International Scholars Journals

African Journal of Agriculture and Food Security ISSN 2375-1177 Vol. 7 (7), pp. 001-006, July, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods

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Accepted 10 April, 2019

This study investigated the chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. Tapioca grits (partially gelatinized irregular flakes from roasted cassava starch), were produced from three different cassava varieties (Odongbo, TMS 30572 and Oko-iyawo) and two roasting methods (traditional and rotary dryer). The chemical composition and pasting properties of the tapioca grits were evaluated. The results showed that the effect of cassava variety and roasting methods on chemical composition of tapioca grits was significantly different (P<0.05). The principal component analysis (PCA) of variation in the chemical properties of the tapioca grits indicated that moisture, sugar and starch accounted for 83% of the variation in the chemical properties of tapioca grits. This study showed that peak and hot paste viscosities are the key pasting parameters in characterizing tapioca grits from the cassava varieties and roasting methods studied and that variation in peak viscosity of the tapioca grits might be due more too varietal influence than the roasting method.

Key words: Cassava, variety, roasting, tapioca grits, chemical, pasting.

INTRODUCTION

Cassava is one of the most drought tolerant crops and can be successfully grown on marginal soils, giving reasonable yields where many other crops do not grow well. The Collaborative Study on Cassava in Africa (COSCA) revealed that between 1961 and 1999, total cassava production in Africa nearly tripled from 33 million tonnes per year from 1961 to 1965, and to 87 million tones per year from 1995 to 1999, in contrast to the more moderate increases in Asia and Latin America (Nweke et al., 2002). Most of the increases in cassava production in Africa were achieved in Ghana and Nigeria. One of the advantages cassava has over other starchy crops is the variety of uses to which the roots can be put. Apart from being a staple food for humans (especially in Africa), it additionally has an excellent potential as livestock feed, and in textile, plywood, paper, brewing, chemical and pharmaceutical industries. Originally, the research focused on improved yields, cultivation practices and crop protection. Cassava research has, since 1985, also focused on processing, quality control and new product development (Dufour et al., 2002). A major constraint to cassava utilization is that cassava deteriorates rapidly. Cassava has a shelf life of 24 – 48 h after harvest (Wenham, 1995). Hence, fresh cassava roots must be processed into a more shelf -stable form within 2 to 3 days from harvest. One of such cassava product is tapioca grit. Tapioca grit is a partially gelatinized dried cassava starch, which appears as flakes or irregularly shaped granules. It is consumed in many parts of West Africa, and widely accepted as a convenient diet (Hollesman and Ates, 1956).

A number of reports are available in the literature on tapioca (Oyewole and Obieze, 1995; Sanni et al., 1997; Oyewole et al., 2003; Adebowale et al., 2006, 2007). There is no published work on the effect of cassava variety and roasting methods on chemical and pasting of tapioca grits. The main objective of this study therefore was to evaluate the effect of cassava varieties and roasting methods on the chemical composition and pasting properties of tapioca grits.

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Table 1. Chemical components (%) of tapioca grits from different cassava variety and roasting method.

Tapioca samples	Moisture	Sugar	Starch	Carbohydrate	Amylose	Protein	Fat
Odongbo Traditionally roasted	9.30^{b}	2.25^{b}	92.08^{bc}	94.34^{b}	23.12^{a}	0.24^{a}	0.25^{c}
Odongbo rotary dryer roasted	10.53^{b}	2.59^{c}	94.75^{d}	97.34^{c}	22.95^{a}	0.23^{a}	0.21^{bc}
TMS 30572 traditionally roasted	7.80^{a}	2.75^{c}	87.59^{a}	90.34^{a}	24.20^{b}	0.23^{a}	0.20^{bc}
TMS 30572 rotary dryer roasted	7.20^{a}	2.09^{ab}	93.81^{cd}	95.90^{bc}	24.30^{b}	0.26^{b}	0.20^{bc}
Oko-iyawo traditionally roasted	9.53^{b}	2.82^{c}	86.96^{a}	89.79^{a}	23.19^{a}	0.24^{a}	0.15^{ab}
Oko-iyawo rotary dryer roasted	7.40^{a}	1.88^{a}	89.96^{b}	91.85^{a}	23.27^{a}	0.23^{a}	0.12^{a}
Range	7.20-10.50	1.88-2.75	86.96-94.75	89.79-97.34	22.95-24.30	0.23-0.26	0.12-0.25
SD	1.35	0.38	3.32	3.08	0.59	0.01	0.05
CV	7.4	5.94	1.51	1.43	1.01	3.64	18.85
P of Variety	***	ns	***	***	***	ns	***
P of Roasting Method	ns	***	***	***	ns	ns	ns
P of Variety X Roasting Methods	***	***	Ns	ns	ns	***	ns

*** Interactions significant at P<0.01

ns. Interactions not significantly different at P>0.05

Mean values having the same superscript with column are significantly different (P<0.05)

MATERIALS AND METHODS

Three cassava varieties (one improved variety; TMS30572, and two traditional varieties; *Odongbo* and *Oko-iyawo*) were obtained from the Teaching and Research Farm of the University of Agriculture, Abeokuta, Nigeria. The varieties were grown under rain-fed conditions. No fertilizer or herbicides were used, and hand weeding was done when necessary. All the cassava varieties were harvested at 12 months after planting. The harvested roots were processed within 60 min after harvesting.

Preparation of tapioca grits

Fifty kg of freshly harvested cassava roots were peeled, washed with water and grated with a diesel engine powered mechanical grater (action zone made of 3 mm stainless steel, Nigerian made). The resultant pulp was immediately sieved through a screen and suspended in 70l of water. This separates the fibrous and other coarse root material from the starch pulp. The starch pulp was allowed to settle for 4 - 6 h before decanting. The thick starch cake at the bottom of the bowl was pressed to remove water. This was screened through a screen (20mesh/inch size) to produce coarse-grained moist starch flour.

In the traditional method, the moist starch flour was roasted over an open firewood flame in a large, shallow stainless steel pan for 20 min at temperature range 120 - 150°C with constant stirring using a piece of stainless steel plate. Vegetable oil was used to rub the pan before roasting to prevent stickiness and burning (Adebowale et al., 2006). In the rotary dryer method, the moist starch flour was roasted in a locally fabricated electrically powered rotary dryer. Charcoal was used as heating source (Figure 1) . Roasting temperature was 100^{o}C and an elapsed time of 20 min. The dryer has a suction fan that removes steam generated during roasting. The fan was switched off during the first 10 min after loading the flour into the dryer to effect partial gelatinization. The fan was switched on thereafter to effect drying of the partially gelatinized starch granules (Sanni et al., 2006). The rotary dyer has a drying capacity of 250 kg/man day.

Analytical determinations

The moisture, protein and fat contents of the samples were determined using the AOAC (1990) method. The starch and total sugars content were determined using a colorimetric method (Dubois et al., 1956). Absorbance was read at 490 nm using a spectrophotometer (model Spectronic 601, Milton Roy Company, USA). The amylase content was determined using the method of Williams et al (1958) involving the preparation of stock iodine solution and iodine reagent. Absorbance was read using a pectrophotometer at 620 nm. A blank was used to standardize the spectrophotometer.

Pasting properties were determined using a Rapid Visco Analyser (RVA) (model RVA 3D+; Network Scientific, 5Australia). The sample was turned into slurry by mixing 3 g with 25 ml of water inside the RVA can and inserted into the tower, which was then lowered into the system. The slurry was heated from 50 to 95°C and cools back to 50°C within 12 min, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. Parameters estimated were peak viscosity, setback viscosity, final viscosity, pasting temperature and time to reach peak viscosity.

Statistical analysis

Each analytical determination was carried out in three replicates. Data were subjected to analysis of variance (ANOVA) and principal component analysis (PCA) using SAS version 8e software (SAS Institute Inc., Cary, NC, USA) at *P*<0.05. Means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSIONS

Chemical composition of tapioca grits from different cassava varieties and roasting methods

The effect of cassava varieties and roasting methods on the chemical properties of tapioca grits from different cassava varieties and roasting methods are presented in Table 1. Rotary dryer roasted TMS 30572 tapioca grits had the least moisture while traditionally roasted tapioca grits from *Odongbo* cassava variety had the highest moisture content. The lower the initial moisture content of a product to be stored the better the storage stability of

Table 2. Percentage variance explained by each chemical component of tapioca grits.

Component Number	Component Name	Eigenvalues	% of variance	Cumulative %
1	Moisture	2.57	36.72	36.72
2	Sugar	2.11	30.11	66.83
3	Starch	1.16	16.53	83.36
4	Carbohydrate	0.68	9.68	93.05
5	Amylose	0.33	4.68	97.73
6	Protein	0.16	2.27	100.00
7	Fat	1.35E-07	1.93E-06	100.00

Extraction Method: Principal Component Analysis.

the product. Also, the lower the initial moisture content of the product the more the efficiency of the drying method because this shows that much of the water contained in the fresh sample or product had been removed during drying (Pierre, 1989). The moisture content of all the tapioca grits were below the 10% stipulated standard of the revised regulation of the Standard Organization of Nigeria (SON, 1988; Sanni et al., 2005). All the tapioca grits can be stored for up to 7 months because their moisture contents were below the levels reported by Ukpabi and Ndimele (1990) who found that *gari* samples with a moisture content of < 16% but > 13% could be stored for 2- 7 months without mould infestation. The varietal effect on the moisture content of tapioca grits was significantly different ($P<0.01$), but the effect of roasting methods was not significantly different ($P>0.05$) . This indicates that irrespective of either traditional or rotary dryer roasting, tapioca grits with low moisture and hence longer shelf life can be produced from the cassava varieties processed.

Tapioca grits from TMS 30572 traditionally roasted had the highest sugar content while rotary dryer roasted tapioca grits from *Oko-iyawo* cassava contained the minimum level of sugar. Traditionally roasted tapioca grits from *Oko-iyawo* cassava variety had the least content of starch while the rotary dryer roasted *Odongbo* variety tapioca grits had the highest starch content. Similar trend was displayed by the carbohydrate content. Tapioca grit is essentially a starchy product from moistened roasted cassava starch. The starch and sugar content for all tapioca grits were higher than values recorded by Oyewole and Obieze (1995). The amylose content of the tapioca grits ranged between 22.95% and 24.30%, with rotary dryer roasted tapioca grits recording the highest amylose content and rotary dryer roasted *Odongbo* tapioca grits containing the highest amount of amylose. The protein and fat content of the tapioca grits ranged from 0.23 to 0.26% and from 0.12 to 0.25% respectively. The amylose content of the tapioca grits were higher than that obtained by Oyewole and Obieze (1995). Raja and Ramakrishna (1990) reported that heat treatment causes a reduction in the amylose content of cassava, but this study showed little variation in the amylose content of tapioca grits from the two roasting methods. Also, the interactions between cassava variety and roasting methods on amylose content of the tapioca grits were not significantly different ($P>0.05$), but the varietal effect was significantly different ($P<0.01$).

The parameters of Principal Component Analysis (PCA) are as shown in Table 2. The results showed that moisture, starch and sugar content accounted for 83% of the variations in the chemical properties of the tapioca samples. Hence, in characterizing the chemical composition of tapioca grits from different cassava variety and roasting methods, moisture, sugar and starch are the key components of variance assessment.

Pasting properties of tapioca grits from different cassava varieties and roasting methods

The pasting profile of tapioca grits from different cassava varieties and roasting methods are shown in Table 3. Tapioca grits are usually cooked into paste referred to as tapioca meal before consumption, although some consumer's prefer eating tapioca grits as snack. The pasting properties become important in predicting the behaviour of tapioca paste during and after cooking. When starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size. Over a critical temperature, which is characteristics of a parti-cular starch, the starch undergoes an irreversible process known as gelatinization. When the temperature rises above the gelatinization temperature, the starch granules begin to swell and viscosity increases on shearing. The temperature at the onset of this rise in viscosity is referred to as the pasting temperature. The pasting temperature of the tapioca samples was lower than values reported for other cassava products (Sanni and Jaji, 2003; Sanni et al., 2004; Adebowale et al., 2005). The lower pasting temperature exhibited by tapioca grits is as a results of the partial gelatinization of starch granules during roasting. The pasting temperature is a measure of the minimum temperature required to cook a given food sample, it can have implications for the stability of other

Table 3. Pasting properties of tapioca grits from different cassava varieties and roasting methods.

Tapioca samples	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Set back viscosity (RVU)	Peak time (min)	Pasting temperature (°C)
Odongbo Traditionally roasted	449.30^{b}	162.55^{a}	285.91^{b}	210.89^{a}	48.33^{a}	3.85^{bc}	63.53^{b}
Odongbo rotary dryer roasted	352.86^{a}	179.03^{c}	173.84^{a}	244.16^{b}	65.14^{b}	4.27^{d}	63.60^{b}
TMS 30572 traditionally roasted	477.83^{bc}	176.78^{bc}	282.44^{b}	233.89^{b}	57.11^{ab}	3.76^{b}	63.07a
TMS 30572 rotary dryer roasted	476.52^{bc}	165.42^{b}	282.25^{b}	228.05^{ab}	62.64^{b}	3.63^{a}	63.17^{a}
Oko-iyawo traditionally roasted	513.55^{c}	178.44^{c}	325.19^{c}	237.14^{b}	58.70^{ab}	3.82^{bc}	63.17^{a}
Oko-iyawo rotary dryer roasted	467.30^{bc}	167.97^{ab}	294.17^{bc}	226.81^{ab}	58.83^{ab}	3.89^{c}	63.17^{a}
Range	352.86-513.55	162.55-179.03	173.84-325.19	210.89-244.16	48.33-65.14	3.63-4.27	63.07-63.60
	6.48	2.63	10.28	4.59	11.56	1.13	0.21
P of Variety	***	ns	***	ns	ns	***	**
P of Roasting Method	**	ns	**	ns	**	***	ns
P of Variety X Roasting Methods	Ns	***	**	**	ns	***	ns

*** Interactions significant at P<0.01
**Interactions significant at P<0.05
ns Interactions not significantly different at P>0.05

components in a formula and also indicate energy costs (Newport Scientific, 1998). The pasting temperature of the tapioca grits is generally lower than the boiling temperature; hence the tapioca grits can form a paste in hot water below boiling point. This, at commercial level, is a remarkable cost saving. As the temperature increases during the pasting test, the granules rupture and amylose leaches into the solution, followed at a slower rate in some cases by the amylopectin fraction. The series of processes that follow gelatinization is collectively referred to as the pasting profile.

Peak viscosity, which is the maximum viscosity, developed during or soon after the heating portion of the pasting test (Newport Scientific, 1998), is also lower compared to values obtained for dried fufu by Adebowale et al. (2005). This is also because tapioca is partially gelatinized. Varietal differences exist in the peak viscosity of the tapioca grits at $P<0.01$, while the effect of different roasting methods is significant at $P<0.05$.The statistical significant ($P>0.05$). Therefore, variation in peak viscosity of the tapioca grits might be due more to genetic variation interaction between variety and roasting method is not than processing variable. Peak viscosity is often correlated with the final product quality. It also provides an indication of the viscous load likely to be encountered during mixing (Maziya- Dixon et al., 2004, 2005). It is customary to measure the peak time that occurs with peak viscosity. The peak time is a measure of the cooking time (Adebowale et al., 2005). The time to attain peak viscosity obtained for tapioca grits is considerably lower than that reported for other cassava product by Sanni et al. (2004) and Adebowale et al. (2005). This might be due to the fact that tapioca is partially gelatinized. During the hold period of a typical pasting test, the sample is subjected to a period of constant temperature (usually 95°C) and mechanical shear stress. This further disrupts the starch granule and amylose molecules generally leach out into solution and align in the direction of the shear (Maziya-Dixon et al., 2005). The period is sometimes called shear thinning, holding strength, hot paste viscosity or trough due to the accompanied breakdown in viscosity. It is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during

Table 4. Percentage variance explained by each of the pasting parameters.

Component number	Component name	Eigenvalues	% of Variance	Cumulative %
1	Peak	4.09	58	58
2	Trough	1.81	26	84
3	Breakdown	0.54	8	91
4	Final viscosity	0.43	6	98
5	Set back	0.12	2	99
6	Peak time	8.93E-03	0.13	100
7	Pasting temperature	1.91E-08	2.72E-07	100

Extraction Method: Principal Component Analysis.

cooling (Newport Scientific, 1998). The effect of cassava variety as well as the roasting method on the hot paste viscosity of tapioca grits is not significant ($P>0.05$). But the interaction between variety and roasting method is significant at $P<0.01$. Large values indicate little breakdown of sample starches.

The rate of starch breakdown depends on the nature of the material, the temperature, and the degree of mixing and shear applied to the mixture (Newport Scientific, 1998) . The ability of a mixture to withstand heating and shear stress that is usually encountered during processing is an important factor for many processes especially those requiring stable paste and low retrogradetion/seneresis. The breakdown viscosity recorded by traditionally roasted tapioca grits is higher than those of the rotary dryer method for all the three varieties. There are significant differences in the breakdown viscosity for tapioca grit from different cassava varieties and roasting methods ($P<0.05$).

The final viscosity indicates the ability of the starch-based food to form a viscous paste or gel after cooking and cooling. The viscosity after cooling to 50°C represents the setback or viscosity of cooked paste. It is a stage where retrogradation or re-ordering of starch molecules occurs. Sanni et al*.,* (2004) stated that lower setback during the cooling of the paste indicates greater resistance to retrogradation.

Principal component analysis (PCA) for the pasting parameters of the tapioca grits showed that peak viscosity and hot paste viscosity accounted for 84% of the variance in the pasting profile of tapioca grits from different cassava variety and roasting methods (Table 4).

Conclusion

This study has revealed that in characterizing the chemical composition of tapioca grits from different cassava variety and roasting methods, moisture, sugar and starch are the key component of variation in chemical composition of tapioca. The pasting temperature of the tapioca grits is generally lower than the boiling temperature; hence the tapioca grits can form a paste in hot water below boiling point. This, at commercial level, is a remarkable cost saving. This study found out peak and hot paste viscosities as the key pasting parameters in characterizing tapioca grits from the cassava varieties and roasting methods studied and that variation in peak viscosity of the tapioca grits might be due more to genetic variation than roasting method.

ACKNOWLEDGEMENT

The authors wish to acknowledge the financial support by EU/INCDEV/UNAAB Cassava SME project and the Integrated Cassava Project, International Institute of Tropical agriculture, Ibadan, Nigeria.

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