in planting corresponding to each treatment were applied. These doses were defined based on what is practiced in the region, as well as what would be applied following the recommendation of Silva; Gomes (2008), i.e., 60 kg ha$^{-1}$ of $P_2O_5$. In the subplots, the four table cassava cultivars (Água Morna, BRS Gema de Ovo, Recife and Venâncio) were applied.

The cultivars worked had characteristics that accredited them for local commerce. According to the proposal of Fukuda et al. (2010), the roots had the following morphological descriptors: external color dark brown for all cultivars; cortex color white or cream (BRS Gema de Ovo and Recife) and pink (Água Morna and Venâncio); and pulp color cream (Água Morna), yellow (BRS Gema de Ovo) and white (Recife and Venâncio) (Figure 2).

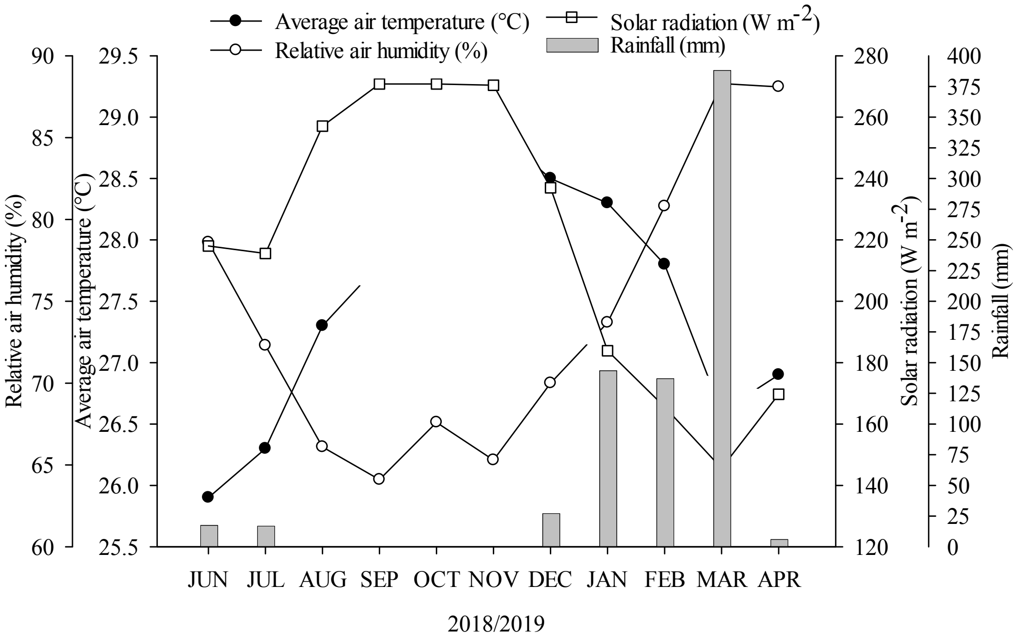


**Figure 1**. Average values of Temperature (ºC), Relative humidity (%), Solar radiation (W $m^{-2}$) and Precipitation (mm) in the agricultural year 2018-2019.

**Table 1**. Chemical and physical analysis of the soil in the experimental area (depths 0-0.20 m and 0.20-0.40m) in the agricultural year 2018-2019.

| Depth | pH | P* | $K^+$ | $Na^+$ | $Ca^{2+}$ | $Mg^{2+}$ | Sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|---|
| m | | ------------mg $dm^{-3}$---------- | | | ----cmolc $dm^{-3}$---- | | -----------kg $kg^{-1}$----------- | | |
| 0-0.20 | 5.90 | 8.3 | 38.9 | 1.2 | 0.80 | 0.50 | 0.91 | 0.02 | 0.07 |
| 0.20-0.40 | 5.50 | 2.0 | 50.8 | 1.2 | 0.70 | 0.20 | 0.88 | 0.03 | 0.09 |

*Extractor: Mehlich-1.

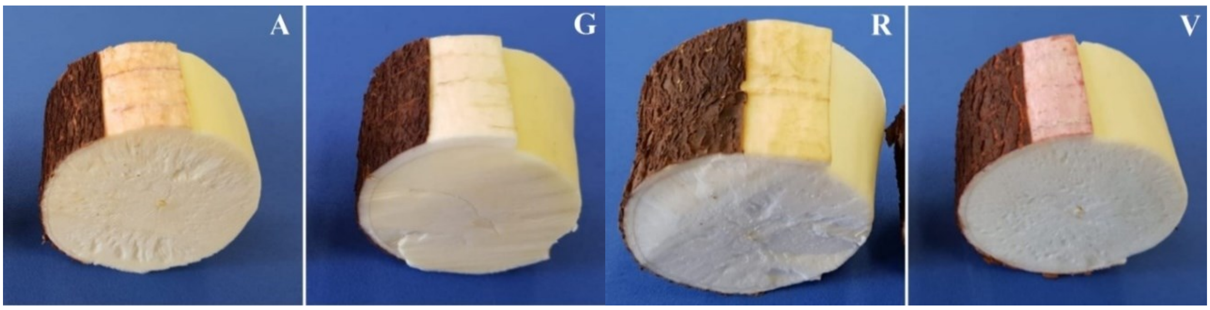


**Figure 2**. Morphological descriptors of the roots of the cassava cultivars of Água Morna (A), BRS Gema de Ovo (G), Recife (R) and Venâncio (V) evaluated in the agricultural year 2018-2019 in the municipality of Mossoró, RN, Brazilian semiarid.

The experimental units consisted of four 6.0 m long planting lines, spaced 1.0 m apart, with an area of 24.0 m² (6.0 m × 4.0 m). As the useful area of the experimental unit, the two central lines were considered, discarding the plants of the upper and lower borders, totaling 9.6 m².

Before the installation of the experiment, soil preparation operations were carried out with heavy harrow to incorporate the remaining plant material in the area and leveling harrow to homogenize the soil surface. Fertilization was carried out following Silva's recommendations; Silva and Gomes (2008) based on soil analysis, with the exception of P, in which treatments were considered, with 30 kg $ha^{-1}$ of nitrogen (N) and 40 kg $ha^{-1}$ of potassium oxide ($K_2O$) applied. As sources of N, P and K, urea (45% N), simple superphosphate (18% $P_2O_5$) and potassium chloride (60% $K_2O$) were used, respectively. The phosphate fertilization was completed entirely in planting. Half of the recommended dose of N was applied at 30 d after emergence of the plants, together with the total dose of K, and at 60 d after emergence, the second half of nitrogen fertilization was applied. N and K were applied via the irrigation system using a bypass tank (“lung”).

An area for multiplication of the seedlings used in the experiment was implemented to homogenize the planting materials of the four cultivars. The area was set up at the Rafael Fernandes experimental farm, 10 months before the installation of the research.

The experiment was planted manually, with a 0.10–0.15 m length and 5–7 buds per hole, at a depth of 0.10 m and with a spacing of 1.00 m between rows for 0.60 m between pits, accounting for a population density of ~16,666.7 plants $ha^{-1}$.

The drip system used was a drip, with emitters spaced at 0.30 m and a flow rate of 1.6 L $h^{-1}$, applying a 4.8 mm daily blade until eight months after planting. Irrigation was calculated using the crop coefficient (Kc) according to the phenological phase. The control of weeds was carried out manually for three seasons, checking the need for the operation, as well as the control of mites, due to the occurrence of this pest, using a commercial product with the active ingredient spiromesifen to control the infestation.

Cassava was harvested 10 months after planting. After harvesting, root samples from each treatment were separated and taken to the growth analysis laboratory and to the post-harvest laboratory for post-harvest evaluation. The roots were peeled and washed to be evaluated.

Initially, the firmness and elasticity of the pulp of the root in natura were determined simultaneously with a texture analyzer (Stable Micro Systems, model TA.XT Express/TA.XT2icon) equipped with a cylindrical tip of 8 mm. The equipment was programmed to insert the tip at a distance of 5 mm, a test speed of 2 mm $s^{-1}$ and 25 g of trigger force. Three readings were performed on three slices cut from the median region of three roots, in the internal region of the pulp. These root blanks were passed through a multiprocessor and from the crushed root mass the following characteristics were analyzed: soluble solids, according to AOAC (2002); titratable acidity following the Zenebon, Pascuet and Tigle (2008); total soluble sugars by the Antrona method described by Yemm and Willis (1954); and starch, according to the methodology adapted from Figueira (2009). The cooking time was evaluated using the fork methodology adapted from Borges, Fukuda and Rossetti (2002), in which three samples of the median region of three roots were cut from each repetition and placed in a pan with boiling water. The timing of the time began and, when it was possible to penetrate the material with the fork without offering resistance, the cooking time was recorded.

The results obtained were subjected to analysis of variance by the F test ($P < 0.05$) using statistical software SISVAR 5.6 (FERREIRA, 2014). For the doses of P, regression was performed using Table Curve 2D software v5.01 (JANDEL SCIENTIFIC, 1991), with the models chosen based on the coefficient of determination and its significance. The graphics were created using SigmaPlot software, version 12.0 (SYSTAT SOFTWARE, 2011). The averages for cassava cultivars were compared using the Tukey test at 5% probability.

# RESULTS AND DISCUSSION

The cultivars Água Morna and BRS Gema de Ovo showed a reduction in the firmness of the root pulp with increasing doses of P (Figure 3A), while the cultivars Recife and Venâncio showed the opposite behavior. The maximum estimated firmness, for the cultivars Água Morna (20.83 N) and BRS Gema de Ovo (14.70 N), was obtained with the treatment without phosphate fertilization, and for the cultivar Recife (19.13 N) with the maximum dose of 240 kg $ha^{-1}$ of $P_2O_5$. For the cultivar Venâncio, there was no adjustment in the regression model; however, the greatest firmness, 19.86 N, was also achieved with the dose of 240 kg $ha^{-1}$ of $P_2O_5$.

The firmness of the pulp is an important attribute in the useful life of agricultural products, as it makes them more resistant to mechanical injuries that can occur during transport and commercialization. It is also an essential characteristic in quality, as it is related to the structure of the fabric (CHITARRA; CHITARRA, 2005). It can suffer alteration of the genetic characteristics of the cultivar, as well as of cultural handling. The loss of firmness is related to the loss of the integrity of the cell membrane and the degradation of the polymeric molecules that make up the cell wall, such as cellulose, hemicellulose and pectin, which generate changes in the cell wall, leading to softening.

Phosphorus (such as phosphate, $PO_4^{-3}$) is an integral component of important compounds in plant cells, including phosphate sugars, intermediates in respiration and photosynthesis, as well as the phospholipids that make up plant membranes. It is also a component of nucleotides used in plant energy metabolism (such as ATP) and in DNA and RNA (TAIZ et al., 2017). In this sense, the behavior observed for root firmness, among cultivars due to phosphate fertilization, may reflect changes intrinsic to the evaluated genotypes.

Evaluating the P doses (40, 80, 120 and 160 kg $ha^{-1}$ of $P_2O_5$) as fresh sweet potatoes, Deus (2019) did not identify any variation in root firmness, with an average of 127.26 N.

The elasticity increased with the doses of P for the cultivars Água Morna and BRS Gema de Ovo, reaching maximum estimated values of -33.33 and -39.77 mm, respectively, with the dose of 240 kg $ha^{-1}$ of $P_2O_5$ (Figure 3B). For the cultivars Recife and Venâncio, although no adjustment was found for regression, the highest values observed, -34.03 and -38.23 mm, respectively, were also achieved with the maximum dose of phosphate fertilizer, suggesting that the increase in carbohydrate content with increased doses of P can make the root more malleable.

The reduction in firmness and the increase in elasticity in the root pulp are behaviors of the desirable physical parameters because they provide better product quality, greater softness, as well as ease of handling, regarding the processing of the root to offer it in another method for adding value.

For titratable acidity, an increasing behavior was observed with increasing P dose, followed by a decrease for the highest doses (Figure 3C). The BRS Gema de Ovo cultivar showed an estimated maximum titratable acidity of 2.65 mEq $H_3O^+$/100 g with a dose of 35.90 kg $ha^{-1}$ of $P_2O_5$. There was no adjustment in the regression models for the cultivars Água Morna, Recife and Venâncio, presenting higher values of titratable acidity of 3.32, 2.20 and 2.60 mEq $H_3O^+$/100 g with doses of 60, 120 and 60 kg $ha^{-1}$ of $P_2O_5$, respectively. Fernandes et al. (2018) evaluated doses of NPK in the quality of parsnip, finding a reduction to titratable acidity with an increase in the supply of nutrients, explaining that this reduction occurs due to the effect of the dilution of these components due to the increase in root size. In contrast, Deus (2019) observed an increase in the titratable acidity of sweet potatoes with doses of P, reaching an estimated maximum of 0.512% with the dose of 125 kg $ha^{-1}$ of $P_2O_5$.

The cooking time decreased with increasing P dose (Figure 3D). The cultivars BRS Gema de Ovo and Venâncio required a longer estimated time for cooking the roots, 39 and 29 min, respectively, with the treatment without phosphate fertilization. The cultivar Recife had the longest cooking time (23 min) with doses of 0 and 60 kg $ha^{-1}$ of $P_2O_5$. In contrast, the cultivar Água Morna, obtained the longest cooking time (32 min) with the dose maximum of 240 kg $ha^{-1}$ of $P_2O_5$. No regression adjustment was found for these two cultivars. Lorenzi (1994) observed a 17-min variation in the cooking of table cassava between soils, with a reduction in time in more fertile soil, illustrating the relationship between plant nutrition and the improvement in this characteristic.

The cooking time sometimes exceeded 30 min, indicated as the ideal maximum time for table manioc with good quality (FUKUDA; SILVA; IGLESIAS, 2002). Oliveira and Moraes (2009) comment that high precipitation in a period before the harvest affects the cooking time of cassava. In soils with low humidity, the osmotic potential at the root is greater, thus favoring the entry of water during the cooking process. From analysis of the meteorological data, it appears that the period before the harvest was marked by intense precipitation (Figure 1), which affected the quality of the root and increased the cooking time.

The variation in the cooking time of cassava roots is due to the influence of internal factors, within the plant itself and between plants of the same genotype, and by external factors, by the variation of the genotype, the type of soil and the time of harvest (LORENZI, 1994).

Phosphate fertilization increased the starch content of the evaluated table cassava cultivars (Figure 3E). The cultivars Água Morna, Recife and Venâncio had maximum estimated starch contents of 26.33%, 25.54% and 26.37% with doses of 240.00, 134.00 and 163.00 kg $ha^{-1}$ of $P_2O_5$, respectively. For the cultivar BRS Gema de Ovo, the maximum starch content observed was 25.41%, with a dose of 120.00 kg $ha^{-1}$ of $P_2O_5$. It is important to note that the cultivar Venâncio required a lower amount of P (60 kg $ha^{-1}$ of $P_2O_5$) to achieve a higher starch content among the evaluated cultivars and that the cultivars BRS Gema de Ovo and Recife were more responsive, presenting greater amplitude in the increase of the starch content with doses of 120 and 60 kg $ha^{-1}$ of $P_2O_5$, respectively.

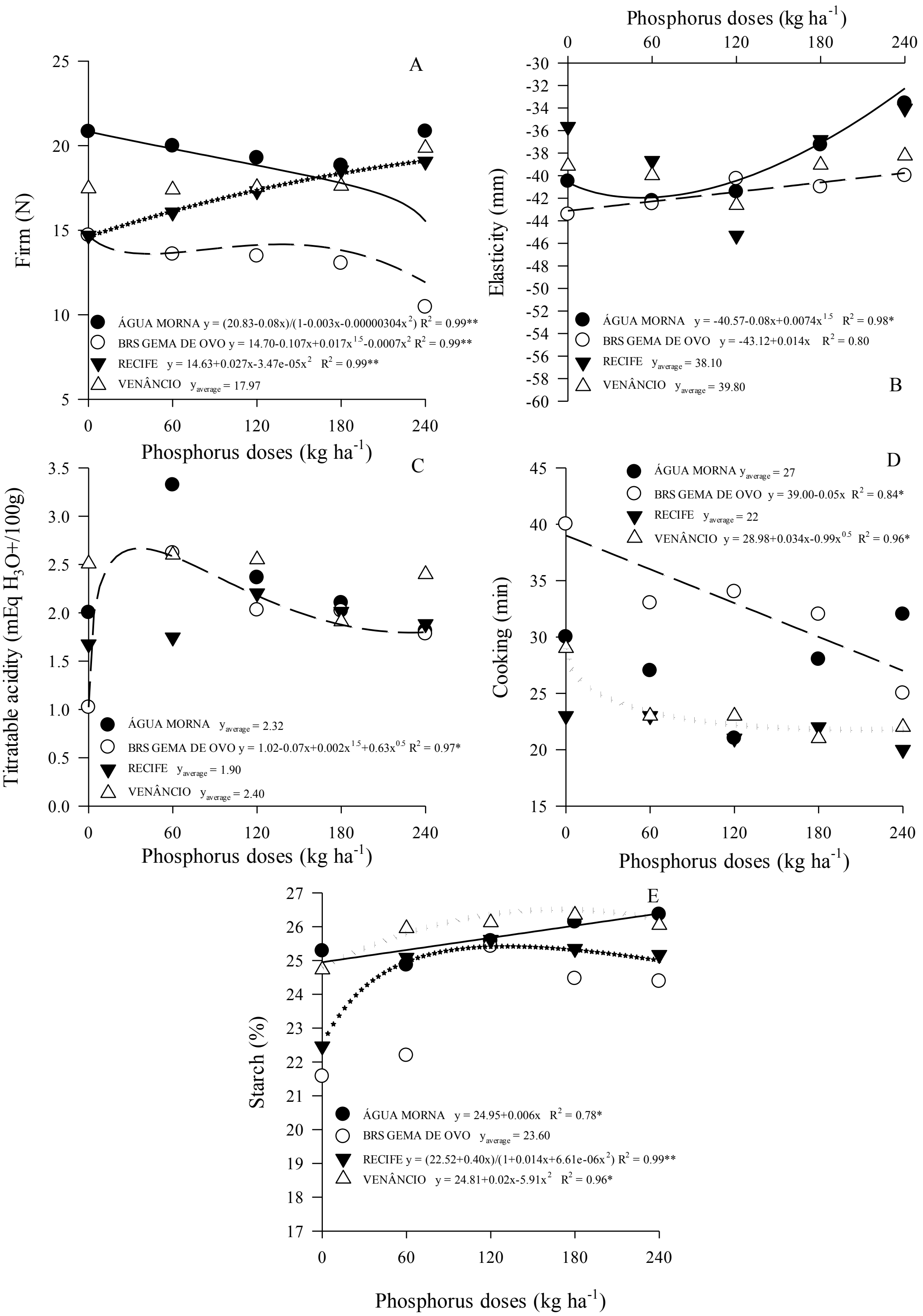


**Figure 3**. Firmness (A), Elasticity (B), Titratable acidity (C), Cooking time (D) and Starch content (E) of table cassava cultivars fertilized with phosphorus doses in the agricultural year 2018-2019 in the municipality of Mossoró, RN, Brazilian semiarid.

Cuvaca et al. (2015) observed a tendency towards a decrease in the starch content in cassava with an increase in the addition of N and K, in addition to an increase in the starch content with the addition of P. Oliveira et al. (2005), working with five doses of $P_2O_5$ (0, 100, 200, 300 and 400 kg ha$^{-1}$) in the fertilization of sweet potatoes, observed the maximum starch content with a dose of 293 kg ha$^{-1}$ of $P_2O_5$. Alternatively, Nunes (2019) observed that sweet potato cultivars responded differently in the starch content for P application, with one cultivar showing an increase in the content with increasing doses and another, a reduction in the starch content, with an increasing P dose.

P acts directly on the synthesis and transport of starch in plants (TAIZ et al., 2017). This was observed in the present study; however, the variation was 4.8% between the minimum and maximum levels obtained, indicating that the evaluated cultivars have the characteristic of low starch accumulation, in addition to the low starch production, with a little maximum content observed higher than 26%. This is in contrast to cultivars for industry, which have a minimum requirement of 30% in the starch content (CARDOSO et al., 2014); however, with the knowledge that the management of P for cultivated crops promoted an increase in this attribute.

Unlike in this study, Deus (2019), who evaluated doses of P (40, 80, 120 and 160 kg ha$^{-1}$ of $P_2O_5$) as sweet potato, did not identify variation in the starch content with the doses of $P_2O_5$, presenting an average of 15.63%.

There was no significant interaction between cassava cultivars and P doses for the soluble solids content. This fact was also observed by Silva et al. (2019) in their evaluation of doses of P (0, 90, 180 and 270 kg ha$^{-1}$ of $P_2O_5$) in beet cultivars and by Novo Júnior et al. (2016), who evaluated doses of P (0.00, 33.75, 67.50, 101.25, 135.00 and 168.75 kg ha$^{-1}$ of $P_2O_5$) in the onion culture. There was no effect of P doses for total soluble sugars, with an overall average of 4.17%, a fact also observed by Nunes (2019), who found no effect of P doses (0, 50, 100, 200 and 400 kg ha$^{-1}$) for total sugars in two sweet potato cultivars.

A reduction in the content of soluble solids was observed with increasing P dose, with a maximum estimated content of 6.97% with a dose of 35.80 kg ha$^{-1}$ of $P_2O_5$ (Figure 4). Deus (2019) also observed a reduction in the content of soluble solids with doses of P in sweet potatoes, with an average of 12.06%. Fernandes et al. (2018), in evaluating NPK doses in the quality of parsnip, found a reduction to soluble solids with increasing doses, noting that this reduction is due to the effect of the dilution of these components due to the increase in the size of the roots.

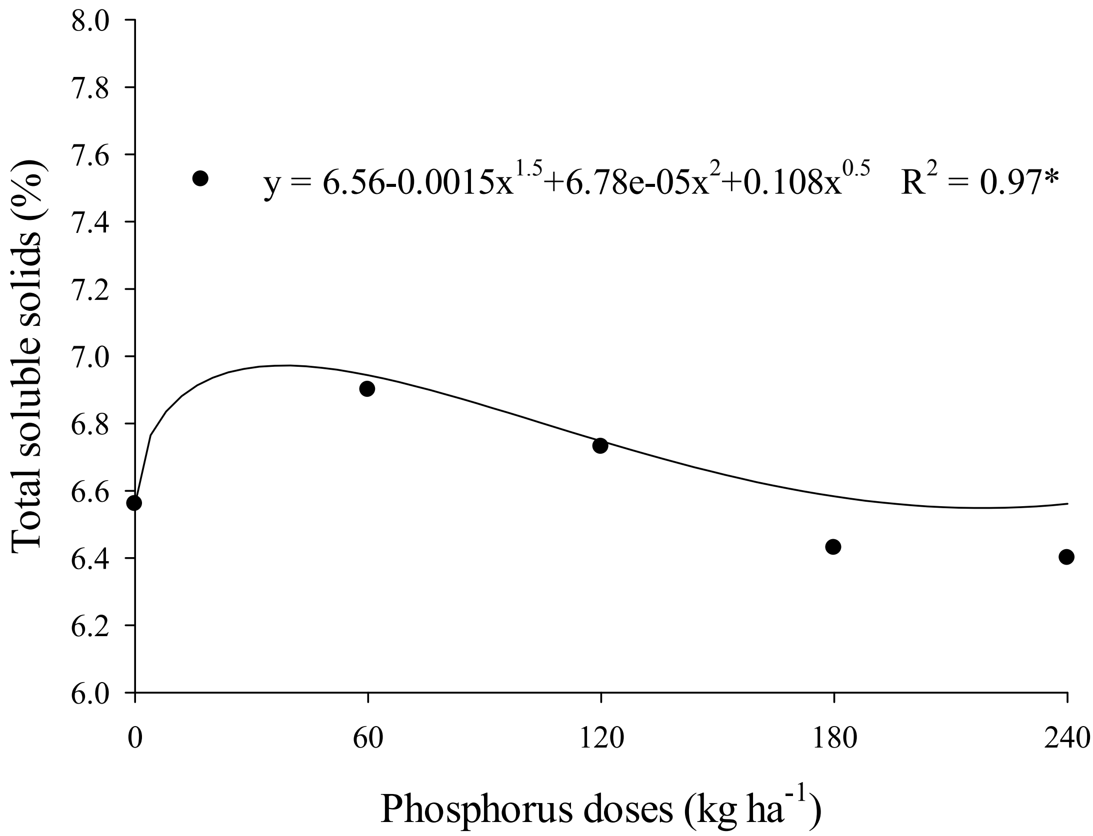


**Figure 4**. Soluble solids from table manioc cultivars fertilized with phosphorus doses in the agricultural year 2018-2019 in the municipality of Mossoró, RN, Brazilian semiarid.

The cultivar Água Morna showed greater firmness in the root pulp among the evaluated cultivars (Table 2), while the cultivar BRS Gema de Ovo showed the lowest values, demonstrating that this parameter is influenced by genetics. Albuquerque et al. (2018) found variation in root firmness among sweet potato cultivars and associated this behavior with the starch content. Cultivars with a higher starch content tend to have greater root firmness and cultivars with a lower starch content consequently have less firmness. The relationship between firmness and starch content was also observed in this research. The cultivars Água Morna, Recife and Venâncio showed greater firmness and starch content, when compared to the cultivar BRS Gema de Ovo, which had less firmness and starch content. Talma et al. (2013) found variation in the firmness of cassava roots among 15 cultivars harvested 11 months after planting.

**Table 2**. Average values of the root quality variables of table cassava cultivars fertilized with phosphorus doses in the agricultural year 2018-2019 in the municipality of Mossoró, RN, Brazilian semiarid.

| Cultivar | Firm (N) | Elasticity (mm) | SS* (%) | TSS** (%) | Cooking (min) | Acidity (mEq $H_3O$ + 100 $g^{-1}$) | Starch (%) |
|---|---|---|---|---|---|---|---|
| Água Morna | 19.95 a[1] | -39.01 ab | 6.10 b | 3.62 c | 27.67 b | 2.32 a | 25.64 a |
| BRS Gema de Ovo | 13.04 c | -41.44 b | 6.25 b | 4.56 a | 32.93 a | 1.89 b | 23.60 c |
| Recife | 17.13 b | -38.10 a | 6.96 a | 4.14 b | 21.73 d | 1.90 b | 24.73 b |
| Venâncio | 17.97 b | -39.80 ab | 7.11 a | 4.36 ab | 23.60 c | 2.39 a | 25.84 a |

*Soluble solids; **Total soluble sugars; [1]Means followed by different lower case letters in the column differ, at the level of 5% probability, by the Tukey test.

Assessing the quality of seven cassava cultivars at different times and seasons, Franck et al. (2011) found that roots harvested with a dry period prior to harvest have less firmness, however some cultivars were not influenced by the season in this parameter. Thus, meteorological variables may also have influenced this characteristic.

From the analysis of the behavior of the cultivars regarding the elasticity of the root pulp, it was observed that the cultivar Recife obtained the highest values. In turn, the cultivar BRS Gema de Ovo expressed the lowest values. It is observed that there is an inverse relationship between elasticity and cooking time. The cultivars BRS Gema de Ovo and Recife, which expressed the lowest and highest values for elasticity presented the longest and shortest cooking times, respectively.

Regarding the soluble solids variable, the highest values were observed for the cultivars Recife and Venâncio, while Água Morna and BRS Gema de Ovo had the lowest levels. Araújo et al. (2019) evaluated the chemical composition of 16 genotypes of table cassava and found a variation of 1.94% to 2.99% in soluble solids.

For total soluble sugars, BRS Gema de Ovo stood out among the cultivars, while Água Morna expressed the lowest results. Padonou, Mestres and Nago (2005) found a variation of 1.76 to 2.57% in soluble sugars in thirteen cultivars of table cassava in Benin. Deus (2019), evaluating doses of P (40, 80, 120 and 160 kg $ha^{-1}$ of $P_2O_5$) as sweet potato, did not identify variation in the content of total soluble sugars with the doses of $P_2O_5$, presenting an average of 4.80%. However, Albuquerque et al. (2018) observed variation in the content of soluble solids and total soluble sugars among sweet potato cultivars.

Cooking time is one of the criteria chosen by the consumer to choose a cultivar with good culinary characteristics. In this research, it was observed that the cultivar BRS Gema de Ovo required more time for cooking the roots, while the cultivar Recife obtained the best responses, with the shortest cooking time. The cooking time varies with the age of the plant, there are cultivars that present adequate cooking conditions throughout the cycle and others that lose this condition (FUKUDA; SILVA; IGLESIAS, 2002). An average variation of 11.2 min was observed in the cooking time between the cultivars evaluated. Several studies show the variation in cooking time between cassava cultivars (WHEATLEY; GOMEZ, 1985; LORENZI, 1994; RIMOLDI et al., 2006, TALMA et al., 2013), but they emphasize that the harvest age changes this parameter, being necessary to evaluate it at different times to find the period that guarantees the most satisfactory time.

The behavior of table cassava cultivars varied for titratable acidity, with emphasis on the cultivars Água Morna and Venâncio with the highest values, and BRS Gema de Ovo and Recife with the lowest values. Araújo et al. (2019) evaluated the chemical composition of 16 table cassava genotypes and found a variation from 1.76% to 4.37% in titratable acidity. This is a physicochemical characteristic that is influenced by the genotype.

The starch content is an important characteristic, mainly for industrial cassava cultivars, however, for table cultivars, it may indicate double suitability for this genotype. In this sense, among the cultivars evaluated in the research, Água Morna and Venâncio had the highest levels, while the cultivar BRS Gema de Ovo expressed the lowest levels. Rimoldi et al. (2006), Silva et al. (2014) and Araújo et al. (2019) found a difference in the starch content in table cassava cultivars ranging from 19% to 33.50%, attributed to genetic factors.

Analyzing the starch content and cooking time of 26 varieties of table manioc, Borges, Fukuda and Rossetti (2002) observed a significant variation for the two variables between the varieties, but they did not observe a correlation between cooking time and starch content, differently from what was observed in this research. The application of doses of P caused an increase in the starch content and a reduction in the cooking time of the cassava cultivars of the table. The cultivar Venâncio had the highest starch content and the shortest cooking time, and the BRS Gema de Ovo cultivar had the lowest starch content and the longest cooking time.

The results indicate that the cultivars evaluated in this study are suitable for table consumption, have good physicochemical and culinary qualities, starting with the visual aspect (Figure 2), which is within the standard required by local commerce, as well as in peeling ease, which was verified in the four cultivars. The anticipation of the harvest season could be an alternative to be able to optimize the quality of the roots, considering that the prolonged time in which these cultivars were exposed to variations in weather conditions, pest attack and the age of the plants possibly altered some variables, especially cooking and starch content.

## CONCLUSIONS

The quality of table cassava roots varied depending on cultivars and doses of P.

Doses of P between 120 and 240 kg ha$^{-1}$ of $P_2O_5$ provide an increase in the starch content and a reduction in the cooking time of table cassava roots.

The cultivar Recife presented the best culinary characteristics.

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