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AGRONOMIC CHARACTERISTICS, COOKING AND POSTHARVEST CONSERVATION FOR SELECTING SWEET CASSAVA CLONES[1]

VANDERLEI DA SILVA SANTOS[2]*, MARIA LUIZA MIRANDA DOS SANTOS[3],
FABIANA FUMI CERQUEIRA SASAKI[2], LUCIANA ALVES DE OLIVEIRA[2],
CARLOS ALBERTO DA SILVA LEDO[2]

ABSTRACT – The objective of this work was to evaluate the agronomic performance, cooking time and postharvest conservation of roots of sweet cassava clones, to select those superior to the Manteiga variety control, in the Baixo Sul region of Bahia state. A randomized block design in split plot scheme, with three replications was used. Eleven genotypes were evaluated at 10 and 12 months after planting. Considering the mean of two harvests, BRS Kiriris and Saracura showed total root yield (39.85 and 33.91 t ha^{-1}, respectively) and commercial root yield (26.54 and 26.71 t ha^{-1}) that are higher compared to Manteiga (total root yield: 28.06 t ha^{-1}, commercial root yield: 16.95 t ha^{-1}). However, both had cooking time (26.76 and 28.30 min, respectively) higher than that of Manteiga (23.89 min), and BRS Kiriris was unstable regarding the cooking percentage between 10 (91.67%) and 12 months (50%). BRS Aipim Brasil, 2003 14-11, BRS Kiriris, Eucalipto, Saracura and Manteiga were more tolerant to postharvest physiological deterioration. Although some of the evaluated clones presented good performance in the evaluated traits, by analyzing the set of traits, none of them shows sufficient superiority to be indicated as a potential substitute for Manteiga, grown in the Baixo Sul region of Bahia state.

Keywords: *Manihot esculenta*. Postharvest physiological deterioration. Commercial roots.

CARACTERÍSTICAS AGRONÔMICAS, COZIMENTO E CONSERVAÇÃO PÓS-COLHEITA PARA SELEÇÃO DE CLONES DE MANDIOCA DE MESA

RESUMO – O objetivo desse trabalho foi avaliar desempenho agronômico, tempo de cozimento e conservação pós-colheita de raízes de clones de mandioca de mesa, para selecionar aqueles superiores à testemunha Manteiga, na região do Baixo Sul do estado da Bahia. O delineamento foi em blocos casualizados e em esquema de parcelas subdivididas, com três repetições. Onze clones foram avaliados aos 10 e 12 meses após o plantio. Na média das duas colheitas, BRS Kiriris e Saracura tiveram produção total de raízes (39,85 e 33,91 t ha^{-1}, respectivamente) e produção de raízes comerciais (26,54 e 26,71 t ha^{-1}) superiores, comparados ao Manteiga (produção total de raízes: 28,06 t ha^{-1}, produção de raízes comerciais: 16,95 t ha^{-1}). Entretanto, ambos tiveram tempo de cozimento (26,76 e 28,30 min, respectivamente) maiores que o do Manteiga (23,89 min), e BRS Kiriris foi instável com relação à porcentagem de cozimento entre 10 (91,67%) e 12 meses (50%). BRS Aipim Brasil, 2003 14-11, BRS Kiriris, Eucalipto, Saracura e Manteiga foram mais tolerantes à deterioração fisiológica de pós-colheita. Embora alguns dos clones avaliados tenham apresentado bom desempenho nas características avaliadas, analisando-se o conjunto de características, nenhum deles apresenta superioridade suficiente para ser indicado como um potencial substituto do Manteiga, cultivado na região do Baixo Sul do estado da Bahia.

Palavras-chave: *Manihot esculenta*. Deterioração fisiológica de pós-colheita. Raízes comerciais.

*Corresponding author
[1]Received for publication in 02/26/2021; accepted in 01/18/2022.
[2]Embrapa Mandioca e Fruticultura, Cruz das Almas, BA, Brazil; vanderlei.silva-santos@embrapa.br – ORCID: 0000-0002-3666-7136, fabiana.sasaki@embrapa.br – ORCID: 0000-0002-5342-6270, luciana.oliveira@embrapa.br – ORCID: 0000-0002-6601-5884, carlos.ledo@embrapa.br - ORCID: 0000-0001-9578-4167.
[3]Universidade Federal do Recôncavo da Bahia, Cruz das Almas, BA, Brazil; luiza_pssantos@hotmail.com – ORCID: 0000-0003-3018-726X.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a plant whose main product is the root, rich in starch. Its hardiness allows it to be cultivated in poor and water -deficient soils (ZHAO et al., 2015). These characteristics make it an essential plant for feeding the poorest populations in developing countries (CEBALLOS et al., 2015), being the third largest source of food energy in tropical regions, after rice and corn (LUKUYU et al., 2014).

Cassava plant contains substances in its leaves and roots called cyanogenic compounds, precursors of hydrocyanic acid (HCN), which in certain concentrations can be toxic or even lethal. Cassava cultivars are classified as sweet or bitter, according to the cyanogenic compounds content from their roots, and those with up to 50 $\mu g\ g^{-1}$ HCN content are considered sweet (FEELEY et al., 2012).

Root yield and starch content are the most important characteristics of cassava varieties for industry, while for sweet cassava, additional characteristics related to root quality are considered, such as cooking, postharvest conservation, and absence of both fiber and bitterness (VIEIRA et al., 2018).

In addition to being an important feature in itself, cooking influences organoleptic characteristics, so the shorter the cooking time, the better the quality of the cooked root (PEDRI et al., 2018).

Cassava roots are highly perishable (MORANTE et al., 2010; DJABOU et al., 2017). From 24 to 48 hours after harvesting, symptoms of postharvest physiological deterioration begin to appear, with dark blue vascular streaks, followed by general discoloration of the root pulp. This problem causes increased root losses and production costs, and limits the distance between production and marketing sites, as well as the time between harvest and root consumption (MORANTE et al., 2010).

Manteiga is the most cultivated variety in the Baixo Sul region of Bahia state. Despite its good cooking characteristics and lower postharvest physiological deterioration, its root yield is low.

Thus, the objective of this work was to evaluate agronomic performance, cooking time and postharvest conservation of roots of sweet cassava clones, to select those superior to the Manteiga control, in the Baixo Sul region of Bahia state.

MATERIAL AND METHODS

The experiment was carried out in the area of the Casa Familiar Rural de Tancredo Neves (CFR), in the municipality of Presidente Tancredo Neves, in the Baixo Sul region of Bahia state, with an altitude of 253 m, average temperature of 23 ^{o}C and geographic coordinates of 13° 27' 14" S and 39° 25' 15" W with average annual precipitation of 1,594 mm. The region's climate is classified as tropical forest Af, according to the Köppen-Geiger classification (CLIMATE-DATA, 2021).

The experimental design consisted of randomized blocks in a split-plot scheme, with 3 replications, in which the clones were allocated to the plots and the harvesting times to the subplots.

The three plots of each genotype were composed of 28 plants, planted in a spacing of 0.90 m x 0.70 m and distributed in 4 rows (seven plants per row). Thus the sub-plot had 14 plants, being 14 plants harvested at 10 months and the remaining 14 at 12 months. 20-centimeter length cuttings taken from 12-month old plants from the experimental field in Embrapa Mandioca e Fruticultura were planted at the depth of 10 centimeters.

Soil in the area where the experiment was conducted belongs to Latossolo Vermelho Distrófico (Oxisol) type, according to the classification of Santos et al. (2018). The area is flat and the soil deep and well drained. The results from soil analysis were: pH (H_2O): 5.17, phosphorus: 8.68 mg dm^{-3}, potassium: 0.23 cmolc dm^{-3}, sodium: 0.04 cmolc dm^{-3}, calcium: 3.0 cmolc dm^{-3}, magnesium: 1.10 cmolc dm^{-3}, aluminum: 0.00 cmolc dm^{-3}. Fertilization was performed based on soil analysis and following the recommendations of Gomes; Silva (2006). Phosphorus (40 kg ha^{-1} of P_2O_5) and potassium (30 kg ha^{-1} of K_2O) were applied in the groove while planting and nitrogen 40 days after planting at a dosage of 30 kg ha^{-1} of N.

Planting was carried out in August 2017. Eleven clones were planted, 10 from Embrapa (2003 14-11, 2004 28-28, BRS Aipim Brasil, BRS Dourada, BRS Gema de Ovo, BRS Jari, BRS Kiriris, Eucalipto, Paraguai and Saracura) and a local control (Manteiga).

The clones compared to the Manteiga control in this work are from the Embrapa breeding program. Cultivars BRS Gema de Ovo, BRS Dourada and BRS Jari come from the cassava biofortification project (OLIVEIRA et al., 2017), and present beta-carotene content higher than cultivars with white pulp. 2003 14-11 and 2004 28-28 were also obtained in the scope of the biofortification project but were not yet released, while BRS Aipim Brasil, BRS Kiriris, Paraguai and Saracura are white pulp sweet cultivars, released throughout the aforementioned breeding program and Eucalipto is a cream pulp accession of sweet cassava belonging to the Cassava Germplasm Bank of Embrapa Mandioca e Fruticultura.

The cultural practices included two weedings using hoes, carried out at 35 and 60 days after planting, and ant control with chemical anticide baits during the first 90 days.

The harvests were performed at two times, at

10 and 12 months after planting (May and July 2018, respectively), and all genotypes were harvested at both periods. After harvesting, the roots were separated from the shoots and then a worker with experience in root marketing visually classified the roots from each plot into commercial standard (which means well accepted by buyers) and non-commercial (meaning they are not well accepted by buyers). In this visual classification, the diameter, the length, and the occurrence of deformations and/or constrictions were considered. Then, in one replication five roots previously classified as commercial standard from each plot were measured around the perimeter (in the central region) and length using a flexible measuring tape. Diameter was calculated as perimeter/π.

Roots from each plot were counted. Dividing the total amount of roots (commercial + non-commercial) from each plot by the number of harvested plants we obtained the total number of roots per plant (TNR), and by repeating the procedure for the amount of commercial roots calculated the number of commercial roots per plant (NCR). Then the ratio (%) between the number of commercial roots and the total number of roots (NCR/TNR x 100) was calculated.

The roots were weighed with a digital scale (Brecknell ElectroSamson 45 kg x 0.01 kg, Fairmont, Minnesota, USA), obtaining the total root yield (TRY, t ha^{-1}) and commercial root yield (CRY, t ha^{-1}). The percentage of commercial root yield in relation to the total root yield (CRY/TRY, %) was then calculated.

To estimate dry matter content (DMC, %), a 5-kilo sample of roots (W_{air}) from each plot was weighed in the aforementioned digital scale. Then, the sample was weighed immersed in 50 L of water using a more precise scale (Brecknell ElectroSamson 10 kg x 0.005 kg, Fairmont, Minnesota, USA), to obtain weight in water (W_{water}). The DMC was estimated using the following Equation (KAWANO; FUKUDA; CENPUKDEE, 1987):

$$\text{DMC (\%)} = 158.3 * \frac{W_{air}}{W_{air} - W_{water}} - 142$$

To evaluate cooking time (CT, min), a 5-cm long piece was removed from the central region of 10 roots of each genotype from each of the 3 repetitions. The 10 pieces were peeled, washed in fresh water and placed in 1.5 L of boiling water. The cooking time was recorded when 6 pieces (50% + 1) no longer resisted penetration with a fork (OLIVEIRA; MORAES, 2009). The roots continued to cook for a maximum of 30 min in total and after this period, the number of tender cooked pieces was recorded. The cooking percentage (CP, %) was calculated by dividing the number of tender cooked pieces by the total number.

For the evaluation of postharvest physiological deterioration, at each harvest time (10 and 12 months), 18 undamaged roots were selected from each plot and genotype and placed in plastic boxes to avoid any damage that could favor deterioration. The roots were then transported to the postharvest laboratory of Embrapa Mandioca e Fruticultura in the municipality of Cruz das Almas, Bahia, where they were washed in fresh water and dried with paper towel and stored side by side on shelves at room temperature (25 ± 1°C). Evaluations were performed at 0, 2, 4, 6, 8 and 10 days after harvest, after removal of a cylinder (1 cm thick) from the central part of the roots. Sampling was performed on three roots per plot on each day of analysis. Postharvest physiological deterioration was assessed using a symptom scale ranging from 0 to 100% at 10% intervals (VENTURINI; SANTOS; OLIVEIRA, 2015a; VENTURINI; SANTOS; OLIVEIRA, 2015b). These values were used to calculate the area under the deterioration progress curve (AUDPC), given by the following equation (CAMPBELL; MADDEN, 1990):

$$\text{AUDPC} = \sum_{i=1}^{n} \left(\frac{y_{i+1} + y_i}{2} \right) * \left(t_{i+1} - t_i \right)$$

where: n is the number of times of postharvest physiological deterioration assessment (6), y_i is the value (%) of the postharvest physiological deterioration at the i-th assessment period and t_i is the time (in days), in the i-th period.

Regarding statistical analysis, normality of residuals was initially verified (Shapiro-Wilk test), and residuals variance homogeneity was verified by Bartlett Test. Due to the lack of homogeneity in residual variance, cooking time was transformed into $\sqrt{x}$. Then, variance analysis and means comparison were carried out (Scott-Knott test), using the R program (R CORE TEAM, 2018).

RESULTS AND DISCUSSION

The clones source of variation was highly significant in all evaluated traits (Tables 1 and 2), which demonstrates genetic variability among the evaluated clones. Regarding harvesting times, significance was observed in the characteristics proportion between the number of commercial roots and the total number of roots (NCR/TNR), cooking percentage (CP), both at 0.1%, commercial root yield (CRY) and cooking time (CT) at 1%, total root yield (TRY) and ratio between commercial root yield and total root yield (CRY/TRY) at 5%. The clones x harvesting times interaction was significant only for two characteristics, the ratio between number of commercial roots per total number of roots per plant (NCR/TNR), and cooking percentage (CP).

Table 1. Analysis of variance of traits: total number of roots per plant (TNR), number of commercial roots per plant (NCR), percentage of the number of commercial roots in relation to total number of roots (NCR/TNR, %), total root yield (TRY, t ha^{-1}) and commercial root yield (CRY, t ha^{-1}) for 11 sweet cassava clones harvested 10 and 12 months after planting. Presidente Tancredo Neves, Bahia, Brazil.

SV	DF	MEAN SQUARES				
		TNR	NCR	NCR/TNR	TRY	CRY
Clones	10	13.0485**	2.5314***	365.12***	231.2***	155.79***
Block	2	1.2219ns	1.1745ns	148.15ns	198.23**	108.7**
Error a	20	4.2497	0.3843	47.5	33.37	15.42
Harvesting times	1	2.1348ns	7.1281ns	892.11***	590.53*	437.57**
Clones*harvesting times interaction	10	5.8238ns	2.0867ns	168.83*	129.45ns	90.83ns
Error b	22	8.4554	1.907	68.74	116.15	60.33
CV1		27.08	22.38	19.01	21.72	22.54
CV2		38.20	49.85	22.87	40.53	44.58

***, **, *: Significant at 0.1%, 1% and 5%, respectively; ns: nonsignificant.

Table 2. Analysis of variance of traits: percentage of commercial root yield in relation to total root yield (CRY/TRY, %), dry matter content (DMC, %), cooking time (CT, min), cooking percentage (CP, %) and area under the deterioration progress curve (AUDPC) for 11 sweet cassava clones harvested 10 and 12 months after planting. Presidente Tancredo Neves, Bahia, Brazil.

SV	DF	MEAN SQUARES				
		CRY/TRY	DMC	CT[1]	CP	AUDPC
Clones	10	463.11***	46.704***	0.46502***	2570.8***	25943.8**
Block	2	160.62ns	23.499ns	0.088ns	458.6ns	2316.4ns
Error a	20	72.41	7.308	0.03363	408.4	6454.8
Harvesting times	1	357.24*	3.659ns	0.82222**	9094.7***	13650.1ns
Clones*harvesting times interaction	10	119.97ns	4.844ns	0.07937ns	1631.5***	15185.6ns
Error b	22	70.22	4.094	0.06936	314.4	8278.5
CV1		13.21	9.68	3.60	27.33	30.92
CV2		13.01	7.25	5.17	23.97	35.01

[1]: transformed into $\sqrt{x}$.
***, **, *: Significant at 0.1%, 1% and 5%, respectively; ns: nonsignificant.

The coefficients of variation (CV) in the number of commercial roots, total root yield and commercial root yield were greater than 40% (Table 1). High CV values are common when it comes to cassava root production. Akinbo; Labuschagne; Fregene (2011) report CV of 42%, in relation to root production. The CV of the number of commercial roots (NCR) was very high (49.85%). Streck et al. (2014) report a CV of 12.65% for this trait. There are two possible explanations for this high value: the low number of plants harvested by sub-plot in each harvest (14), and the subjectivity due to the fact that the classification of roots as commercial was made visually and is therefore subject to great variations. These two factors may have contributed to an increase of experimental error, and consequently to increase the value of CV of the NCR characteristic.

Two groups were formed by the Scott-Knott test regarding the total number of roots per plant (TNR), the lowest mean being found for BRS Gema de Ovo and Eucalipto (5.19 and 4.95 roots per plant, respectively). In the other group, the means ranged from 6.85 (Paraguai) to 9.46 roots per plant (BRS Kiriris), with 8.17 roots per plant being the mean value for the group and 9.00 the mean for the Manteiga control (Table 3).

The means of the number of commercial roots (NCR) were classified in three groups, the highest group made up of the clones BRS Jari, BRS Kiriris and Saracura (3.27, 3.53 and 3.98 roots per plant, respectively). Manteiga presented 2.88 roots per plant, an intermediate value (Table 3).

The diameter of commercial roots ranged from 4.01 to 7.20 cm, while the length ranged from 22.2 to 34.8 cm. These values were obtained in five roots visually classified as commercial.

Table 3. Means of traits: total number of roots per plant (TNR), number of commercial roots per plant (NCR), percentage of the number of commercial roots in relation to total number of roots (NCR/TNR, %), total root yield (TRY, t ha^{-1}) and commercial root yield (CRY, t ha^{-1}), in 11 sweet cassava clones harvested at 10 and 12 months after planting. Presidente Tancredo Neves, Bahia, Brazil.

Genotypes			10 months[1]	12 months		
	TNR	NCR	NCR/TNR	NCR/TNR	TRY	CRY
2003 14-11	8.30a	2.46b	22.22bA	35.91bA	27.33b	15.53b
2004 28-28	7.74a	1.74c	19.23bA	27.47bA	20.20c	9.66b
BRS Aipim Brasil	7.57a	2.89b	30.95bA	44.03aA	25.19b	16.79b
BRS Dourada	7.74a	2.67b	39.32aA	28.17bA	26.23b	16.47b
BRS Gema de Ovo	5.19b	2.00c	21.53bB	42.55aA	21.75c	14.19b
BRS Jari	9.15a	3.27a	26.30bB	49.41aA	28.91b	18.89b
BRS Kiriris	9.46a	3.53a	36.65aA	37.18bA	39.85a	26.54a
Eucalipto	4.95b	2.40b	47.84aA	48.75aA	18.49c	14.64b
Manteiga (control)	9.00a	2.88b	31.33bA	30.58bA	28.06b	16.95b
Paraguai	6.85a	2.68b	40.15aA	38.59bA	22.59c	15.30b
Saracura	7.79a	3.98a	42.76aA	56.50aA	33.91a	26.71a

[1]: The means of NCR/NTR, a trait in which clones x harvesting times interaction was significant, are presented by harvesting time (10 and 12 months). The means for the other traits are those of the joint analysis.
Means followed by the same lowercase letter in the columns belong to the same group according to Scott-Knott test at a 5% probability.
Means followed by the same capital letter in the rows (NCR/TNR) do not differ statistically among themselves according to F test at a 5% probability.

Regarding the ratio between the number of commercial roots and the total number of roots (NCR/TNR), at 10 months, the means of BRS Gema de Ovo (21.53%) and BRS Jari (26.30%) were lower than those at 12 months (42.55% and 49.41%, respectively).

Only Eucalipto (47.84% at 10 months and 48.75% at 12) and Saracura clones (42.76% at 10 months and 56.50% at 12) were classified as superior at both harvesting times. The Manteiga control had a lower mean at both times (31.33% at 10 months and 30.58% at 12). The importance of classifying cassava roots as commercial and non-commercial is that although the demand for processed roots is increasing, the commercialization of fresh roots still predominates in some regions of Brazil, and thus the appearance of the roots is fundamental.

The means for total root yield (TRY, commercial + non-commercial roots) ranged from 18.49 t ha^{-1} (Eucalipto) to 39.85 t ha^{-1} (BRS Kiriris) and were classified into three groups, the group with highest means made up of BRS Kiriris and Saracura and the group with lowest average by clones 2004 28 -28, BRS Gema de Ovo, Eucalipto and Paraguai. The mean of Manteiga (28.06 t ha^{-1}) was classified in the intermediate group. Vieira et al. (2018), evaluating 14 genotypes between 11 and 12 months after planting, observed root yield values ranging from 13.18 to 41.00 t ha^{-1}.

The means of commercial root yield (CRY) ranged from 9.66 t ha^{-1} (2004 28-28) to 26.71 t ha^{-1} (Saracura). As well as in relation to TRY, clones BRS Kiriris and Saracura also stood out for their CRY (Table 3).

In turn, the means of the ratio between commercial root yield and total root yield (CRY/ TRY) were classified into three groups (Table 4), the highest one formed by Eucalipto (78.46%) and Saracura (76.73%) clones. BRS Kiriris clone was classified in an intermediate group (66.48%), although, together with Saracura, it presented the best means for TRY and CRY (Table 3). The reason is that, especially at 12 months, BRS Kiriris had a high percentage of very thick (non-commercial) roots, which contributed to lower the CRY/TRY, and consequently the average value of the two harvests.

It is important to notice that when roots are processed, some non-commercial roots (very thick or shorter) are utilized. In this context, the concept of commercial roots, while not completely losing its importance, becomes less determinant. Perhaps for this reason, papers in which roots are classified as commercial and non-commercial are rare. However, in regions where roots are still marketed mainly whole, this classification is of the utmost importance, since roots classified as non-commercial are either not bought or are priced lower than commercial-standard roots (AGUIAR et al., 2011).

Table 4. Means of traits: percentage of commercial root yield in relation to total root yield (CRY/TRY, %), dry matter content (DMC, %) , cooking time (CT, min), cooking percentage (CP, %) and area under the deterioration progress curve (AUDPC) in 11 sweet cassava clones harvested at 10 and 12 months after planting. Presidente Tancredo Neves, Bahia, Brazil.

Genotypes				10 months[1]	12 months	
	CRY/TRY	DMC	CT	CP	CP	AUDPC
2003 14-11	55.22c	32.17b	26.40c	88.43aA	50.00bB	156.68a
2004 28-28	47.55c	31.93b	28.30d	81.55aA	13.33cB	291.81b
BRS Aipim Brasil	65.07b	32.97b	25.37c	90.48aA	90,00aA	260.28a
BRS Dourada	62.84b	29.35b	29.83d	62.10aA	34.81bA	343.98b
BRS Gema de Ovo	62.65b	36.15a	26.48c	92.86aA	90.00aA	-[2]
BRS Jari	66.67b	30.64b	27.76d	77.98aA	0.00cB	298.61b
BRS Kiriris	66.48b	34.24a	26.76c	91.67aA	50.00bB	255.42a
Eucalipto	78.46a	31.31b	23.61b	100.00aA	96.67aA	185.00a
Manteiga (control)	59.18c	32.13b	23.89b	87.50aA	96.67aA	239.72a
Paraguai	67.77b	38.33a	19.94a	71.03aA	100.00aA	359.45b
Saracura	76.73a	29.05b	28.30d	99.07aA	62.93aB	207.66a

[1]: The means of CP, a trait in which clones x harvesting times interaction was significant, are presented by harvesting time (10 and 12 months). The means for the other traits are those of the joint analysis.
[2]: There were no sufficient roots.
Means followed by the same lowercase letter in the columns belong to the same group according to Scott-Knott test at a 5% probability.
Means followed by the same capital letter in the rows (CP) do not differ statistically among themselves according to F test at a 5% probability.

From the nine clones that stood out for TNR, only two (BRS Kiriris and Saracura) stood out for TRY (Table 3). These results suggest that the number of roots alone is not a good indication of cassava root yield.

The means of DMC were classified in two groups, with BRS Gema de Ovo (36.15%), BRS Kiriris (34.24%) and Paraguai (38.33%) standing out, while the means of the others ranged from 29.05% (Saracura) to 32.97% (BRS Aipim Brasil) (Table 4).

Root tenderness after cooking is a truly relevant attribute for sweet cassava. Dry matter content plays an important role in root cooking and tenderness (BECHOFF et al., 2017), and according to Pedri et al. (2018), the easier the cooking, the better the taste of the cooked product. From this the importance of dry matter content for sweet cassava can be inferred.

The means for cooking time (CT) ranged from 19.94 to 29.83 min, and four groups were formed: the group with the shortest (and in this case better) cooking time means was represented by the Paraguai clone (19.94 min) and the group with the longest means, by clones 2004 28-28, BRS Dourada, BRS Jari and Saracura (Table 4). Talma et al. (2013) observed that the clone BRS Gema de Ovo had a cooking time of 19 min and Eucalipto, 26 min, while in this work, the averages were 26.48 and 23.61 min, respectively. Differences between the means of a same clone from this study and that of Talma et al. (2013) can be attributed to the fact that the environmental conditions (soil, temperature, latitude and longitude) are very different in each work.

Only the Paraguai clone presented cooking time below 20 min, which is considered acceptable for cassava (PEDRI et al., 2018). This result corroborates the authors who state that it is difficult to select varieties with low cooking time and stability in this trait because it is affected by many factors (SILVEIRA et al., 2021; MAIEVES et al., 2012). On the other hand, most forms of sweet cassava consumption require cooking.

Considering simultaneously DMC and CT, the Paraguai clone presented high DMC and low CT, while BRS Gema de Ovo and BRS Kiriris presented high DMC and high CT, and Eucalipto and Manteiga clones showed low DMC and low CT. These results seem to suggest that there is no direct relation between dry matter content and cassava root cooking time. However, Vieira, Fialho, and Carvalho (2014) report a correlation of -0.35 between these traits.

Cooking percentage (CP) is rarely mentioned in previous studies. However, given the importance of cooking sweet cassava and the large variation observed between clones for this trait, it was incorporated in this study. In the 10-month harvest, the means ranged from 62.10% to 100%, without, however, statistically significant differences between them. At 12 months, the means were classified into 3 groups, the lowest being formed by clones 2004 28-28 (13.33%) and BRS Jari (0.00%), and the intermediate group by 2003 14-11 (50.00%), BRS Dourada (34.81%) and BRS Kiriris (50%). The means of the other clones ranged from 62.93% (Saracura) to 100% (Paraguai) (Table 4). For the clones 2003 14-11, 2004 28-28, BRS Jari, BRS Kiriris and Saracura, the mean of CP at 12 months was lower than at 10 months, which is in agreement with information from previous studies that cassava roots tend to become more difficult to cook as the plant age increases (PEDRI et al., 2018).

There is a wide variation for symptoms of postharvest physiological deterioration (PPD) even among roots from the same genotype, making the interpretation of the results difficult. For this reason, Venturini et al. (2016) proposed to express this trait in terms of the area under the deterioration progress curve (AUDPC), an adaptation of the concept of area under the disease progress curve (CAMPBELL; MADDEN, 1990). The values for area under the deterioration progress curve (AUDPC) were classified into two groups. The group of lowest means (lower susceptibility to deterioration) was represented by clones 2003 14-11, BRS Aipim Brasil, BRS Kiriris, Eucalipto, Manteiga and Saracura (Table 4). These data demonstrate the possibility of selecting more tolerant genotypes to postharvest physiological deterioration, in accordance with the results obtained by Morante et al. (2010). Eucalipto was one of 418 genotypes evaluated by Venturini et al. (2016), who also identified it as one of the most tolerant to PPD.

Considering the mean values of the harvesting times (Table 5), the means of total root yield (TRY), commercial root yield (CRY), and ratio of commercial root yield to total root yield (CRY/TRY) at 12 months were higher than at 10 months, indicating the continuous growing of the roots between the two harvests. Similar results were obtained by Aguiar et al. (2011).

Regarding the characteristics related to cooking, the average cooking time (CT) at 12 months (27.27 min) was statistically higher than at 10 months (24.97 min). For the cooking percentage (CP), the opposite was the case: at 10 months, the percentage was 99.07%, while at 12 months, the value was significantly lower (62.93%). Decreased cooking percentage and increased cooking time are reflections of decreased root quality with increasing age, reported by Pedri et al. (2018).

Table 5. Means by harvesting time of traits: commercial root yield (CRY, t ha^{-1}), total root yield (TRY, t ha^{-1}), percentage of commercial root yield in relation to total root yield (CRY/TRY, %), cooking time (CT, min) and cooking percentage (CP, %) in 11 sweet cassava clones. Presidente Tancredo Neves, Bahia, Brazil.

Harvesting time	Trait				
	TRY	CRY	CRY/TRY	CT	CP
Time 1 (10 months) mmmomomonths)	23.60b	14.85b	62.09b	24.97a	99.07a
Time 2 (12 months)	29.58a	20.00a	66.75a	27.27b	62.93b

Means followed by the same letters in columns do not differ statistically according to F test at 5% probability.

In genetic breeding, the higher the number of characters considered, the less likely it is to select a genotype with adequate performance on all characters. Tables 3 and 4 show the occurrence of clones with performance similar or superior to the Manteiga control in at least one characteristic. However, analyzing the favorable and unfavorable characteristics of each of the evaluated clones, it is clear that all have at least one deficiency in a fundamental characteristic for the acceptance of a cultivar. For example, BRS Kiriris and Saracura clones, which stood out in terms of both total and commercial root yield and low physiological root deterioration, on the other hand, were unstable in cooking (a significant decrease in cooking percentage from 10 to 12 months), and had a high cooking time. However it is important to observe that the cooking is influenced by several factors besides genotype (BORGES; FUKUDA; ROSSETTI, 2002). For example, these authors report that the Saracura clone presented a cooking time among the best in evaluations at 8, 10 and 12 months after planting (25 minutes on average).

BRS Aipim Brasil, Eucalipto and Paraguai were statistically similar or superior to the Manteiga control in almost all characteristics evaluated. However, the stems of BRS Aipim Brasil present difficulty in sprouting and its roots have a white external color and are not accepted by local consumers, who associate the white external color with high levels of cyanogenic compounds. And in turn, Eucalipto and Paraguai had average root yields similar (commercial roots) or lower (total yield) than the Manteiga control, whose main deficiency is the relatively low root yield.

On the other hand, the identification of genotypes with greater tolerance to PPD, lower CT and higher percentage of commercial standard roots are important to guide future crosses for the generation of varieties with better characteristics than current ones.

CONCLUSIONS

The roots of the clones 2003 14-11, 2004 28-28, BRS Jari, BRS Kiriris and Saracura tended to become more difficult to cook with increasing age.

The clones 2003 14-11, BRS Aipim Brasil, BRS Kiriris, Eucalipto, Saracura and Manteiga were more tolerant to postharvest physiological deterioration.

None of the clones evaluated had sufficient performance to be recommended for cultivation in the Baixo Sul region of Bahia state.

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