INFLUENCE OF DRYING METHODS ON PHYSICO-CHEMICAL, CHEMICAL AND PASTING PROPERTIES OF CHIPS OF DIFFERENT CASSAVA VARIETIES

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Abstract

Cassava (Manihot esculenta Crantz), one of the major carbohydrate sources in developing countries is highly perishable and needs to be processed promptly. Processing it into chips will make it available for further processing into other cassava products like gari. Studies were carried out to investigate the effects of drying methods on physico-chemical and pasting properties on cassava chips of four varieties [two indigenous-odongbo and oko-iyawo; two improved- arubielu (TMS 30572) and ege-funfun (TMS 23576)] of cassava. The drying methods include sun, solar and cabinet (60 °C) drying. The swelling capacity of the samples has the range 1.20 - 2.0% and the titratable acidity (0.100 – 0.173%) values obtained show that the products are of high quality. Results of analyses for physico-chemical and pasting properties indicated significant differences (p<0.05) among the varieties and drying conditions. Also there was great reduction of the level of hydrocyanic acid (HCN) thereby making the chips safe to produce food for consumption. The results obtained also establish the fact that though all the drying methods can be adopted to dry chips for the production of other cassava products but sun drying method gave the best results for both physico-chemical and pasting properties. This process technology gives relief to the farmers to safeguard investment losses during glut period.

Keywords: Drying methods, cassava chips, physico-chemical, pasting, varieties.

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1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is the most important root crop in tropical countries which provides the major source of dietary calories for about 500 million people in many developing countries (Aguado *et al*., 1999). The edible part of fresh cassava root contains 32 – 35% carbohydrate, 2 – 3% protein, 65 – 80% moisture, 0.1% fat, 1.0% fibre and 0.70 – 2.50% ash (Oluwole *et al.*, 2004). Cassava tubers deteriorate rapidly after harvesting due to high moisture content (65 – 80%) and this deterioration is caused by physiological changes and mechanical damage during harvesting, transportation and handling (Oyewole, 2002; Oyewole and Asagbra, 2003). Also, the bulky nature of cassava makes its transportation from rural areas difficult and expensive (Ukwuru and Egbonu, 2013). These rapid post-harvest deterioration and bulkiness of cassava roots place serious constraints on their distribution and use especially where there are delays in marketing and on the holding of buffer stock for large-scale processing; hence, there is the need for its immediate processing.

The main reasons for processing cassava roots are to increase shelf-life and facilitate transportation. Processing the tubers into a product with low moisture content makes it more durable and stable, and with less volume, which makes transportation easier (IITA, 1990; Ugwu, 1996). Also, cassava is traded internationally in some processed form like chips (FAO, 2005). Processing provides a variety of products which are convenient to cook, prepare and consume.

Chips are the most common form in which dried cassava roots are produced, stored and marketed by most exporting countries (IITA, 2005). Cassava chips are made directly from fresh roots by peeling and sun drying or hot-air drying the roots (Hahn, 1989). Drying as a unit operation has been reported to significantly affect the quality of

dried food products (Tunde-Akintunde and Afon, 2009). Thus the most important unit operation in the production of cassava chips is drying as it can have a greater influence on the product quality. Different drying methods (sun, solar, and hot air) have been reported to significantly affect the quality of food products (Barimah *et al*., 1999; Bechoff *et al*., 2009). It is therefore important to study the effect of different drying methods on the quality of cassava chips.
Therefore this work aimed at studying the effects of different drying methods (sun, solar and cabinet drying) on some quality parameters of chips of different varieties of cassava.

2. MATERIALS AND METHODS
Materials

Four varieties (two indigenous- *odongbo* and *oko-iyawo*; two improved- *arubielu* (TMS 30572) and *ege-funfun* (TMS 23576) of cassava (*Manihot esculenta*) were harvested after 12 months from Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Nigeria. The study was conducted in Owodunni Food Processing Laboratory, Department of Food Science and Engineering, Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Nigeria.

Preparation of cassava chips

Each variety of cassava was washed, peeled manually and sliced into chips of uniform slices (length 4 – 5 cm, thickness 1.5 cm). A locally fabricated chipping machine was used for uniform drying. Drying was done using different methods (sun, solar and cabinet at 60 °C).

Drying of the cassava chips

The method of Tunde-Akintunde *et al*. (2005) was modified to dry cassava chips using sun, solar and cabinet (i.e. hot-air) drying.

Sun drying

The sun drying was done by placing the chips under direct sunlight in the dry season. The products was spread evenly on black nylon and placed under the sun and the chips were turned periodically during drying for proper heat and mass transfer. This was done for three days in the month of February until the moisture reached about 9 percent. The drying temperatures were monitored daily which was between 30 and 40 °C until the drying was complete.

Solar drying

The dryer base was lined with a reflective material with the trays fixed in the drying chamber while the collector base was painted black. This was done for three days in the month of February until the moisture reached about 9 percent. The drying temperatures were monitored daily which was between 35 and 45 °C until the drying was complete.

Cabinet (hot-air) drying

A batch tray drier was used for the hot-air drying method. The perforated trays were filled with one layer of wet cassava chips. There was a gap of 10 cm between the trays to allow for adequate air movement. The air in the dryer was heated using an electrical burner and the drying was done at a drying temperature of 60 °C (Tunde-Akintunde and Afon, 2009) until the moisture reached about 9 percent.

Physico-chemical and chemical properties determination

The swelling capacity was determined by using the method of Sathe and Salunkhe (1981), water absorption capacity and solubility index were determined using the method of Malomo *et al*. (2012), loose and bulk densities were determined according to Balami *et al.* (2004). The pH was determined using a pH meter (Oyewole and Odunfa, 1989), total titrable acidity (TTA) was determined as described by Owuamanam *et al*. (2010), hydrogen cyanide content was determined by using A.O.A.C (2005) and amylose and amylopectin contents were determined using the method of Juliano (1971).

Determination of pasting properties

The pasting profile of cassava chips was studied using a Rapid Visco-Analyzer

(RVA) (Newport Scientific, 1998) with the aid of a thermocline for windows version 1.1 software (1996). The parameters that were measured (RVA units) are: peak viscosity, holding strength, breakdown, cold paste (final) viscosity, setback, peak time and pasting temperature.

Statistical analysis

All experiments were done in three replicates and the means of determinations were presented in tables. The statistical significance of difference were evaluated by one-way analysis of variance (ANOVA) at the 5% significance level by means of comparing the effect of different varieties of cassava as well as the different drying methods on chip samples.

3. RESULTS AND DISCUSSION

Physico-chemical and chemical properties of dried cassava chips

The physico-chemical properties of cassava chips of different varieties dried with different drying methods are as shown in Table 1. The swelling capacity of a food material is the measure of the ability of flour/starch to absorb water and swell. The values obtained ranged between 1.20 (in both cabinet-dried *odongbo* and solar-dried *oko-iyawo*) and 2.00 in solar-dried *odongbo* variety. The ANOVA shows that the values significantly ($p<0.05$) differ among the varieties. In terms of drying methods, the significant ($p<0.05$) difference was observed in all drying methods used to dry *odongbo*, *oko-iyawo* and *ege-funfun* samples but no significant difference was observed in the values obtained in *arubielu* variety. This value range agreed with the finding on Ajala *et al*. (2012) who reported 1.10 to 1.31 for dried cassava chips using tunnel dryer.

The water solubility index ranged from 11.43% in sun- dried *ege-funfun* to 14.23% in cabinet-dried *oko-iyawo* sample. Water solubility index values were significantly different ($p<0.05$) for both the drying methods and varieties considered. This property reflects the extent of starch degradation (Diosady *et al*., 1985). The values of water solubility index obtained in this study are generally low which indicates the starch of the chips is of the least starch degradation. The values obtained are similar to those obtained by Eriksson *et al*. (2014) who reported similar range (12.27 – 20.77%) of water solubility index in their study on three varieties of cassava.

Water absorption capacity ranged from 140.00% for solar-dried *arubielu* variety to 200.00% for cabinet-dried *ege-funfun* chips. The higher value obtained for cabinet-dried samples might be due to higher temperature and shorter used to dry the samples. The values were significantly different ($p<0.05$) for both varieties and the drying methods. Water absorption capacity measures the volume occupied by the starch after swelling in excess water which indicates the integrity of the starch in aqueous dispersion. It has been reported to be dependent on the starch of the chips (Ajala *et al*., 2012). Water absorption capacity is important in the development of ready to eat foods and a high absorption capacity may assure product cohesiveness (Housen and Ayenor, 2002). The high values of water absorption capacity obtained in all samples could be attributed to the loose association of starch polymer, amylose and amylopectin in the native granules (Biliarderis *et al*., 1993). Therefore, the values obtained in this study show that all the samples could be used for the production of ready to eat foods such as snacks inclusion in breakfast cereals.

Loose density of the sample was found to be within the range of 0.30 - 0.39 g/cm^3 with solar-dried *ege-funfun* having the lowest value and sun-dried *oko-iyawo*, the highest. Bulk density ranged from 0.50 g/cm^3 in solar-dried *ege-funfun* sample and 0.59 g/cm^3 in sun-dried *oko-iyawo* with the mean value of 0.54 g/cm^3. The values are significantly different ($p<0.05$) for both the varieties and drying methods. The values obtained were comparable to the values reported by Ajala *et al*. (2012) which ranged from 0.35 - 0.55 g/cm^3 for dried cassava chips. They were found lower than the values reported by Sanni *et al.* (2005) for cassava flour. Bulk density has been reported as an important parameter that determines the suitability of the chips for case of packaging and transportation of particulate foods (Shittu *et al*., 2005). Lower values of bulk density of cassava chips obtained from this study imply the enhancement of material handling in terms of packaging and transportation. Also, it has been reported lower bulk density is desirable in infant food preparation (Nelson-Quartey *et al*., 2007).

The pH of the samples ranged from 5.90 (solar-dried *odongbo*) to 7.90 (sun-dried *arubielu*) and the mean value was 6.96. The pH of flour/chips is an important parameter in determining its quality. This range falls between the range (6 - 7) given by CSIR-FRI (2009) for high quality cassava chips. There were significant differences ($p<0.05$) in the values obtained. It was also observed that the chips produced from the sun-drying method gave the highest pH value considering each variety of the four varieties examined; this might be as a result of a reduction in the cyanide content.

The titratable acidity of the dried cassava chips ranged from 0.10% in cabinet-dried *odongbo* variety to 0.17 in sun-dried *ege-funfun* sample. The titratable acidity values were significantly different from each other with exception of solar and cabinet drying samples that were slightly significant. The results showed that the products obtained are of high quality because CSIR-FRI (2009) specifies a lower acidity (i.e < 0.25%) for high quality cassava chips.

The cyanide content of the samples ranged between 0.00 in sun-dried *oko-iyawo* sample and 0.05 mg/100 g in solar-dried *ege-funfun*. The range of values obtained is below the safe level of 10 mg HCN equivalents/1 kg flour (10 ppm) recommended by Food and Agriculture Organisation/World Health Organisation (FAO/WHO, 1991). The values obtained were significantly different ($p<0.05$) for both varieties and the drying methods except in sample B (*oko-iyawo*) that showed very slight significant difference between sun drying and other two methods. It was observed from the values obtained that sun drying method eliminated more cyanide content and this could be due to the fact that there was prolong contact time between linamarin and the enzyme linamarase which ultimately catalyzed the hydrolytic breakdown (Bandna, 2012).

The amylose and amylopectin contents of dried cassava chips were found to be within the ranges 22.067 - 25.533% and 74.467 - 77.933% respectively. The lowest value of amylose was found in cabinet-dried *odongbo* variety and the solar-dried *ege-funfun* variety had the highest value. The solar-dried *ege-funfun* sample had the lowest amylopectin content while cabinet-dried *odongbo* sample had the highest value. There were significant differences ($p<0.05$) in amylose content among the varieties studied. The amylose portion of the starch affects its swelling and hot-paste viscosities. Shimelis and Rakshit (2005) stated that as the amylose content increases, the swelling tends to be restricted and the viscosity of the hot paste viscosity stabilizes. Moreover, high amylose contents are desired in starches that are to be used for the manufacture of extrudates (Lii and Chang, 1981). Nuwamanya *et al*. (2009) observed a range of 18.8 – 25% of amylose in cassava starch obtained from both the parents and progenies. A range of 15.9 – 22.4% of amylose was reported by Albert *et al*. (2005) for five cultivars of cassava starches.

Table 1: Physicochemical and chemical properties of cassava chips produced from different varieties and drying methods

Sample	SC	SI (%)	WAC (%)	LD (g/cm³)	BD (g/cm³)	pH	TTA (%)	HCN (mg/100 g)	Amylose (%)	Amylopectin (%)
A_{su}	**1.500c**	**12.600f**	**160.000d**	**0.364e**	**0.553d**	**6.900f**	**0.130c**	**0.020e**	**22.667h**	**76.333d**
A_{so}	2.000a	13.167d	180.000c	0.371d	0.560c	5.900k	0.113de	0.037bc	24.133d	75.867e
A_{ca}	1.200f	12.800ef	180.000c	0.377b	0.557cd	6.333i	0.117d	0.027de	22.067j	77.933a
B_{su}	1.400d	13.133d	180.000c	0.386a	0.585a	7.467e	0.110def	0.000g	24.567b	75.333f
B_{so}	1.200f	13.800b	160.000d	0.353g	0.554d	6.000j	0.103fg	0.007fg	22.733gh	77.267c
B_{ca}	1.400d	14.233a	180.000c	0.344h	0.520f	6.400h	0.100g	0.003fg	22.333i	77.667b
C_{su}	1.300e	12.067g	186.670bc	0.344h	0.518f	7.900a	0.150b	0.010f	24.300c	75.700e
C_{so}	1.300e	13.533c	140.000e	0.378c	0.566b	6.800g	0.110def	0.020e	22.833g	77.167b
C_{ca}	1.300e	13.000de	190.000b	0.356f	0.525e	7.767b	0.107efg	0.030cd	22.800g	77.200b
D_{su}	1.600b	11.433h	180.000c	0.316j	0.512g	7.700c	0.173a	0.037bc	23.167f	76.833c
D_{so}	1.500c	11.933g	180.000c	0.303k	0.505h	6.767g	0.150b	0.047a	25.533a	74.467g
D_{ca}	1.400d	12.133g	200.000a	0.335i	0.528e	7.600d	0.130c	0.043ab	23.367e	76.633d

Mean values (n=3) with different alphabet (s) in the same column are significantly different at $p<0.05$.
A: *odongbo*; B: *oko-iyawo*; C: *arubielu* (TMS 30572); D: *ege-funfun* (TMS 23576) and subscripts su, so and ca represent sun, solar and cabinet drying methods respectively.
SC: Swelling capacity; SI: Solubility Index; WAC: Water Absorption Capacity; LD: Loose Density; BD: Bulk Density;
TTA: Titratable Acidity; HCN HCN: Cyanide content

Table 2: Pasting properties of cassava chips of different varieties and drying methods

Sample	Peak viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (RVU)	Pasting temperature (°C)
A_{su}	251.850c	220.110b	31.735l	309.220c	89.115e	5.105i	84.225a
A_{so}	235.900d	108.560i	127.340a	183.410h	74.845f	5.550d	79.665j
A_{ca}	169.440h	109.090h	60.345e	230.640f	121.540c	5.210h	82.665d
B_{su}	197.420e	158.950d	38.450i	249.300d	94.350d	5.110i	83.365c
B_{so}	191.180g	156.020e	35.150k	224.340g	62.165h	5.285g	82.025g
B_{ca}	135.060i	98.000j	37.055j	160.160i	68.315g	5.610c	83.335c
C_{su}	278.620b	199.860c	78.760b	391.600b	191.740a	5.365f	83.625b
C_{so}	197.350e	124.160g	73.185c	157.940j	33.780j	5.435e	81.410i
C_{ca}	133.510j	85.055k	48.455g	145.280k	60.220h	6.220a	83.365c
D_{su}	301.090a	240.340a	60.750d	413.860a	173.520b	5.190h	82.430e
D_{so}	194.260f	148.780f	45.490h	237.560e	55.715i	6.135b	82.345f
D_{ca}	119.660k	70.940l	48.730f	126.520l	88.780e	5.340f	81.765h

Mean values (n=3) with different alphabet (s) in the same column are significantly different at $p<0.05$.
A: *odongbo*; B: *oko-iyawo*; C: *arubielu* (TMS 30572); D: *ege-funfun* (TMS 23576) and subscripts su, so and ca represent sun, solar and cabinet drying methods respectively

Pasting Properties of Dried Cassava Chips

The pasting properties are important indices to predict the pasting behaviour during and after cooking of starch-based products (Richard *et al*., 1991). The values of pasting properties obtained for cassava chips of different varieties dried with sun, solar and cabinet drying methods are as shown in Table 2. The peak viscosity which is the maximum viscosity obtained immediately after the heating portion ranged from 119.660 to 301.090 RVU with the cabinet-dried and sun-dried *ege-funfun* (TMS 23567) having the lowest and highest values respectively. There was significant ($p<0.05$) difference in the values obtained which might be due to the variation in the amylose contents of the chips since Oguntunde (1987) gave a report that the associative binding of the amylose fraction is responsible for the structure and the pasting characteristic of starch granule (Ikegwu *et al*., 2009).

Trough is the ability of paste to withstand breakdown during cooling and the results obtained ranged from 70.940 to 240.340 RVU in cabinet and sun-dried *ege-funfun* samples respectively. The breakdown viscosity which is an index of the stability of starch ranged from 31.735 (sun-dried *odongbo* chips) to 127.340 RVU (solar-dried *odongbo* chips). There are significant ($p<0.05$) differences for both trough and breakdown viscosities in terms of drying methods and varieties considered. The rate of breakdown of starch-based food depends on the nature of the material, temperature and the degree of mixing and the shear applied to the mixture (Maxiya-Dixon *et al*., 2004). The high value of breakdown viscosity indicates the inability of the sample to withstand heating and shearing stress during cooking (Adebowale *et al*., 2008). This indicates that all the samples except solar-dried *odongbo* sample might be able to withstand heating and shear stress during cooking because of their low breakdown values.

The final viscosity of cassava chips gave the range of 145.280 - 413.860 RVU with the cabinet-dried *arubielu* having the lowest and sun-dried *ege-funfun* had the highest value. The results obtained are significantly ($p<0.05$) different from each other for both drying methods and varieties considered. Final viscosity is the ability of sample to form various paste/gel after cooking/cooling and it is the most commonly used characteristic to determine the quality of a particular starch-based product (Osungbaro *et al*., 2010). The variation in the values of final viscosity obtained might be due to the kinetic effect of cooling on viscosity and re-association of the starch molecules in the chips (Bentil, 2011). It was observed from the results obtained that sun dried samples gave the highest values of final viscosity in all the varieties considered. There is an indication that sun-dried chips will be more stable after cooling due to their high values of final viscosity.

The results of setback of cassava chips of different varieties dried with different drying methods ranged from 33.780 to 191.740 RVU. The highest value was obtained in sun-dried *arubielu*, the lowest in solar dried *arubielu* and the values were significantly ($p<0.05$) different except for sun-dried *odongbo* and solar-dried *ege-funfun* samples were not different significantly. Setback viscosity is an ability to retrograde on cooling. Osungbaro *et al*. (2010) gave 45 – 81.75 RVU in composite cassava-sorgum flour meals. Lower value of setback will give higher resistance to retrogradation during cooling (Sanni *et al*., 2005). It was observed that all solar-dried samples were found low in setback values in all the varieties considered. This implies that solar-dried chips would give highest resistance to retrogradation during cooling.

There are significant ($p<0.05$) differences in both peak time and pasting temperature values. Peak time ranged from 5.105 (sun-dried *odongbo*) to 6.220 (cabinet-dried *arubielu*) minutes. Low values obtained for peak time in all the samples indicates that there would early gelatinization as it has reported by Ahmed *et al*. (2005) that low pasting time favours early gelatinization. Pasting temperature ranged between 79.665 and 84.225 °C for solar-dried *odongbo* and sun-dried *odongbo* samples respectively. Pasting temperature gave an indication of the minimum temperature required to cook the sample. It shows that solar-dried *odongbo* sample will cook faster which will save time and cost compared to other samples. The value range obtained was higher than the range (69 – 78 °C) reported by Sefa-Dedeh *et al*. (2004) on maize. The higher pasting temperature may call for continuous stirring when cooking any product produced from these chips to avoid scorching because higher temperatures are likely to induced scorching before a paste is well-cooked.

4. CONCLUSION

Significant effects among the varieties and drying methods were observed in all the properties determined but variety was found to have a more significant effect on the chemical and physico-chemical properties while drying method was found to have a more significant effect than that of the variety on pasting properties of cassava chips. The values of swelling capacity, water absorption capacity and bulk density obtained indicated that the chips are of high quality which can be used for further processes in the production of other cassava products of high quality. Based on the findings, it is therefore recommended *oko-iyawo*- a local variety and *arubielu* (TMS 30572)- an improved variety of cassava for the production of cassava chips. Also, cabinet drying method can be adopted.

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