British Journal of Applied Science & Technology
4(14): 2079-2089, 2014

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Effects of Drying Methods on Proximate and Physico-chemical Properties of Fufu Flour Fortified with Soybean

A. Ojo[1], O. A. Abiodun[1*], J. O. Odedeji[1] and O. A. Akintoyese[1]

[1]Food Science and Technology Department, Osun State Polytechnic, Iree, Osun State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OAA and JOO managed the analyses of the study. Author OAA managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

Received 10th January 2014
Accepted 10th March 2014
Published 25th March 2014

ABSTRACT

Aims: Effects of drying methods on proximate and physico-chemical properties of fufu flour fortified with soybeans was investigated.
Study Design: Analysis of Variance (ANOVA) was employed in this work.
Place and Duration of Study: Department of Food Science and Technology, Osun State Polytechnic, Iree, Osun State, Nigeria, between January 2013 and August 2013.
Methodology: The peeled cassava roots (*Manihot esculenta* crantz) were steeped in water for two days. The roots were thereafter grated. The grated pulp was steeped in water for another two days for fermentation. The fermented pulp was sieved and packed in jute bags and dewatered using hydraulic press. The cassava cake was pulverized by hand and dried using oven, sun and solar drying methods. Soybean seeds were washed and boiled for 20 mins. The boiled seeds were drained and dehulled to remove seed coats. The dehulled soybeans seeds were dried, milled, sieved and packaged. Flour from cassava and soybean were mixed in the ratio of 80%:20% for this research work.
Results: The protein contents of fufu fortified flours using different drying methods were higher than fufu flour. Bulk density, water absorption capacity, swelling capacity and gelation of fufu and fufu fortified flours were not affected by the drying methods. But there was increase in the proximate and functional properties due to soybean inclusion into the

**Corresponding author: E-mail: funmiabiodun2003@yahoo.com;*

flours as the values were higher than that of fufu flours. Viscosities of fufu flour were higher than the fortified fufu flour.
Conclusion: There were increase in proximate constituents and functional properties of the fufu flours with addition of soybean flour. The foam capacity and pasting parameters were significantly affected by the drying methods coupled with addition of soybean flour.

Keywords: Proximate; fufu; flour; soybeans; fortification; drying methods.

1. INTRODUCTION

Fresh root of cassava (*Manihot esculenta* crantz) have over the years been used in the production of different types of food in Nigeria among which are fufu, lafun and gari [1]. These products are processed from freshly harvested cassava roots [2]. Cassava root is highly perishable and therefore cannot be stored in fresh state after harvest for more than afew days [3]. Postharvest losses of the crop occur during storage due to high physiological and microorganism activities that infest the bruises received during harvesting [4]. Processing cassava roots into more shelf stable products like fufu flour reduces these postharvest problems. Fufu is a fermented wet paste made from cassava roots. It is ranked next to garri as an indigenous food of most Nigerians in the south [5].

Fufu which is known as ‘Akpu’is made by steeping whole or cut, peeled cassava roots in water to ferment for maximum of five days depending on the ambient temperature [5]. Fermentation process helps to detoxify the cassava pulp and enhance flavour development [6]. Fufu preparation varies from locality to locality [6]. During steeping, fermentation takes place leading to softening of the roots and reduction of potentially toxic cyanogenic compounds [7]. The keeping quality of fufu could be greatly affected by the methods of processing. Fufu is traditionally sold in the wet form or cooked form which rendered it highly perishable. The poor or low shelf life is a serious limitation for large scale processors. A practical approach to improving the shelf life and marketability of fufu is drying the fufu paste to powder. Drying of fufu is aimed at getting re-constitutable fufu with peculiar physicochemical characteristics of cooked wet paste [8]. Akingboola et al. [9] reported that drying, of fufu in the oven at 60ºC for 48 hrs reduces the repulsive dour of fufu but the product was sticky, bland and the quality was unacceptable when compared with wet fufu, this restricts the consumption of fufu to its traditional base. Sanni et al. [10] dried wet fufu with flash and rotary driers and observed changes on the physicochemical and organoleptic qualities of the resultant fufu dough.

Nutritionally, fufu contains high percentage of carbohydrate which is needed for energy production and source of calories. The problems of malnutrition are therefore imminent. The problems of malnutrition in Nigeria although different in magnitude and severity among different areas are due to protein, vitamins, iron and other mineral deficiency [11]. There is the need to enrich or fortify fufu in order to improve its nutritional status. Example of appropriate food fortifier include soy flour, fish protein concentration etc. [12]. Legumes such as African yam beans, pigeonpea and full fat soybeans had been incorporated into the fufu flour to improve the protein contents and its acceptability [13-15]. This study therefore investigates the effects of drying methods on proximate, functional and pasting properties of fufu flour fortified with soy bean flour.

2. MATERIALS AND METHODS

2.1 Materials

Matured cassava root (*Manihot esculenta* crantz) and soya beans (*Glycine max*) seeds were purchased from Ada market, Osun State, Nigeria.

2.1.1 Production of fufu flour

Matured cassava tubers were peeled manually with knife, washed and steeped in water at ambient temperature for two days, grated, steeped in water(two days for fermentation), sieved (Seive no 246209, aperture 2.0mm), packed in jute bags and dewatered using hydraulic press. The cassava cake was pulverized by hand, spread in trays and oven dried at 50ºC for 48 hrs, sun dried for 48 hrs and solar dried for 48 hrs (fabricated solar drier). The dried flours were milled with attrition mill (fabricated) and sieved (600µm) to obtain fufu flour.

2.2 Production of Soybeans Flour

Modified method of Osho [16] was used for production of soybean flour. The soybean seeds were sorted and washed with portable water. The seeds were boiled in warm water for 20 mins, drained and dehulled to remove seed coats. The dehulled soybeans seeds were dried in the oven (60ºC), milled with attrition mill and sieved (600 µm) and packaged in a sealed polyethylene bag for further analytical work. Flour from cassava and soybean were mixed in the ratio of 80%: 20% for this research work.

2.3 Analyses

The proximate analyses of the flours were carried out [17]. Carbohydrate determination was done by difference. Bulk density was determined using the method of Okaka and Potter [18]. The water absorption capacity and swelling capacity were determined using the procedure of Lin et al. [19]. Foam capacity was determined using the method of Narayana et al. [20]. Pasting properties were determined using Rapid Visco Analyzer (RVA) (Network scientific, Austria) described by Adebowale et al. [21].

2.4 Statistical Analyses

Statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL). All experiments were performed in triplicate and the mean values were reported. Comparisons between means were performed with Turkeys test. Differences between means were evaluated as significant at $P<0.05$.

3. RESULTS AND DISCUSSION

The proximate analysis results of fufu flour and fortified fufu flour dried using sun, solar and oven drying methods are presented in Tables 1 and 2. From the result, it was observed that there were differences in the proximate constituents of raw fufu flour and fortified flour. The crude protein content for raw flour ranged from 1.02-1.21% with the flour dried using solar drying method having the highest value and sundried flour having the least value while the fortified flours has protein value of 6.90-7.10%. There was no significant differences ($p<0.05$) in the protein values of sundried and solar dried fortified fufu flours. This showed that protein contents of fufu were more retained using the two methods. The protein contents obtained were lower than the value (13.65%) observed by Akoja and Mohammed [14] for fufu fortified with 20 % pigeon pea flour. This may be due to the variety of legume, method of processing and analytical method used. There was significant increase in protein content of fortified fufu flour due to incorporation of soybean flour, a rich and cheap source of protein. In the rural area, where sun drying is majorly used as method of drying, the method preserved appreciable amount of protein and could be used to dry fortified fufu products. Legumes which include soybeans are good examples of the low priced source of protein rich foods that have been of importance in alleviating protein malnutrition [22].

Table 1. Proximate composition of fufu flour

Drying method	Crude protein (%)	Moisture content (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
Oven dried	1.17±0.32b	8.70±0.16a	0.72±0.11a	0.23±0. 20a	0.35±0.21a	88.83±0.27a
Sun dried	1.02±0.41c	8.50±0.23b	0.62±0.09b	0.17±0.1 3b	0.30±0.17b	88.39±0.33c
Solar dried	1.21±0.27a	8.00±0.19c	0.70±0.10a	0.15±0 .10b	0.32±0.11b	88.62±0.22b

Table 2. Proximate composition of fortified fufu flour

Drying method	Crude protein (%)	Moisture content (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
Oven dried	6.90±0.35b	8.67±0.29a	1.24±0.08c	1.20±0. 31b	0.41±0.27c	85.58±0.41a
Sun dried	7.10±0.61a	8.22±0.21b	1.30±0.10b	1.27±0.2 6a	0.81±0.19b	81.30±0.53b
Solar dried	7.10±0.50a	8.22±0.15b	1.37±0.19a	1.28±0 .33a	0.87±0.20a	81.06±0.37c

Proteins are needed in the body for repair and replacement of worn-out tissues, serve as antibodies, primary sources of amino acids and the building block of cellular protein [12]. The moisture content for raw flour ranged between 8.00 and 8.70% while the fortified flour recorded 8.22 and 8.67%. The moisture contents of sundried and solar dried flour was the same (8.22%). There was variation in the moisture contents (water activity) of the raw and fortified flours based on the methods of drying employed. However, the moisture content of both flours were in the ranged of dried or powdered product (15%) [23]. The lower the moisture contents of food product, the longer the shelf life of the product.

The fat content for the raw flours ranged between 0.62 and 0.72% while the fortified flours had value ranging from 1.24 to 1.37%. The sundried flour recorded the lowest value of fat (0.62%) in the raw flour while the oven dried flour recorded the lowest value in the fortified flours. There was significant difference ($p<0.05$) in the fat contents (124-1.37%) of the fortified fufu flours using different drying methods. Although, lower fat contents were observed in the flours but there was increase in the fat contents of the fortified fufu flour which could be due to incorporation of soybean flour. The storage life of the flour may however be elongated owing to these low fat content since all fats and fat containing foods are potentially susceptible to oxidative rancidity [23].

The crude fibre contents of raw and fortified fufu flours ranged from 0.15-1.28%, while the fortified flours have higher values for crude fibre. Owing to the different methods of drying employed, there are variations in the value for both fufu and fortified fufu flour. Flour dried using solar method recorded the highest value 1.28% crude fibre content for fortified flour while the oven dried flour recorded the highest values 0.23% for the fufu flour. Crude fibre has been proved to aids peristalsis movement of food through the digestive tract [12].

Increase in crude fibre contributes to the bulk density which could help in the bowel movement, lower blood cholesterol and helps prevent cancer of the colon [24].

Ash contents for raw and fortified fufu flour flours ranged from (0.32-0.87%). Ash content of food product gives insight to the mineral content of food products [12]. The ash content of the fortified flour dried using the specified methods were relatively higher than their unfortified counterparts. This suggests that the inclusion of soybean flour has the potential of improving the mineral content of fufu flour when used as fortifier. The ash contents were significantly affected by drying methods. Flour dried using solar method recorded the highest value for fortified flour 0.87%.

The carbohydrate content of the fortified flour decreased compared to the raw flours. The values ranged from (88.39-88.83%) for raw flours to (81.06-85.58%) for fortified flour. The decrease could be due to low carbohydrate level of the added soybean. Iwe [25] reported similar results when higher levels of soybean flour were added to sweet potatoes and plantain flour.

The results of functional properties of fufu flour fortified with soybean and dried using oven, sun and drying methods are presented in Tables 3 and 4. From the results, the bulk densities for flours from the three methods of drying were the same (0.59 and 0.62g/cm^3 for fufu and fufu fortified flours respectively). This revealed that the methods of drying employed did not have any effect on the bulk density. The bulk densities increased with addition of soybean flour. Increase in bulk density increased the sinkability of powdered particles and this aids their ability to disperse [26-27]. Bulk density is an indication of the porosity of a product which influences package design. It helps in determining suitable packaging material for food products [28]. It is also important in infant feeding, where less bulk is desirable [29]. The fermentation process undergone by the cassava reduced the bulk densities of the fufu flour. It has been reported that fermentation and germination are possible factors that cause decrease in bulk density [30].

Water absorption capacities of the fortified fufu flours were equally the same 1.43ml H_2O/g higher than fufu flours 1.20ml H_2O/g. There was no significant ($p>0.05$) difference in the values obtained for fufu and fufu fortified flours. Water absorption capacity is the ability of the flour to absorb or take in water during processing [19]. This is an indication of the extent to which protein can be incorporated into the food formulation increase in water absorption capacity implies high digestibility of starch The water absorption characteristics represent the ability of a product to associate with water under condition where water is limiting in order to improve its handling characteristics [31] and dough making potentials [29].

Table 3. Functional Properties of fufu Flour

Drying method	Bulk density (g/cm^3)	Water absorption (ml H_2O/g)	Swelling power	Foam capacity	Gelation
Oven dried	0.59±0.04a	1.20±0.01a	1.66±0.05a	9.25±0. 10b	6.0±0.01a
Sun dried	0.59±0.01a	1.20±0.02a	1.67±0.02a	9.10±0.1 5c	6.0±0.01a
Solar dried	0.59±0.02a	1.20±0.01a	1.67±0.07a	9.50±0 .10a	6.0±0.01a

Table 4. Functional Properties of fufu Fortified with Soybeans Flour

Drying method	Bulk density (g/cm^3)	Water absorption (ml H_2O/g)	Swelling power	Foam capacity	Gelation
Oven dried	0.62±0.02a	1.43±0.02a	1.41±0.02a	12.30±0 .06c	4.0±0.01a
Sun dried	0.62±0.02a	1.43±0.01a	1.41±0.04a	15.60±0.03a	4.0±0.01a
Solar dried	0.62±0.02a	1.43±0.02a	1.41±0.02a	14.80±0.02b	4.0±0.02a

Fermentation and germination has been reported to increase water absorption of flours. During fermentation, proteolytic activities takes place which cause increase in the number of polar group [32]. The addition of soybeans flour helps in the water binding properties because of the presence of protein and the damage of starch as a result of milling process. Sanni et al. [10] reported that high water absorption capacity is attributed to loose structure of the starch polymers while low value indicates the compactness of the molecular structure. Water absorption capacity has a linear relationship with swelling capacity, is a useful indication of whether protein can be incorporated. The swelling capacity for the three flours followed the same trend. For the fufu flour, the sun and solar drying methods had the same values of 1.67 while all the fortified fufu flours recorded the same value of 1.41. This showed that fufu flour swelled more than the fortified flours. Reduction in swelling power may be due to incorporation of soybean flour into the fufu flour. High swelling capacity has been reported as part of the criteria for a good product [33]. The result for foam capacity revealed that flour dried using sun drying method recorded 15.60%, followed by solar drying method which recorded 14.80% and oven drying method with the value of 12.30% indicating that the drying methods had significant effect on this parameter. Foam capacity is known as aerating or whipping properties of food. It is the ability to incorporate air by it or a mixture with other ingredients and to hold the aerated structure long enough so that it can be set by heat or other means [24]. Sun dried fortified fufu flour had the ability to hold the aerated structure than other flours. The increase in the foaming capacity may be attributed to the increase in the addition of soybean flour [18]. The gelation capacity was not affected by the drying methods employed as all the flours recorded the same values of 6.0 and 4.0% in fufu and fufu fortified flours. This is dependent on the starch contents of the flours. This showed that addition of soybean flour to fufu flour cause considerable reduction in the gelling ability of the flours. The rate of gelling and gel firmness depend on temperature, time of heating and protein concentration [34]. Gelatinization affects digestibility and texture of starch containing foods [35-36].

The pasting properties of fufu flour fortified with soybean and dried using oven, sun and solar drying methods are presented in Tables 5 and 6. There were significant differences ($p<0.05$) in all the pasting properties of the fufu flours ($P<0.05$). Fufu flour is cooked into paste before consumption hence, the pasting characteristics of fufu flour are important quality index in predicting the behaviour of fufu paste during and after cooking [26]. The drying methods have significant effect on the pasting quality of the fufu. Higher peak viscosities were observed in both fufu and fortified fufu using solar drying method. The highest final viscosities for fufu and fortified fufu were obtained with solar and sun drying methods respectively.

Table 5. Pasting properties of fufu flour

Drying method	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Pasting time (min)	Pasting Temp (ºC)
Oven dried	355.82±0.94b	245.31±1.18b	110.51±0.81b	317.36±0.99b	72.05±0.46b	5.46±0.02a	76.23±0.05a
Sun dried	349.99±1.41c	234.47±1.10c	115.52±1.16a	309.43±0.86c	74.96±0.23a	5.46±0.02a	76.23±0.02a
Solar dried	357.58±1.26a	250.26±1.14a	107.32±1.12c	320.12±1.01a	69.86±0.33c	5.43±0.01c	76.20±0.02c

Table 6. Pasting properties of fufu fortified with soybeans flour

Drying method	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Pasting time (min)	Pasting Temp (ºC)
Oven dried	235.12±0.99b	131.75±1.21a	103.37±0.52b	204.42±0.61c	72.67±0.25c	5.60±0.10b	77.56±0.09a
Sun dried	231.87±0.86c	129.25±0.69b	102.62±0.49c	217.42±1.01a	88.17±0.41a	6.60±0.16a	76.55±0.06b
Solar dried	235.29±0.83a	128.75±0.71c	106.54±0.37a	212.33±0.90b	83.58±0.52b	5.07±0.11c	76.25±0.02c

Viscosity is the parameter used to determine a particular starch based flour quality [10]. Fufu flour fortified with soybeans flour sun dried had the lowest viscosity due to the denatured protein by heat processing [37] and low starch content in soybean [38]. The low viscosities showed that the associative forces between the starch molecules are relatively weak [30]. Setback viscosities showed variations in the fufu flours processed and dried with different methods. Values ranged from 72.05-88.17 RVU. The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the flour [39]. Sun dried fortified fufu flour would have low retrogradation and staling rate after cooling than other flours. Setback value is the difference between final viscosity and hot paste viscosity or trough [10]. It is a measure of the stability of the paste after cooking. It is a phase where during cooling of the mixture, a re-association of the starch granule occur which affects retrogradation or re-ordering of the starch molecules leading to syneresis or the release of water. The high values of setback indicate low stability after cooking.

The pasting temperature and time varied with the different drying methods. The pasting time ranged from 5.07-6.60mins. Pasting time was significantly influenced by the methods of drying and soybean flour addition. Sun drying method recorded highest value of 6.60mins followed by oven drying method (5.60mins) and solar drying method recorded the least value of 5.07mins. There was increase in the pasting time of sundried fortified fufu flour indicating more time for cooking than oven and solar dried fufu flour. Pasting time is an indication that the product is easy to cook.

The pasting temperature ranged from 76.20-77.56ºC. Oven dried fufu flour had higher pasting temperature than other flour. Pasting temperature observed for fufu flours were higher than the values (63.77-65.11ºC) reported by Sanni et al. [10] using flash and rotary driers. Differences in the pasting temperatures may be due to cultivar of cassava used, processing methods and methods of drying. Pasting temperature is the temperature above the gelatinization temperature at which the viscosity begins to rise. It provides an indication of the minimum temperature required to cook flour, which can have implication on the stability of other components in a formulation and also indicates energy loss. Pasting temperature gives an indication of the gelatinization time during processing [40]. It is the temperature at which the first detectable increase in viscosity is measured and it is an index characterized by the initial change due to the swelling of starch [41]. Pasting temperature has been reported to relate to water binding capacity. A higher pasting temperature implies higher swelling properties of starch due to a high degree of association between starch granules [41-42].

4. CONCLUSION

Fortification of fufu flour with soybean flour resulted in increase in proximate constituents and functional properties of the flours. The functional properties results revealed that except for foam capacity, all other properties like bulk density, water absorption capacity and swelling capacity were not significantly affected by the drying methods as all the flours recorded the same values for these parameters. The pasting parameters were significantly affected by the method of drying coupled with addition of soybean flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Omodamiro RM, Iwe MO, Ukpabi UJ. Pasting and functional properties of lafun and starch processed from some improved cassava genotypes in Nigeria. Nigeria Food Journal. 2007;2(2):122–129.
2. Oyewole OB, Afolami OA. Quality and preference of different cassava varieties for 'Lafun' production. Journal of Food Technology in Africa. 2001;6(1):27-29.
3. Oyewole OB. Lactic fermented food in Africa and their benefit. Food Control. 1997;8(6):289-297.
4. Wenhaam JE. Post-harvest deterioration of cassava; A Biotechnology perspective. FAO Plant Production and Protection Paper. 1995;130:8–10.
5. Sanni LO, Idowu MA, Taiwo BB. Production and storage of foam-mat dried tomato powder. West African Journal of Foods and Nutrition. 1999;2(l):54–59.
6. Oyewole OB. Fermentation of cassava for lafun and fufu production in Nigeria. Food Laboratory News. 1991;7(2):29-31.
7. Sanni LO, Oyewole OB, Akingbola JO. The effect of controlled and uncontrolled solar drying temperatures heat flukes on proximate composition and functional properties of soybeans. Tropical Oil Seed Journal. 2000;5;62-64.
8. Lasekan OO, Akintola AM. Production and nutritional evaluation of puffed soy-maize snack. Nigerian Food Journal. 2002;20:15-19.
9. Akingbola JO, Oguntimehin B, Abass AB. Effect of processing method on the quantity and acceptability of fufu from low cyanide cassava. Food Chemistry. 1991;58(4):255-258.
10. Sanni LO, Adebowale AA, FilaniTA, Oyewole OB, Westby A. Quality of flash and rotary dried fufu flour. Journal of Food Agriculture and Environment. 2006;4:3–4.
11. Adebooye OC. Proximate composition and nutrient analysis of six selected leafy vegetable of South-West Nigeria. Ife Journal Agriculture. 1996;18:56–63.
12. Adeleke RO, Odedeji JO. Acceptability studies on bread fortified with tilapia fish flour. Pakistan Journal of Nutrition. 2010;9(6):531-534.
13. Nwokeke B, Adedokun I, Osuji C. Effect of blending on the proximate pasting and sensory attributes of cassava-African yam bean fufu flour. International Journal of Scientific and Research Publications. 2013;3(8):1-7.
14. Akoja SS, Mohammed AO. Evaluation of the proximate, pasting and sensory characteristics of cassava flour (*fufu*) fortified with pigeon pea flour. Pakistan Journal of Nutrition. 2011;10(2):124-128.
15. Numfor FA, Noubi L. Effect of full-fat soya bean flour on the quality and acceptabiIity of fermented cassava flour. Food and Nutrition Bulletin. 1995;16:3.
16. Osho SM. Soybean as food in Nigeria. Training Manual, IITA. 1991;11-20
17. AOAC. Official methods of analysis. Association of official and analytical chemists.15th edition. Washington D.C; 1990.
18. Okaka JC, Potter NN. Physicochemical and functional properties of cowpea powders processed to reduce beany flavor. Journal of Food Science. 1979;44:1235-1240.
19. Lin MJ, Humbert EA, Sosuki FW. Certain functional properties of sun flower products. Journal food Science. 1974;39:368-371.
20. Naranaya K, NarasinyaRao MS. Functional properties of raw heat processed winged bean (P*sophocapus tetragonolobus*) flour. Journal food Science. 1982;42:534-538.

21. Adebowale AA, Sanni LO, Awonorin SO. Effect of texture modifies on the physicochemical and sensory properties of dried fufu. Food Science Technology International. 2005;11:373–382.
22. Akyroyd WR, Doughty J, Walker A. Legume in human nutrition FAO. Food and Nutrition Rome. 1982;20:67-67.
23. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the tropics. Macmillian Publisher, London. 1985;236-358.
24. Hung HC, Joshipura KJ, Jiang R. Fruit and vegetable intake and risk of major chronic disease. Journal of National Cancer Institute. 2004;96:1577.
25. Iwe MO. Proximate, physical and sensory properties of soy- sweet potato flour cookies. Global Journal of Pure and Applied Science. 2001;8(2):187-191.
26. Udensi EA, Okaka JC. Predicting the effect of blanching, drying temperature and particle size profile on the dispersibility of cowpea flour. Nigerian Food Journal. 2000;18:25-31.
27. Ekwu FC, Ozo, NO, Ikegwu OJ. Quality of fufu flour from white yam varieties (*Dioscorea* spp). Nigerian Food Journal. 2005;23:107-113.
28. Iwe MO, Egwuekwe EI. Production and Evaluation of cookies from *Xanthosona segittifolium* and *Cococariaes culenta* blends. Nigerian Food Journal. 2010;28(l):145–153.
29. IweMO, Onadipe OO. Effect of extruded full fat soy flour into sweet potato flour on functional properties of thee mixture. Journal of Sustainable Agriculture and Environment. 2001;3(l):109-117.
30. Etudaiye HA, Nwabueze TU, Sanni LO. Pasting and functional properties of fufu processed from cassava mosaic disease resistant varieties cultivated in a high rainfall zone. Nigeria Food Journal. 2009;2:187–188.
31. GiamiSV, Bekebian DA. Proximate composition and functional properties of raw and processed full fat fluted pumpkin. (*Telfaria occidentalis*) seed flour. Journal of Science of Food and Agriculture. 1992;59:321-325.
32. Onimawo AI, Akubor PI. Food chemistry (integrated approach with biochemical background) first edition, Published by AMDIK press Ltd. Benin City, Edo State. 2005;222–224.
33. Achinewhu SC, Baiberi LJ, Ijeoma JO. Physicochemical properties and certification of selected cassava cultivars in Rivers State. Plant Food Human Nutrition. 1998;52:133–140.
34. Padmashere TS, Vigayaalaakshmi L, Puttaras S. Effect of Traditional Processing on the Functional Properties of Cowpea (*Vigna cajan*) Flour. 1987;24:221–226.
35. Iwe MO, Vanzuilichem DJ, Stolp W, Ngoddy PO. Effect of extrusion cooking of soy-sweet potato mixture on available lysine content and browning index of extrudates. Journal of Food Engineering. 2003;62:143-150.
36. Rickard JE, Asoaka M, Blanshard JMO. The physicochemical properties of cassava starch. Tropical Science. 1991;31:189–207.
37. Lawal OS, Adebowale KO, Oderinde RA. Functional properties of amylopectin and analyse fractions isolated from Bambara groundnut (*Voandexia subterranean*) starch. African journal of Biotechnology. 2004;3(8):399-400.
38. Fukushimi D. Recent progress in soybean protein. Food chemistry, technology and nutrition. Food Reviews International. 1991;7(3):323–330.
39. Adeyemi IA, Idowu MA. Evaluation of pregelatinized maize in the development of “Maissa” – a baked product. Nigerian Food Journal. 1990;8:63–73.

40. Odedeji JO, Adeleke RO. Pasting characteristics of wheat and sweet potato flour blends. Pakistan Journal of Nutrition. 2010;9(6):555-557.
41. Eniola L, Delarosa LC. Physicochemical characteristics of yam starches. Journal of Food Biochemistry. 1981;5:115–130.
42. Numfor FA, Walter WM, Schwartz JJ. Effect of emulsifiers on the physical properties of native and fermented cassava starches. Journal of Agriculture Food Chemistry. 1996;44:2595–2599.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=468&id=5&aid=4099