Comparative study of the functional, proximate and sensory qualities of yellow-flesh sweet potato and cassava starch tapioca grits

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Abstract
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. Sweet potato is highly underutilized in Nigeria and many West African countries. Hence, producing tapioca grits from sweet potato starch has the potential of adding value to underutilized plant species in Nigeria. This study was therefore conducted to produce and evaluate the quality of tapioca grits made from yellow-fleshed sweet potato starch. Starch was extracted from yellow-fleshed sweet potato tuber and processed into tapioca grits. The tapioca grits were analyzed for proximate, functional, pasting, and sensory properties using standard laboratory procedures. Tapioca from cassava starch was used as control. The moisture, protein and carbohydrate contents of sweet potato starch tapioca grits were significantly different P≤0.05) from that of tapioca grits from cassava starch while ash, fat and fibre contents were not significantly different (P>0.05). The functional properties of the yellow-fleshed sweet potato tapioca grits were significantly different (P≤0.05) from cassava starch tapioca grits. The mean sensory scores for colour, flavour, taste, texture and overall acceptability of the tapioca grit samples ranged from 6.55-8.30, 6.75-6.90, 6.95-7.15, 6.30-7.80 and 7.15-7.40, respectively. The study concluded that tapioca grits of acceptable functional and sensory qualities can be obtained from yellow-fleshed sweet potato. Findings from this study are useful in finding alternative economically viable uses for orange fleshed sweet potato in West Africa.

Key words: proximate composition, functional properties, sensory evaluation

Introduction
Sweet potato (*Ipomea batatas* (L.) Lam.) is a high yielding crop with wide adaptation and high resistance to drought (*Lu et al*., 2006). The roots are rich in starch, sugars, vitamin C, pro-vitamin A, iron and minerals (Woolfe, 1992). Starch from sweet potato is very valuable for professional and home cooks. This starchy root vegetable is also a rich source of flavonoid anti-oxidants, vitamins, minerals, and dietary fiber that are essential for optimal health.

A recent report by Olorunnisomo (2007) revealed that in Nigeria, sweetness in tuber crops is largely unacceptable and that yam is preferred to sweet potato root as a staple hence sweet potato is usually consumed as a snack. During periods of peak production a high proportion of the sweet potato root produced is wasted because supply exceeds demand at these periods. Despite its growing importance and known potential as food and raw material source, records of sweet potato production, processing and marketing in Nigeria's food system are scanty (Fawole, 2007). Post-harvest losses for sweet potatoes like other root and tuber crops appear to be higher than for the cereal crops, given their higher water content and bulkiness. Sweet potatoes are perishable; therefore a certain percentage of the harvest is lost. Processing and value addition offers great potential for increased productivity and utilization of sweet potato tubers.

Tapioca grits is customarily made from partly gelatinized cassava starch through the application of heat treatment to moist mash in shallow pans. When heated, the wet granules gelatinize, burst and stick together. The mass is stirred to prevent scorching. It is manufactured in the form of irregular lumps called grits. Tapioca is consumed in many parts of West Africa (Adebowale et al 2005, 2007). It is usually soaked or cooked in water; sugar (and/or) milk is added before consumption as gruel (Adebowale and Sanni, 2013). The high postharvest losses and low consumption of sweet potato may be enhanced by the development of convenience foods such as tapioca grits. Hence, the goal of this study is to convert sweet potato into a more shelf stable product and thus increase its commercial utilization.

Materials and Methods

Source of raw materials

Sweet potatoes were purchased from Kuto market in Abeokuta, Ogun State, Nigeria, while freshly harvested cassava roots were obtained from the Teaching and Research Farms of the Federal University of Agriculture, Abeokuta, Nigeria.

Processing of sweet potato and cassava starch

The sweet potato tuber was sorted, peeled, washed with tap water and sliced using a vegetable slicer. The sliced sample (10 kg) was ground using a blender and the slurry was filtered twice through 250 μm and 106 μm metallic sieves to allow most of the starch granules to pass. The starch suspension was allowed to stand for 2 h. The starch granules were recovered by decanting.

Also, the cassava roots were peeled, washed and grated with diesel engine powered mechanical grater. The resultant pulp was immediately sieved with a muslin cloth and suspended in 15 L 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.

Processing of sweet potato and cassava tapioca

This was done using the traditional method of Oyewole and Obieze (1995) as modified by Adebowale et al (2008). The moist starch was roasted over an open firewood flame in a large, shallow stainless steel pan for 20 min at temperature range 120-150 °C with a constant stirring using a piece of stainless steel plate. Vegetable oil was used to rub the pan before roasting to prevent stickiness and burning.

Determination of Proximate Composition

The moisture, protein, fat, ash, and crude fibre contents of the tapioca grits were determined using the method described by AOAC (1990). Carbohydrate content was determined by differ [i.e % carbohydrate = 100 – (% moisture + % crude protein + % fat + % crude fibre + % ash)]

Functional Properties Determination

Bulk density was determined by the method of Wang and Kinsella (1976), water absorption by Anderson *et al*. (1982), swelling power by Takashi and Seib (1988), dispersibility by the method described by Kulkarni (1991), and wettability index was carried out on the sample using the method described by Okezi and Bello (1988). The pH of the sample was measured with a pH meter.

Pasting properties analysis

A Rapid Visco Analyser, RVA (Model RVA-SUPER3) was used to assess the pasting characteristics of the tapioca samples.

Results and Discussion

Pasting properties of yellow-fleshed sweet potato and cassava tapioca

The pasting profile of Tapioca grits from Sweet Potato and Cassava starches are shown in Table 1. The peak viscosity, trough, breakdown, final viscosity, setback, of sweet potato starch tapioca was significantly different ($P \leq 0.05$) from the control. The peak viscosity which is the maximum viscosity developed during or soon after the heating portion of the pasting test (Newport Scientific, 1998) was lower compared to values obtained for cassava tapioca by Adebowale *et al*., (2008). Sweet potato tapioca had the highest peak, trough, final and setback viscosities of 406.20, 273.90, 443.25 and 169. 35 RVU, respectively at pasting temperature of 72.95 °C. Tapioca grits are usually cooked into paste or the tapioca grits taken as snacks. The pasting properties become important in predicting the behavior of tapioca paste during and after cooking. The pasting temperature of the sweet potato tapioca was higher than values reported by Adebowale *et al.,* (2008) for tapioca grits from different cassava variety. The pasting temperature is a measure of the minimum temperature required to cook a given food sample, it can have implication for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998). Hence, sweet potato tapioca grits will require higher temperature to cook compared to cassava tapioca. 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. The peak viscosity of sweet potato tapioca was found to be higher than that of cassava tapioca.

Peak viscosity provides information on the viscous load likely to be encountered during mixing (Adebowale et al 2008). 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., 2007). The period is sometimes called shear thinning 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 cooling. Higher trough value recorded by sweet potato starch indicates that its paste is more stable compared to cassava tapioca. Setback viscosity is an index of resistance of starch paste to retrogradation. Higher setback viscosity exhibited by sweet potato tapioca implies that it's more prone to retrogradation than cassava tapioca (Adebowale et al 2008).

Proximate composition of yellow-fleshed sweet potato and cassava tapioca

The proximate composition of tapioca grits made from sweet potato and cassava starch are shown in Table 2. Cassava tapioca had the lowest moisture content while sweet potato tapioca had the highest. The lower the initial moisture content of a product to be stored, the better the storage stability of 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 product had been removed during drying. The moisture content of the cassava tapioca was below the 10 % stipulated specifications in the revised regulation of the Standard Organization of Nigeria (SON, 1988; Sanni *et al*., 2005) while that of the sweet potato tapioca (10.13 %) was slightly higher. However, both the tapioca grits can be stored for up to 7 months because their moisture content was 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 moisture, protein and carbohydrate contents are significantly different ($P<0.05$) while ash, fat and crude fibre contents were not significant ($P>0.05$). The fat content ranged from 0.26 % in cassava tapioca to 0.39 % in sweet potato tapioca. Fat is important in diet because it is a high energy nutrient and does not add to the bulk of the diet (Bogert *et al*., 1994). Crude Fibre which is the amount of indigestible sugars present in a food sample was highest in sweet potato tapioca (0.25 %) and lowest in cassava tapioca (0.20 %). It has been reported that a diet low in fibre is undesirable as it could cause constipation and that such diets have been associated with diseases of colon like piles, appendicitis and cancer (Okon, 1983).

Functional properties of yellow-fleshed sweet potato and cassava tapioca

Table 3 shows the functional properties of sweet potato and cassava tapioca. Significant variation ($P<0.05$) was found between the functional properties of sweet potato and cassava tapioca samples.. Cassava tapioca had the highest water absorption capacity of 8.07 % while Sweet potato tapioca had the lowest water absorption capacity of 4.40 %. The bulk density of sweet potato tapioca was higher than that of cassava tapioca. Plaami, (1997) reported that bulk density is influenced by the structure of the starch polymers, and loose structure of the starch polymers could result in low bulk density. Water absorption capacity is influenced by quantity of damaged and undamaged starch contained in the tapioca samples. Adebowale et al (2005) reported that more water is absorbed by undamaged starch than damaged starch. This means that cassava tapioca was least damaged during roasting because the more the water absorption capacity, the better for the tapioca sample.

Tapioca from yellow-fleshed sweet potato starch had the lowest dispersibility of 64.0% and cassava tapioca had the highest value of 76.0%. The higher the dispersibility, the better the flour reconstitutes in water Adebowale et al (2005, 2008). According to Kulkarni *et al*. (1991), the higher the dispersibility of a product, the higher its reconstitutability. Sweet potato tapioca had the lowest wettability of 125.67s while cassava tapioca had the highest value of 162.67s.

Sensory qualities of yellow-fleshed sweet potato and cassava tapioca

The sensory panelist scores for yellow-fleshed sweet potato and cassava tapioca meal is shown in Table 4. The colour, flavour, taste, texture and overall acceptability of the tapioca meal from sweet potato and cassava ranged from 6.55 (sweet potato tapioca meal) to 8.30 (cassava tapioca meal), 6.75 (cassava tapioca meal) to 6.90 (sweet potato tapioca meal), 6.95 (cassava tapioca meal), to 7.15 (sweet potato tapioca meal), 6.30 (sweet potato tapioca meal) to 7.80 (cassava tapioca meal) and 7.14 (sweet potato tapioca) to 7.40 (cassava tapioca meal) respectively. The sensory rating of the sweet potato tapioca meal was not significantly (P>0.05) different from that of cassava tapioca meal except for colour and texture. The overall acceptability was found to be highest for cassava tapioca meal with a score of 7.40 while it was 7.15 for sweet potato tapioca meal.

Conclusion

The production and quality evaluation of yellow–fleshed sweet potato tapioca was achieved in this study. The sweet potato tapioca was more acceptable than cassava tapioca in terms of taste and flavour, although, cassava tapioca had the highest value of overall acceptability.

Table 1: Pasting Properties of yellow-fleshed sweet potato and cassava tapioca grits

Tapioca	Peak Viscosity	Trough	Breakdown	Final viscosity	Setback	Peak time (min)^{ns}	Pasting temperature (°C)
			(RVU)				
Sweet Potato	406.20±4.4^{b}	273.90±2.7^{b}	132.30±1.7^{a}	443.25±5.7^{b}	169.35±3.0^{b}	4.83±0.1	72.95±0.6^{b}
Cassava	363.30±8.2^{a}	195.95±3.2^{a}	167.35±5.0^{b}	267.60±3.8^{a}	71.65±0.6^{a}	4.17±0.1	50.23±0.04^{a}

± Standard deviation of 3 replicates
Means values having different superscript within the same column are significantly different (P≤0.05)
ns = no significant difference (P>0.05)

Table 2: Proximate composition (%) of yellow-fleshed sweet potato tapioca and cassava tapioca grits

Tapioca sample	Moisture content	Ash	Protein	Fat	Crude Fibre^{ns}	Carbohydrate^{ns}
Sweet Potato	10.13±0.5^{b}	0.67±0.2^{a}	0.38±0.01^{b}	0.39±0.07^{b}	0.25±0.05	88.18±0.8
Cassava	8.57±0.5^{a}	0.80±0.0^{b}	0.23±0.03^{a}	0.26±0.06^{a}	0.20±0.06	89.94±0.5

± Standard deviation of 3 replicates
Means values having different superscript within the same column are significantly different (P≤0.05).
ns = no significant difference (P>0.05)

Table 3: Functional properties of yellow-fleshed sweet potato and cassava tapioca grits

Tapioca sample	Water Absorption Capacity (%)	Dispersibility (%)	pH	Bulk density (g/ml)	Wettability (s)
Sweet Potato	4.40±0.2^{a}	64.00±4.0^{a}	5.45±0.02^{b}	0.82±0.01^{b}	125.67±1.5^{a}
Cassava	8.07±0.4^{b}	76.00±2.0^{b}	4.29±0.02^{a}	0.52^{b}±0.02^{a}	162.67±2.5^{b}

±Standard deviation of 3 replicates
Means values having different superscript within the same column are significantly different (P≤0.05).

Table 4: Sensory acceptability of sweet potato and cassava tapioca grits

Tapioca sample	Colour	Flavour^{ns}	Taste	Texture	Overall acceptability^{ns}
Sweet Potato	6.55±1.3 ^{a}	6.90±0.9	7.15±2.0^{b}	6.30±1.7^{a}	7.15±1.5
Cassava	8.30±0.7^{b}	6.75±1.7	6.95±1.0^{a}	7.80±1.2^{b}	7.40±1.1

±Standard deviation of 30 panelist scores
Means values having different superscript within the same column are significantly different (P≤0.05).
ns = no significant difference (P>0.05)

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