Centre for Research and Development (CERAD) *JoST 2011*
The Federal University of Technology, Akure, Nigeria

Physicochemical and pasting properties of cooked cocoyam flour (*Xanthosoma sagittifolium*)

OYEBODE, E.T., FAGBEMI, T.N. and OLUWALANA, I.B* .
Dept. of Food Science and Technology, Federal University of Technology, Akure, Nigeria

ABSTRACT: This study investigated the chemical, functional and pasting characteristics of the white and red cocoyam varieties in order to determine their suitability for food and industrial purposes. Cormels of the white and red cocoyam (*Xanthosoma sagittifolium*) were cooked, oven dried and milled into flour. The chemical constituents, their functional and pasting properties were evaluated using standard methods. The results which were expressed on dry basis showed the two varieties to contain 5.93 and 5.43% protein respectively. The ash, fibre and crude fat contents were (3.11 and 2.01) %, (1.12 and 0.71) % and (3.65 and 2.22) % respectively for the white and red varieties. White and red samples contain high carbohydrate content of 86.15% and 89.62% respectively. The functional properties showed that they have high water absorption capacity of (377.50 and 375.00) %, oil absorption capacity of (155.00 and 90.00) % for the white and red cocoyam flour respectively. Oxalate content was 0.72% for both varieties while Phytate was 0.25 and 0.28% for white and red varieties respectively. The white variety gelled at a lower concentration of 8% while the red variety gelled at 10%. The pasting properties showed that the white variety exhibited a better pasting characteristics especially the setback value, break down value, pasting temperature and peak viscosity time and hence may be more useful in making a thick paste and as a thickener in food systems.

Keywords: Physicochemical analysis, functional properties, processing, Cocoyam.

JoST. 2011. 2(2): 96-100
Accepted for Publication, August 1, 2011

INTRODUCTION

Cocoyam (*Xanthosoma sagittifolium*) is an important source of carbohydrate in Tropical Africa. It belongs to the family *Araceae*. Almost all the vegetable parts of cocoyam are used as food. The cormels are used for human consumption while the corms serve as planting material. In Nigeria, the cormels are usually eaten as roasted, fried, boiled, mashed or mixed with other staples, such as yam or plantain. Nigeria is the largest producer in the world, accounting for about 40% of total production (Eze and Okorji, 2003).

Cocoyam was found to be a good base for food preparation for infants because of the high digestibility of its starch, reasonable content of calcium and phosphorus, and the protein was reported to be higher than that of any other tuber crop (Onwueme, 1987; Eleje, 1987; Onwueme and Sinha, 1991). The cormels contain substantial amounts of protein, vitamin C, thiamine, riboflavin and niacin. (Niba, 2003; Sefa-Dede and Kofi-Agyir, 2004). It also contains nutritive mineral elements especially K, Na and Mg (Njoku and Ohia, 2007). The disadvantages are that nutritionally, the edible corms and cornels of cocoyam contain raphides which are minute bundles of crystals of calcium oxalate which cause irritation to the skin if not well cooked. Cocoyams also have unattractive mucilage which could discourage their consumption. Oxalate has also been reported to cause kidney stones. These anti-nutritive factors can be reduced by peeling, grating, soaking and fermentation operations during processing, long period of cooking, baking or extraction with ethanol (FAO, 1990; Akpan and Umoh, 2004).

* Correspondence to Oluwalana, I.B.; ioluwalana2002@yahoo.com

Nwokocha *et al*. (2009) reported that cocoyam starch paste is better in withstanding processing conditions when compared with cassava and would present a superior thickening characteristic than cassava starch paste. It was more rigid than cassava starch paste. Recent studies also showed that cocoyam starch can be incorporated in the development of complimentary diets which are easily digestible and accessible to low-income earners in developing countries (Oti and Akobundu, 2007).

Ojinnaka *et al.* (2009) observed that modified starch of cocoyam can be utilized as major raw materials for cookie production.

Past studies on the crop had reported mostly on the utilization of its starch. The objective of this research therefore is to process the white and red cocoyam (*X. sagittifolium)* by cooking, drying and mill it to flour; compare their chemical, functional and pasting properties and suggest their possible industrial applications.

MATERIALS AND METHODS

Materials

The cocoyam cormels used in this study were purchased from Ogbese market, Akure, Nigeria. They were thoroughly washed with water and the outer skins were peeled off using a knife. The fleshy part of the cormels were sliced, cooked, oven dried and ground mechanically using attrition mill. The flour of each sample was then stored in air-tight cellophane bags and kept in a refrigerator at 4 ^{0}C as stock samples until required for analyses.

Methods

Chemical composition

The protein, ash, fat, fibre and the moisture contents of the flour samples were determined according to the standard methods (AOAC, 1990); while the carbohydrates were determined by difference (AOAC, 1990). Phytate was determined using the method of Reddy and Love (1999). Oxalate content was determined using the method of Day and Underwood, (1986). Bulk density of the flour samples were determined by the method of Okezie and Bello (1988). Gelation property, water absorption capacity and oil absorption capacity were estimated by using the method of Abbey and Ibeh (1988).

Pasting characteristics were determined with the Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 2.5g of cocoyam starch samples were weighed into a dried empty canister, and then 25ml of distilled water was dispensed into the canister containing the sample. The slurry was thoroughly mixed and the canister was well fitted into the RVA as recommended. It was then heated from 50 ^{O}C to 95 ^{O}C with a holding time of 2 minutes followed by cooling to 50 ^{O}C with 2 minutes holding time. The rate of heating and cooling were at a constant rate of 11.25 ^{O}C per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermo-cline for windows software connected to a computer (Newport Scientific, 1998).

RESULTS AND DISCUSSION

Chemical composition

The chemical composition results are shown in Table 1. The results were based on dry matter. The protein contents of the white and red varieties were 5.97 and 5.43% respectively. These values were higher than the values of 2.98-5.00 g/100 g reported for the fresh white and red varieties by Sefa-Dede and Kofi-Agyir (2004), but comparable with the range of 3.80 - 4.7% reported by Ndabikunze *et al.* (2011) for Kenya and Tanzania cocoyam. The high carbohydrate content of 86.15% and 89.62% for both white and red varieties respectively is indicative of high starch yield as reported by several authors. The white cocoyam have higher values of fat, ash and fibre than the red variety.

The oxalate content was 0.72% for both samples, while phytate was 0.25% and 0.28% for the white and the red cocoyam.

Table 1: Chemical composition (% d.b.) of cooked White and Red cocoyam (*X.sagittifolium*)

Cocoyam Species	moisture content	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Carbohydrate	Oxalate	Phytate
White	6.76 ±0.01	5.98 ±0.09	3.65 ±0.05	1.12 ±0.01	3.11 ±0.01	86.14 ±0.01	0.72 ±0.14	0.25 ±0.00
Red	6.66 ±0.01	5.43 ±0.25	2.22 ±0.00	0.71 ±0.01	2.01 ±0.02	89.63 ±0.24	0.72 ±0.00	0.28 ±0.01

Functional properties

The result of the functional properties is shown in Table 2. Water absorption capacity of the white variety was 375% while the red was 155%; both being relatively high. It has been reported that increase in water absorption capacity implies good potential as a thickener in food system (Okezie and Bello, 1988). This result therefore suggested the possible inclusion of these flours into food formulation like dough in baked products. The white variety has a higher value of 155% for oil absorption capacity compared with the 90% recorded for the red sample. The white variety gelled at a lower percentage of 8% as against the 10% obtained for the red variety. The white and red flour bulk densities were 0.79 g/ cm^3 and 0.80 g/ cm^3 respectively. High bulk densities of flour material are important in relation to its packaging efficiency (Okezie and Bello, 1988).

Table 2: Functional Properties of cooked White and Red cocoyam (*X. sagittifolium*)

Cocoyam Specie	Water Absorption Capacity%	Oil Absorption Capacity (%)	Least Gelation Concentration (%)	Bulk density (g/cm^3)
White	377.50 ±0.50	155.00 ±5.00	8.00 ± 0.00	0.78±0.01
Red	375.00±7.50	90.00±2.88	10.00 ±0.00	0.81 ±0.01

Pasting properties

Table 3 shows the pasting properties of the flour from cooked white and red cocoyam cormels. The peak viscosity, which is the maximum viscosity developed during or soon after the heating portion, were 129.05 RVU and 133.88 RVU for the white and red cormels in 6.47 min and 5.78 min and at a peak pasting temperature of 48.02 ^oC and 48.38 ^oC respectively. The peak viscosity or more correctly the consistency of a cooked starch paste simply reflects the resistance to stirring of the swollen mass gel particles. Peak viscosity has been reported to be closely associated with the degree of starch damage and high starch damage results in high peak viscosity (Sanni *et al.* 2001). The results show that there were no significant differences in the pasting temperatures of the two varieties used. The gelatinization temperature of a range of 48- 48.38 ^oC obtained was similar to the 49.90 ^OC reported by Nwokocha *et al.* (2009) for red cocoyam starch but lower than those reported for thirteen cultivars of cassava by Ikegwu,. *et al.* (2009). The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability. The result shows that both samples will cook quickly and that less energy would be consumed, thereby saving cost during processing.

Table 3: Pasting Properties of cooked White and Red cocoyam (*X. sagittifolium)* flour.

Cocoyam species	Peak 1 viscosity	Trough	Breakdown	Final viscosity	Set back	Peak time (min)	Pasting temp °C
White	129.05 ±2.37	121.00 ±3.42	8.05 ±5.79	208.35 ±2.25	87.25 ± 6.67	6.47 ±0.11	48.00 ±0.08
Red	133.88 ±4.37	129.67 ±3.58	4.21 ±0.79	201.20 ±5.67	70.20 ±2.30	5.78 ±0.13	48.38 ±0.03

Breakdown viscosity was 5.79 RVU and 4.21 RVU for white and the red samples respectively. Adebowale *et al.* (2005) reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking; therefore both samples might be able to withstand heating and shear stress compared with 88.3 RVU of starch sample of red cocoyam reported by Nwokocha *et al.* (2009). The final viscosity of the flour of the red cocoyam (208.35 RVU) was higher than that of the white (201.20RVU) and both were lower than the value reported for red cocoyam by Nwokocha *et al.* (2009). Shimelis *et al.* (2006) reported that final viscosity is used to indicate the ability of starch to form various paste or gel after cooling; the lower the value the better.
The set back values were 70.20 RVU and 87.25 RVU for red and white varieties respectively. Sanni *et al.* (2001) reported that lower set back indicates higher resistance to retro gradation. This result shows that the red cornel will show a better resistant to retro gradation than the white variety. The results of the pasting properties compared well with the findings of Oladebeyel *et al.* (2009) on red cocoyam.

CONCLUSION

The two varieties of cocoyam studied showed that they have potentials as ingredient in food formulation with the white having better quality in terms of physicochemical properties. From the results of the pasting characteristics, it could be inferred that cocoyam flour could be applied in the production of thick paste and as a thickener in food systems.

REFERENCES

ABBEY, B.W. and IBEH, S.O. (1988). Functional properties of raw and heat processed cowpea (*Vigna unguiculata,* walp) flour. *Journal of Food Science* **53(6):** 1775 – 1791.

ADEBOWALE, A.A., SANNI, L.O. and AWONORIN, S.O. (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Science and Technology International* **1** *(5): 373 –382*

AKPAN, E.J. and UMOH, I.B. (2004). Effect of heat and tetracycline treatments on the food quality and acridity factors in cocoyam (*Xanthosoma sagittifolium* (L.) Schott). *Pakistan Jounal of Nutrition.,* **3**:240-243.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, AOAC. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists. Washington, D.C.

DAY, R.A. and UNDERWOOD, A.L. (1986). Quantitative Analysis. Prentice Pub; 5:701 (1^{st} Edn), Macmillan Publishers Limited, London, **1**: 77-89.

ELEJE, I. (1987). Cocoyam: a major national carbohydrate staple food for the future in Nigeria. In: Proc. 1st National Workshop on cocoyams, (Arene, O.B., Ene, L.S.O., Odurukwe, S.O. and Ezeh, A eds.), NRCRI, Umudike, Nigeria, pp: 11-16.

EZE, C.C. and OKORJI, E.C. (2003). Cocoyam production by women farmers under improved and local technologies in Imo State, Nigeria,*African Journal of Sciences 5(1):*113-116

FOOD AND AGRICULTURAL ORGANISATION, FAO (1990). Roots, tubers, plantains and bananas in human nutrition. Food and Agricultural organization of the United Nations, Rome.

IKEGWU, O.J., NWOBASI V.N., ODOH M.O. and OLEDINMA, N.U. (2009). Evaluation of the pasting and some functional properties of Starch isolated from some improved Cassava varieties in Nigeria. *EJEAFChe,* **8**(8): 647-665.

NEWPORT SCIENTIFIC (1998). Applications manual for the rapid viscose analyzer using thermo cline for windows. Newport scientific pty Ltd. Australia, Pp 2 – 26.

NDABIKUNZE, B.K., TALWANA, H.A.L., MONGI, R.J., ISSA-ZACHARIA, A.1., SEREM, A.K., PALAPALA, V. and NANDI, J.O.M. (2011). Proximate and mineral composition of cocoyam (*Colocasia esculenta* L. and *Xanthosoma sagittifolium* L.) grown along the Lake Victoria Basin in Tanzania and Uganda. *African Journal of Food Science* **5**(4):248 – 254.

NIBA, L.L. (2003). Processing effects on susceptibility of starch to digestion in some dietary starch sources. *Int. J. Food Sci. Nutr.,* **54**: 97-109.

NJOKU, P.C. and OHIA, C.C. (2007). Spectrophometric Estimation Studies of Mineral Nutrient in three Cocoyam Cultivars *Journal of Nutrition* **6**(6): 616-619

NWOKOCHA, L.M., AVIARA, N.A., SENAN, C., and WILLIAMS, P.A. (2009). 'A comparative study of some properties of cassava (Manihot esculenta, Crantz) and cocoyam (Colocasia esculenta, Linn) starches' *Carbohydrate Polymers,* **76**(3):362-367

OJINNAKA, M.C., AKOBUNDU, E.N.T. and IWE, M.O. (2009). Cocoyam Starch Modification Effects on Functional, Sensory and Cookies Qualities. *Pakistan Journal of Nutrition* **8**(5): 558-567.

OKEZIE, B.O. and BELLO, A.B. (1988). Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. *Joural of Food Science* **53**:450-454

OLADEBEYEL, A.O., OSHODI, A.A. and OLADEBEYE, A.A. (2009). Physicochemical Properties of Starches of Sweet Potato (*Ipomea batata*) and Red Cocoyam (*Colocasia esculenta*) Cormels *Pakistan Journal of Nutrition* **8**(4)*:* 313-315.

ONWUEME, I.C. (1987). Strategies for increasing cocoyam (*Colocasia* and *Xanthosoma* spp) in Nigerian Food Basket. In: Proc. 1st National Workshop on cocoyam, (Arene, O.B., Ene, L.S.O., Odurikwe, S.O. and Ezeh, N.O.A. eds.) NRCRI, Umudike, Nigeria, pp. 35 – 42.

ONWUEME, I.C. and SINHA, T.D. (1991). Field Crop production in Tropical Africa Technical Center for Agriculture and Rural Cooperation, Rome.

OTI, E. and AKOBUNDU, E.N.T (2007). Physical, functional and amylograph pasting properties of cocoyam-soybean-crayfish flour blends. *Nigerian Food Journal* **25**(1):161-170

REDDY, M.B. and LOVE, M. (1999). The impacts of food processing on the nutritional quality of vitamins and minerals. *Advance Experimental Medical Biology* **459***:* 99-106.

SEFA-DEDE, S. and KOFI-AGYIR, S.E. (2004). Chemical composition and the effect of processing on oxalate content of cocoyam *Xanthosoma sagittifolium* and *Colocasia esculenta* cormels. *Food Chemistry*, **85**(4):479-487

SANNI, L.O., IKUOMOLA, D.P. and SANNI, S.A. (2001). Effect of length of fermentation and varieties on the qualities of sweet potato gari. Proc. 8th triennial Symposium of the International Society for Tropical Root Crops – Africa Branch (ISTRC-AB), (Akoroda, M.O. ed) IITA, Ibadan., Nigeria, 12 – 16 November 2001, Pp 208 – 211.

SHIMELIS, A.E., MEAZA, M. and RAKSHIT, S. (2006). Physico-chemical Properties, Pasting Behaviour and Functional Characteristics of Flours and Starches from Improved Bean (*Phaseolus Vulgaris L.*) varieties Grown in East Africa. *CIGR E-journal* **8**: 1 – 18.