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Lima de Souza, Hugo Antonio; de Sousa Bentes, Ádria; Souza Ladeira, Taiana Marina; Santos Lopes, Alessandra; da Silva Pena, Rosinelson
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Physicochemical properties of three sugary cassava landraces

Propriedades físico-químicas de três acessos de mandioca

Hugo Antonio Lima de Souza^I Ádria de Sousa Bentes^I Taiana Marina Souza Ladeira^{II}
Alessandra Santos Lopes^{II} Rosinelson da Silva Pena^{II*}

ABSTRACT

*This study evaluates the physical and physicochemical properties of three sugary cassava (*Manihot esculenta* Crantz) landraces: São Francisco Bag 3, Manicueira 62, and Castanhal Iracema. These three landraces showed high estimated productivity ($\geq 3.93 \text{ kg plant}^{-1}$) and had a high sugar content ($\geq 3.92 \text{ g } 100 \text{ g}^{-1}$ of root), making them viable for use in syrup production, especially the São Francisco Bag 3 landrace ($4.76 \text{ g } 100 \text{ g}^{-1}$). The Manicueira 62 landrace had the highest starch content ($4.40 \text{ g } 100 \text{ g}^{-1}$). The three sugary cassava landraces exhibited high levels of cyanide ($> 195 \text{ mg kg}^{-1}$), indicating the need for processing prior to consumption.*

Key words: *Manihot esculenta* Crantz, sugar, starch, composition.

RESUMO

*Neste trabalho, foram avaliadas propriedades físicas e físico-químicas das raízes de três acessos de mandioca (*Manihot esculenta* Crantz): São Francisco Bag 3, Manicueira 62 e Castanhal Iracema. Os três acessos apresentaram elevada produtividade estimada ($\geq 3,93 \text{ kg planta}^{-1}$) e as suas raízes apresentaram altos teores de açúcares ($\geq 3,92 \text{ g } 100 \text{ g}^{-1}$ de raiz), apresentando-se como uma alternativa para a produção de xarope, particularmente o acesso São Francisco Bag 3 ($4,76 \text{ g } 100 \text{ g}^{-1}$). O acesso Manicueira 62 foi o que apresentou o maior conteúdo de amido ($4,40 \text{ g } 100 \text{ g}^{-1}$). As três raízes estudadas apresentaram altos níveis de cianeto total ($> 195 \text{ mg kg}^{-1}$), o que indica que elas também necessitam ser processadas antes de serem consumidas.*

Palavras-chave: *Manihot esculenta* Crantz, açúcar, amido, composição.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a very important crop for Brazil, the world's third-largest producer of this root (FAO, 2011). However, this crop receives little attention within the context of the national economy due to the low verticalization of the Brazilian supply chain (CEREDA & VILPOUX, 2003). The *Manihot* genus (ALBUQUERQUE, 1969; HILLOCKS et al., 2002) may have originated and diversified in Brazil where there is great genetic variety, mainly of local diversity, that is restricted to a few agriculturists. These varieties are known as landraces (SIQUEIRA et al., 2010).

Part of this variety is preserved in banks of germplasm around the world (FUCCILLO et al., 1997). The biggest active germplasm bank in Brazil belongs to Embrapa, located in Cruz das Almas, Bahia (Brazil) which contains approximately 1,700 landraces (FUKUDA et al., 1997). There are several projects related to the genetic improvement of cassava which attempt to increase its productivity and make it more resistant to pests, but few are related to producing roots with compounds of greater added value (TAYLOR et al., 2004).

Within this context, a group of landraces indigenous to the Brazilian Amazon, widely-known as sugary cassava or "mandioca", stand out from

^IDepartamento de Ciência de Alimentos, Faculdade de Engenharia de Alimentos, Universidade de Campinas (UNICAMP), Campinas, SP, Brasil.

^{II}Faculdade de Engenharia de Alimentos, Instituto de Tecnologia (ITEC), Universidade Federal do Pará (UFPA), Rua Augusto Corrêa, 01, Guamá, 66075-900, Belém, PA, Brasil. E-mail: rspena@ufpa.br. *Autor para correspondência.

the other varieties of cassava in terms of their high sugar and low starch content, used by the indigenous people of the Amazonia to make a sweet porridge known as “manicueira” (CARVALHO et al., 2004). The production of a concentrate rich in glucose, by concentrating “manipueira” (liquid obtained by crushing and filtering of cassava), is one of the possible industrial uses of sugary cassava (CARDOSO et al., 2004).

The objective of this study was to quantify sugars and other compounds of three sugary cassava (*Manihot esculenta* Crantz) landraces produced in the state of Pará, Brazil.

MATERIALS AND METHODS

Materials

Three sugary cassava landraces provided by the Active Germplasm Bank of the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA/CPATU) were used in the study: Manicueira 62, Castanhal-Iracema (nine-month-old plant) and São Francisco Bag 3 (twelve-month-old plant). The yields were obtained by weighing the roots of each landrace. The average root yield was evaluated on three plants of each landrace, with and without the peel.

Analyses

Proximate composition – The following analyses were performed in the sugary cassava roots: moisture content: the gravimetric method was used in an air-circulating oven at 105°C based on AOAC (1997) method 925.10; ashes: the sample was incinerated in Muflo oven at 550°C based on AOAC (1997) method 923.03; proteins: the Kjeldahl method was used with a 6.25 nitrogen-protein correlation factor based on AOAC (1997) method 920.87; lipids: extracted with mixing of solvents using the BLIGH & DYER (1959) method; total and reducing sugars: Lane-Eynon titration method based on AOAC (1997) method 920.183b; starch: acid hydrolysis using the RICKARD & BEHN (1987) method; insoluble and total dietary fibers: enzymatic/gravimetric method using the α -amilase thermo-resistant (EC 3.2.1.1), protease (EC 3.4.21.26) and amyloglucosidase (EC 3.2.1.3) enzymes based on AOAC (1997) methods 985.29 and 991.42. The soluble fiber content was determined by the difference.

Glucose, fructose and sucrose contents – Soluble sugars were extracted three times with 80% ethanol at 80°C. The supernatants were combined, and the ethanol was evaporated under vacuum. The residues were reconstituted with water, filtered through 0.22 μ m membrane filters, and analyzed by

HPAE-PAD. The chromatographic analysis was performed on a Dionex DX 500 instrument equipped with a PAD system (ED 40). The analytical column employed was a Carbopac PA1 (250 \times 4mm, 5 μ m particle size). The flow rate was kept constant at 1.0mL min⁻¹, and an isocratic run of 18mM (NaOH) over 25min (DER AGOPIAN et al., 2008).

Physicochemical properties of the roots – Soluble solids: direct reading via an Atago optical refractometer at 20°C based on AOAC (1997) method 932.12; pH: direct reading via a Marconi pH meter based on AOAC (1997) method 943.02; total titratable acidity: titration method based on AOAC (1997) method 942.15; water activity (a_w): direct reading via a Decagon Aqualab 3TE digital thermo hygrometer at 25°C; free and total cyanide (HCN): enzymatic/spectrophotometric method based on ESSERS (1993); and color: tristimulus colorimetry using a model CR 400 MINOLTA colorimeter, with L*, a* and b* values based on the parameters D65 (day light) and 10° (observer angle) according to CIE Lab standards (CHROMA METER, 1989).

RESULTS AND DISCUSSION

Root yields per plant

Table 1 shows the average root yield per landrace. The São Francisco Bag 3 landrace had the highest yield (8.16kg root with peel/plant and 7.32kg root without peel/plant) and also had the highest root/peel ratio (9.71). The Castanhal Iracema landrace had the lowest yield (3.93kg root with peel/plant and 3.46kg root without peel/plant) and the Manicueira 62 landrace had the lowest root/peel ratio (7.64), however, this difference in yield may result from time of harvesting, since landrace with the highest yield was the one harvested with 12 months after planting date compared to the others harvested at 9 months. Thus, future studies to determine the real productivity of these landraces are needed. Considering just the recommended growing space (10,000plants ha⁻¹) (HILLOCKS et al., 2002) and not taking into account pests and other losses, the productivity of the three landraces (≥ 39.3 ton ha⁻¹) would be more than double the current rate of Brazilian productivity, which is 14ton ha⁻¹ (FAO, 2011). VIEIRA et al. (2008) determined the productivity of other four sugary cassava landraces and found them to be low (2.0-8.9ton ha⁻¹).

Root composition

Table 2 shows the data on the composition of sugary cassava landraces. The São Francisco Bag

Table 1 - Root yields per plant by sugary cassava landraces.

Yield	Landrace		
	S. F. Bag 3 ^a	Manicueira 62	Castanhal Iracema
Root with peel ^b	8.16	5.73	3.93
Root without peel ^b	7.32	4.98	3.46
Ratio root/peel	9.71	7.64	8.36

^a São Francisco Bag 3; ^b kg plant⁻¹.

3 landrace had the highest water content of the three (though all three were above 90%) while conventional cassava has a water content of approximately 65% (CEREDA, 2001; HILLOCKS et al., 2002).

The Manicueira 62 landrace had the highest levels of reducing and total sugars (4.67 and 5.84g 100g⁻¹ of root), while the São Francisco Bag 3 landrace had the greatest yields of those sugars per plant (290 and 350g plant⁻¹). However, the three landraces had high levels of reducing sugars (≥ 3.71 g 100g⁻¹ of root) and total sugars (≥ 3.92 g 100g⁻¹ of root) when compared to those found in conventional cassavas (≤ 0.48 and ≤ 0.83 g 100g⁻¹ of root, respectively) (HILLOCKS et al., 2002). The reducing sugars, consisting mainly of glucose, represent the largest part of the total sugars in the three sugary cassava landraces ($\geq 80\%$), however according to CARVALHO et al. (2004), on sugary cassava exist other sugars that were not quantified in this research,

such as galactose, arabinose and rhamnose. This may explain the difference between the sugars determined by chromatography (glucose, fructose and sucrose) and sugars determined by titration (total and reducing sugars). This root composition justifies the use of sugary cassava landraces for the production of a concentrate rich in glucose and fructose.

The Manicueira 62 had the highest starch content (4.40g 100g⁻¹ of root, 219g plant⁻¹) of the three. However, this content is significantly lower than that of conventional cassava (25-30g 100g⁻¹ of root) (VIEIRA et al., 2008). Based on the estimated root productivity of the Manicueira 62 landrace (57.30ton ha⁻¹), the yield in starch would be 2.19ton ha⁻¹ while that a conventional 12-month-old cassava plant would be more than double (4.5ton ha⁻¹) (SAGRILO et al., 2002).

The Manicueira 62 landrace also had the highest protein (0.29%) and lipid (0.17%) content,

Table 2 - Root composition of the sugary cassava landraces.

Component ^c	Landrace		
	S. F. Bag 3 ^d	Manicueira 62	Castanhal Iracema
Moisture content	92.97 \pm 0.56 ^a	90.01 \pm 0.76 ^b	91.01 \pm 0.98 ^b
Reducing sugars	3.96 \pm 0.06 ^b	4.67 \pm 0.10 ^a	3.71 \pm 0.09 ^c
Total sugars	4.76 \pm 0.07 ^b	5.84 \pm 0.12 ^a	3.92 \pm 0.04 ^c
Glucose	2.25 \pm 0.29 ^a	1.31 \pm 0.15 ^b	1.88 \pm 0.06 ^a
Fructose	1.61 \pm 0.20 ^a	0.97 \pm 0.11 ^b	1.54 \pm 0.10 ^a
Sucrose	1.41 \pm 0.16 ^a	1.17 \pm 0.12 ^a	0.84 \pm 0.06 ^b
Starch	1.95 \pm 0.03 ^b	4.40 \pm 0.09 ^a	1.27 \pm 0.02 ^c
Proteins	0.17 \pm 0.00 ^c	0.29 \pm 0.01 ^a	0.20 \pm 0.01 ^b
Lipids	0.06 \pm 0.00 ^b	0.17 \pm 0.01 ^a	0.17 \pm 0.01 ^a
Ashes	0.09 \pm 0.03 ^a	0.16 \pm 0.03 ^a	0.17 \pm 0.03 ^a
Total fibers	ND	ND	3.01 \pm 0.11
Insoluble fibers	ND	ND	2.65 \pm 0.09
Soluble fibers	ND	ND	0.36

^c g 100g⁻¹ of root (wet basis); ^d São Francisco Bag 3. Mean values in the same row followed by different subscript letters are significantly different ($P \leq 0.05$ by Tukey's test); ND – Not determinate.

not differing statistically ($P>0.05$) from the Castanhal Iracema landrace in terms of lipids. On average, the traditional varieties of cassava are made up of 0.53% protein and 0.17% lipids. The ash content of the sugary cassava landraces ($\leq 0.17\%$) was less than that found in conventional cassava (0.84%) (HILLOCKS et al., 2002).

The Castanhal Iracema landrace was made up of 3.01% of total dietary fiber, most of which was insoluble fiber (88.03%). The amount of dietary fiber was determined only for this one landrace since the total sum of the other constituent parts of the other landraces was almost 100%, indicating the low contribution of dietary fiber.

Physicochemical properties of the sugary cassava roots

Table 3 shows the data regarding the physicochemical properties of the sugary cassava landraces. The Castanhal Iracema landrace had lower soluble solids content (4.29%) and the São Francisco Bag 3 landrace had the lowest pH (6.62) and the greatest acidity (2.50meq NaOH 100g⁻¹ of root). As such, all the sugary cassava landraces studied are classified as low acidity products (pH>4.6), according to FELLOWS (2009). The three sugary cassava landraces had a high pH (≥ 6.62) and water activity (≥ 0.98) and are thus regarded as being susceptible to degradation when they are not utilized right after harvesting or when they do not undergo appropriate technological processing.

All three sugary cassava landraces were found to have low free cyanide content ($< 3\text{mg kg}^{-1}$ of root) with the Castanhal Iracema landrace having the lowest of the three on average (2.73mg kg⁻¹ of root). However, the three landraces showed high levels of total

cyanide ($> 100\text{mg kg}^{-1}$ of root), characterizing them as poisonous or unfit for fresh consumption (BOLHUIS, 1954). VIEIRA et al. (2008) evaluated four sugary cassava landraces and all had cyanide content between 115 and 150mg kg⁻¹ of root. According to CARDOSO et al. (2005) the proportion of cyanide in the cassava roots can vary from 1 to 1,550mg kg⁻¹ of root, but the processing of these roots, especially the heating, may reduce their toxicity.

In evaluating the color parameters, the chromaticity coordinate a* tended towards light green in all roots. According to coordinate b*, the three sugary cassava landraces tended towards yellow ($b^*>+6.30$); there was no significant difference ($P>0.05$) among the samples, thus all the roots had a cream color. The cassava root may have several different colors depending on the variety, with cream-, white-, yellow- or even red-colored roots (CARVALHO et al., 2000).

CONCLUSION

The three sugary cassava landraces had high proportions of sugars, consisting mainly of glucose and fructose. This root composition justifies the use of sugary cassava landraces for the production of a concentrate rich in glucose and fructose, mainly the São Francisco Bag 3.

The sugary cassava landraces had a high pH and water activity and are thus regarded as being susceptible to degradation when they are not utilized right after harvesting or when they do not undergo appropriate technological processing.

Table 3 - Physicochemical properties of the sugary cassava roots.

Properties	-----Landrace-----		
	S. F. Bag 3 ^d	Manicueira 62	Castanhal Iracema
Solid solubles ^e	5.69 ± 0.12 ^a	6.29 ± 0.61 ^a	4.29 ± 0.06 ^b
Acidity ^f	2.50 ± 0.03 ^a	1.85 ± 0.08 ^b	1.64 ± 0.07 ^c
pH ^g	6.62 ± 0.02 ^b	6.83 ± 0.05 ^a	6.83 ± 0.05 ^a
Water activity ^g	0.98 ± 0.00 ^b	0.99 ± 0.00 ^a	0.99 ± 0.00 ^a
Free cyanide ^h	2.92 ± 0.08 ^a	2.98 ± 0.07 ^a	2.73 ± 0.05 ^b
Total cyanide ^h	205.87 ± 4.48 ^a	198.65 ± 16.26 ^a	195.49 ± 3.67 ^a
Color parameter, L* ^g	56.39 ± 3.56 ^b	69.17 ± 4.40 ^a	60.69 ± 1.81 ^{ab}
Color parameter, a* ^g	- 1.18 ± 0.07 ^a	- 0.97 ± 0.07 ^b	- 0.98 ± 0.08 ^b
Color parameter, b* ^g	+ 7.32 ± 0.23 ^a	+ 6.34 ± 0.44 ^a	+ 7.01 ± 0.49 ^a

^d São Francisco Bag 3; ^e °Brix; ^f meq.NaOH 100g⁻¹ of root; ^g dimensionless; ^h mg kg⁻¹ of root. Mean values in the same row followed by different subscript letters are significantly different ($P \leq 0.05$ by Tukey's test).

All of the sugary cassava landraces showed high levels of total cyanide, characterizing them as poisonous or unfit for fresh consumption.

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