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Comparative Evaluation of the Quality Parameters of Baked Potato Crisps: Yellow-Fleshed and Orange Fleshed

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Abstract

The goal of this study was to compare the quality parameters of baked crisps from orange-fleshed sweet potato (OFSP) and yellow-fleshed sweet potato (YFSP). The baked sweet potato samples were evaluated for their proximate, vitamin A and sensory properties using standard methods. On the basis of the proximate composition, there was a significant difference ($p < 0.05$) in the values obtained as baked OFSP had higher crude protein, crude fibre, total carotenoid and vitamin-content than YFSP while YFSP had higher NFE and energy than OFSP. Sensory evaluation of baked sweet potato samples also revealed a significant difference ($p < 0.05$) where YFSP baked sample had higher sensory scores in all the rated attributes than OFSP sample. OFSP baked samples however had higher textural values in terms of force at break.

There was also a significant difference at $p < 0.05$ for all the textural parameter of the two baked samples with higher values for OFSP sample and no significant difference in energy required to break between the two baked products.

The study suggested that it is possible to develop crunchy baked crisps from both orange fleshed and yellow fleshed sweet potatoes.

Keywords: *Sweet potato; crisps; proximate; carotenoids; sensory; textural*

Abbreviations: ANOVA: Analysis of Variance; NFE: Nitrogen Free Extract; OFSP: orange-fleshed sweet potato; YFSP: yellow-fleshed sweet potato

Introduction

Sweet potato (*Ipomoea batatas*) is a vital staple crop that serves as an important food crop of major economic importance in the tropical regions where it is grown [1]. It ranked among the world's most important, versatile and under exploited food crops on a fresh-weight basis in most developing countries after rice, wheat, maize and cassava with more than 133 million tonnes in annual production [2,3].

Sweet potatoes are usually consumed boiled, roasted, fried, creamed or baked in their skins [4]; and has a large potential to be used as food in developing nations with limited resources because of its short maturity time and ability to grow under diverse climatic condition and on less fertile soil [5].

The crop has been identified to have the potential of bridging the food gap due to its diversified processing and utilization technologies that have been developed over the years by various researchers but not yet fully exploited. Researchers have worked on increasing the utilization potentials of this crop through production of value-added products (chips, crisps, blending of sweet potato flour with wheat flour for products like chapatti, mandazi or porridge) [6-8]; and these products are intended to increasing both sweet potato production and utilization as a way of improving incomes and food security among the poorer segments of the rural population.

Nutritionally, sweet potatoes ranked among the most nutritious food crops being an excellent source of carbohydrates, vitamin C, and pro-vitamin A (β-carotene), with researches showing that phyto-nutrients present in sweet potatoes may be able to help lower the potential health risk posed by heavy metals and free radicals [9]. This is helpful not only for digestive tract problems like irritable bowel syndrome and ulcerative colitis, but also for anyone who wants to reduce the potential risk posed by heavy metal residues (like mercury) in their diet. Other benefits of sweet potatoes may include anti-inflammatory effects as report by [10], shows that phyto-nutrients in sweet potatoes can reduce markers of inflammation.

Generally, the colour intensity of sweet potato root flesh differs from one cultivar to another and varies from white to deep orange. The intensity of the orange colour reflecting the amount of beta-carotene present in the sweet potato [11].

Orange-fleshed sweet potato as a staple food has an advantage over most vegetables in that it can supply significant amounts of vitamin A and energy simultaneously - thus helping to address the twin-problem of Vitamin A deficiency (VAD) and under-nutrition [12,13]. The crop is also noted to contain pigments - flavones, phenolic acids, and anthocyanins which are considered anti-oxidants having physiological attributes such as anti-cancer, protection against night blindness, ageing and liver injury [14,15]. Therefore, the development of new value-added products from this crop is a way of expanding the consumption and market opportunities for the sweet potato industry [15,16]. Hence, the purpose of this research was to determine and compare the quality characteristics of baked crisps from both orange fleshed sweet potato and yellow fleshed sweet potato.

Materials and Methods

Raw Materials

The yellow - fleshed sweet potato was obtained from Ile - Epo market, Lagos State, Nigeria. The orange - fleshed variety (UMUSPO - 01) was obtained from the National Root Crop Research Institute (NRCRI), Umudike, Abia State, Nigeria. Other baking ingredients such as butter, a blend of spices, table salt and binder were obtained from a local market in Lagos, Nigeria.

Methods

Production of Sweet Potato Baked Crisp

The method of Oluwole., *et al*. [8] was used in the production of baked sweet potato crisps as shown in Figure 1 below. Upon careful weighing and sorting, the raw sweet potatoes were peeled and washed after which they were cut into smaller sizes. The sweet potato slices were cooked with distilled water for about 30 - 35 min, the cooked sweet potato obtained was subsequently mashed. Thereafter, the mashed sweet potatoes along with other ingredients were transferred into a mixer (Hobart) and the content mixed thoroughly for about 30 min to obtain dough of desired consistency. The mixed dough was manually sheeted using a rolling pin on a stainless steel tray of a height 3.3 mm giving the sheeted dough a thickness of 3.3 mm and cut into shapes using a 15 mm radius (30 mm diameter) circular biscuit cutter. Aluminium foil was used to prevent dough sticking to the rolling pin. The cut dough pieces were later transferred to a baking tray lined with aluminium foil [17]. The snacks were baked in a pre-heated air circulation oven (Memmert, Typ: UM 400) at temperatures of 120°C for a period of 40 ± 5 min and allowed to cool for 30 min at room temperatures.

Analysis

Proximate analysis on baked sweet potato crisps

Raw sweet potato tubers and the corresponding crisps of both yellow-fleshed and orange-fleshed were analyzed for their proximate composition including moisture, crude protein, fat, ash, crude fibre, and carbohydrate according to standard methods AOAC [18]. Nitrogen Free Extract (NFE) was calculated by difference while calculated energy value (Kcal/100g) was calculated using the Atwater factor [19]. The total carotenoids and vitamin A was estimated based on the official procedures [18].

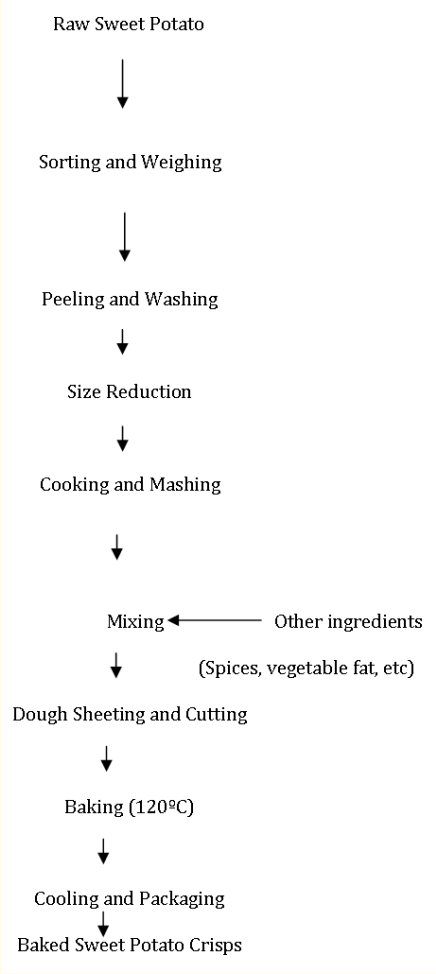

Figure 1: *Production of baked sweet potato crisps.*

Percentage total carotenoids retention in the baked crisps was obtained as a ratio between the total carotenoids content of the crisps and the starting raw sweet potato expressed as a percentage below.

$$\%\ Retention\ of\ carotenoids\ in\ crisps \frac{Total\ carotenoids\ in\ baked\ crisps}{Total\ carotenoids\ in\ raw\ sweet\ potato} \times 100$$

Sensory Evaluation

Organoleptic evaluation of the coded samples of the baked sweet potato crisps was carried out for level of acceptance and preference using a ten-member semi trained panel. The attributes evaluated for include colour, taste, crispiness, texture, flavour, mouth feel and overall acceptability using a nine point hedonic scale, where 1 and 9 representing "extremely dislike" and "extremely like" respectively [20]. Samples were identified with three-digit code numbers and presented in a random sequence to panellists.

Statistical analysis

The data collected from the experiments were subjected to analysis of variance (ANOVA) and samples' means were separated using Duncan's multiple range test. Significance was accepted at 5% significance level.

Note: OFSP - Orange-fleshed sweet potato; YFSP- Yellow-fleshed sweet potato

Results

Proximate analysis of raw sweet potato and baked sweet potato crisps

Table 1 shows the proximate analysis of the raw sweet potato (Orange fleshed and Yellow fleshed) and their corresponding baked crisps. The moisture content ranged between 62.45 and 74.0%, 1.24 to 1.32% crude protein, 0.50 to 4.32% crude fat, 0.77 to 1.77 crude fibre, 0.64 to 0.91% total ash, 17.70 to 34.42% Nitrogen Free extract and 480.66 to 615.27% of energy in both raw sweet potatoes investigated in this study.

Sample		Proximate (%)						Energy (KJ/100g)
		Moisture	Crude Protein	Crude Fat	Crude Fiber	Total Ash	NFE	
Raw	OFSP	$74.00^{a} \pm 1.16$	$1.32^{c} \pm 0.11$	$4.32^{c} \pm 0.34$	$1.74^{b} \pm 0.15$	$0.910^{d} \pm 0.09$	$17.70^{d} \pm 1.08$	$480.66^{d} \pm 28.87$
	YFSP	$62.45^{b} \pm 0.64$	$1.24^{c} \pm 0.16$	$0.50^{b} \pm 0.2$	$0.77^{c} \pm 0.06$	$0.64^{c} \pm 0.06$	$34.42^{c} \pm 0.44$	$615.27^{c} \pm 11.42$
Baked	OFSP	$6.50^{c} \pm 0.33$	$5.76^{a} \pm 0.24$	$11.11^{a} \pm 1.12$	$7.72^{a} \pm 0.21$	$4.25^{a} \pm 0.26$	$64.65^{b} \pm 1.07$	$1595.30^{b} \pm 24.80$
	YFSP	$5.20^{d} \pm 0.38$	$2.26^{b} \pm 0.24$	$10.91^{a} \pm 1.05$	$2.40^{b} \pm 0.13$	$2.62^{b} \pm 0.12$	$76.59^{a} \pm 1.16$	$1728.93^{a} \pm 26.92$

Table 1: *Proximate analysis on raw sweet potato and baked sweet potato crisps.*
Values are mean +/- the standard deviation of 3 determinations; Mean values with different superscript in the same column are significantly different ($p < 0.05$).

The moisture content in the two different baked sweet potato crisps ranged between 5.20 and 6.50%, 2.26 to 5.76% crude protein, 10.91 to 11.11% crude fat, 2.40 and 7.72% crude fibre, 2.62 to 4.25% total ash, 64.65 to 76.59% Nitrogen free extract and 1595.30 to 1728.90 KJ/100g energy.

Generally, there were significant difference in the percentage moisture content, crude protein, crude fibre, total ash, Nitrogen free extract and energy except for percentage crude fat at $p < 0.05$.

Total Carotenoid Contents

Table 2 as shown in the appendix, shows the total carotenoids content in both raw and baked sweet potato crisps derived from orange fleshed and yellow fleshed sweet potato. The total carotenoids content of 15,500 µg/100g and 8755 µg/100g was obtained for both orange fleshed and yellow fleshed sweet potato respectively.

Sample		Total Carotenoid (µg/100g)	Vitamin-A (µg/100g)	% Retention
Raw	OFSP	15500 ± 200	3878 ± 53	-
	YFSP	8755 ± 155	2189 ± 39	-
Baked	OFSP	12940 ± 60	3235 ± 15	83.44
	YFSP	4810 ± 10	1203 ± 03	54.79

Table 2: *Total carotenoid, vitamin-A and % retention of raw sweet potato and baked sweet potato crisps.*
Values are mean +/- the standard deviation of 3 determinations; Mean values with different superscript in the same column are significantly different ($p < 0.05$).

In the corresponding individual baked crisps from both sweet potatoes investigated, the total carotenoids content of 12,940 µg/100g and 4810 µg/100g was obtained for orange fleshed and yellow fleshed baked sweet potato crisps respectively while the percent retention of total carotenoids in both baked crisps relative to the carotenoids content of the individual starting raw material (i.e orange fleshed sweet potato, yellow fleshed sweet potato) was 83.44% for the baked crisps produced using orange fleshed sweet potato and 54.79% for the baked crisps produced from the yellow fleshed sweet potato used in this study.

Sensory Evaluation

The result of the sensory attributes (Figure 2) revealed that the baked crisps from yellow-fleshed sweet potato (YFSP) showed a significant difference ($p < 0.05$) from the orange-fleshed sweet potato (OFSP). YFSP sample was rated higher in most of the measured sensory attributes; however, no significant difference ($p > 0.05$) was recorded for sensory attributes of flavour and mouth feel in both varieties.

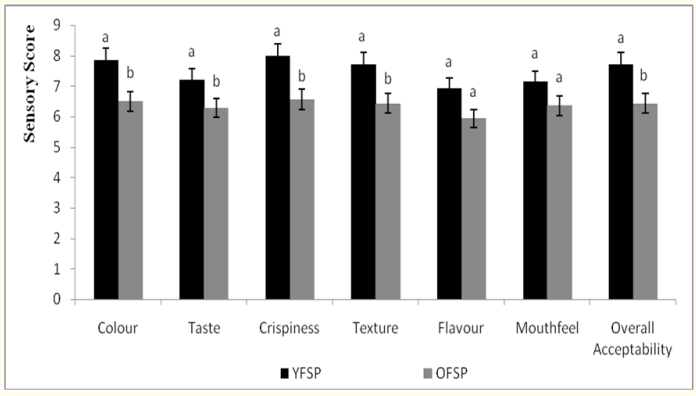

Figure 2: *Sensory evaluation rating of baked sweet potato crisps.*

Textural Characteristics of Baked crisps

Table 3 as shown in the appendix shows the textural characteristics of the developed baked crisps obtained from orange fleshed and yellow fleshed sweet potato.

The results of the textural characteristics obtained in this study indicated that there was a significant difference at $p < 0.05$ for the textural parameters of force at peak, deformation at peak, deformation at break except for the textural parameter of energy to break which there was no significant difference in both baked crisps derived from the two different sweet potatoes investigated in this study at $p < 0.05$.

Discussion

Proximate Analysis

In this present study, it could be noticed that the varieties significantly affected ($p < 0.05$) some of the results obtained for the proximate composition of the yellow and orange fleshed sweet potato tubers and their respective crisps (Table 1). The moisture content obtained for both varieties of raw sweet potato tubers was lowered than the results (81.00% and 80.00% for OFSP and YFSP respectively) reported by Hacineza., *et al*. [21]. The variation might be as a result of difference in the geographical location [22]. The moisture content of the baked crisp samples was reduced to 6.50% and 5.20% respectively for OFSP and YFSP after baking of the sweet potato crisps. This is probably due to the effect of moisture removal from the product during baking. The moisture content obtained for the OFSP was a bit higher than the reported result of Oluwole., *et al*. [8] while the value obtained for YFSP was within the range of reported result.

The crude protein content of raw OFSP tuber was a bit higher than that of raw YFSP tuber but does not show any significant difference ($p > 0.05$). But there was a general increase in the protein content of the product (baked crisps) from the sweet potato varieties when compared with the raw tubers. This observed decrease in protein content of the raw sweet potato to the baked crisps irrespective of the variety may be attributed to the concentration of the nutrient as a result of the removal of moisture from the baked crisps [8]. A similar trend was observed by Hacineza., *et al*. [21] who reported an increase in the crude protein content of dried chips from both OFSP and YFSP when compared with the raw tubers. There was also a significant difference ($p < 0.05$) in the value obtained for baked crisps from the two varieties with OFSP sample having a higher value. The result reveals that OFSP crisps have more protein content than YFSP crisps.

The study also revealed a decrease in the fat content in the OFSP and YFSP raw samples as compared to their baked samples. This is expected due to the inclusion of fat in the recipe for the baked crisps and the value of the fat content falls within the range reported by Oluwole., *et al*. [8].

The total ash of the raw samples was lower than that reported by Hacineza., *et al*. [21] and Oluwole., *et al*. [23] this might be as a result of varietal difference. However, there was an increase in this value in the corresponding baked crisps irrespective of the variety. This might be traced down to the inclusion of some other baking ingredients (butter, spices and salt) in the recipe which contributes to the total ash content of the products as well as concentration of minerals after baking.

The results obtained for the fiber content of the raw sweet potato varieties showed an increase to that reported by Oluwole., *et al*. [23] with OFSP having a greater value. Upon baking, fiber content of the samples increased significantly ($p < 0.05$) irrespective of the variety. The higher quantity of crude fibre in OFSP is an added advantage as studies has shown that fibre-rich food with their high percentage of fibre plays an important role in the prevention and treatment of several diseases such as cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes [24-26]. Apart from this, World Health Organization recommended the consumption of foods containing more than 25 grams (27-45g) of total dietary fibre/day [27].

Nitrogen free extract (NFE) of the raw potato varieties (OFSP and YFSP) showed a significant difference ($p < 0.05$) in there with values with YFSP having a higher value and the value within the range reported by Oluwole., *et al*. [23]. The same trend was also observed with the baked samples and the value also falls within the range reported by Oluwole., *et al*. [8]. This is might be partly attributed to the moisture removal from the product during baking and partly due to the variation in other proximate parameter values. The results obtained in this study showed that the derivable energy from the baked sweet potato crisps was higher in YFSP than in OFSP.

Total Carotenoid Content

Foods generally contain varying levels of vitamin-A or its precursors, which may be absorbed by the body during digestion and used directly by the body or following conversion to vitamin-A [28]. Orange-coloured fruits and vegetables, such as papaya, mango and orange-fleshed sweet potatoes are high in pro-vitamin-A with Vimala., *et al*. [29] reporting that one medium sized OFSP can provide about twice the β-carotene needed for the recommended daily requirement of vitamin-A. According Hacineza et al., [21], the β-carotene content of cream coloured sweet potato ranged from 0.0 - 0.4 mg/100g to 4.29 - 18.55 mg/100g in deep orange coloured sweet potatoes.

In Table 2 as shown in the appendix, the total carotenoid content in the raw sweet potato samples was 15510 µg/100g and 4.81 µg/100g for OFSP and YFSP respectively though a higher figure was reported by Carey., *et al*. [30]. This same trend was also observed with the baked crisps samples with OFSP baked crisps having a higher value than the YFSP baked crisps. This trend can be attributed to the variation in the genetic make-up of samples. This vividly shows that OFSP had higher pro-vitamin-A (β-carotene) content than YFSP due to high concentration of orange pigment present in OFSP as reported by Hacineza., *et al*. [21]; the concentration of pro-vitamin-A (β-carotene) was also responsible for the orange flesh colour of the sweet potato root.

The study as expected also showed that the total carotenoids retention was higher for OFSP baked crisp than YFSP baked crisp which clearly indicated that OFSP has higher total carotenoids retention.

Sensory Evaluation

The study indicated that the developed baked crisps from yellow fleshed sweet potato was more acceptable by the panellist used in this study then the orange fleshed baked sweet potato crisps. This could be attributable to the fact that yellow fleshed sweet potato has been in existence for quite a longer period of time [1] than orange fleshed sweet potatoes [36] and consumers are already familiar with its sensory characteristics in different processed forms such as boiled sweet potato, fried sweet potato, roasted sweet potato etc [2].

Also there was considerable difference at $p < 0.05$ in terms of the proximate composition of both sweet potatoes and this could also reflect in considerable properties determined in this study.

Textural Characteristics

The textural characteristics of the baked crisps samples (Table 3 as shown in the Appendix) revealed a significant difference ($p < 0.05$) in the effect of varieties on the textural characteristics determined as OFSP sample has higher values in all the textural parameters measured except energy to break parameter. According to Bourne [31] and Mochizuki [32], the force at peak value of products could be used to represent the hardness of the products; and Sawant., *et al*. [33] stated that products with higher force at peak may be considered to have higher hardness. Generally, textural properties are mostly related to physical (especially mechanical) characteristics of foods products [34,35] and the result shows that OFSP baked sample would be harder than YFSP samples which is also reflected in the sensory ratings OFSP sample.

Textural Properties	Baked Crisps Sample	
	OFSP	YFSP
Force @ Peak (N)	24.94 ± 1.59^a	21.20 ± 1.12^b
Deformation @ Peak (mm)	0.90 ± 0.03^a	0.63 ± 0.19^b
Deformation @ Break	1.53 ± 0.15^a	1.20 ± 0.11^b
Energy to Break (N/m^2)	0.011 ± 0.004^a	0.007 ± 0.001^a

Table 3: *Textural Characteristics of Baked Crisps Samples.*
Values are mean +/- the standard deviation of 3 determinations; Mean values with different superscript in the same row are significantly different ($p < 0.05$).

Conclusion

This study had revealed the possibility of converting both orange fleshed and yellow fleshed sweet potato into crunchy baked crisps. This process technology and product serve as a value added product/technology for sweet potato farmers and help to boost their livelihood and income.

Also the presence of beta carotene in the baked product indicated that the product could be used as an intervention dietary source of vitamin A for different categories of the populace globally particularly in countries where there is recorded high prevalence of diet related vitamin A deficiency diseases. However, the textural properties of the crisps developed in this study may be further manipulated depending on the age of the target consumers.

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Bibliography

1. Woolfe JA. "Sweet Potato. An Untapped Food Resource". Cambridge University Press, Cambridge, United Kingdom. 1992.
2. CB Owori ROM. *et al*. "Sweet potato recipe book: Sweet potato processed products from Eastern and Central Africa". *African Crop Science Society Kampala, Uganda* (2007): 93.
3. CI Ezeano. "Technology use in sweet potato production, consumption and utilization among households in South-eastern Nigeria". *Journal of Agriculture and Social Research* 10.1 (2010): 36-42.
4. OO Tewe., *et al*. "Sweet Potato Production, utilization, and Marketing in Nigeria". *Social Science Department, International Sweet potato Centre* (CIP), Lima, Peru, (2005).
5. S Singh., *et al*. "Effect of incorporating sweet potato flour to wheat flour on the quality characteristics of cookies". *African Journal of Food Science* 2.6 (2008): 65-72.
6. RA Nungo PJ., *et al*. "Development and promotion of sweet potato products in Western Kenya". (2007).
7. RO Adeleke and JO Odedeji. "Functional Properties of Wheat and Sweet Potato Flour Blends". *Pakistan Journal of Nutrition* 9.6 (2010): 535-538.
8. OB Oluwole., *et al*. "Effect of Baking Temperature on the Quality of Baked Sweet Potato Crisps". *British Journal of Applied Science & Technology* 4.23 (2014): 3419-3429.
9. BJ Burri., *et al*. "Evaluating sweet potato as an intervention food to prevent vitamin A deficiency". *Comprehensive Review of Food Science and Food Safety* 10.2 (2011): 118-130.
10. ML Failla., *et al*. "In vitro bioaccessibility of b-carotene in orange fleshed sweet potato (Ipomoea batatas Lam.)". *Journal of Agriculture and Food Chemistry* 57.22 (2009): 10922-10927.
11. MC Ojinnaka and GI Onwuka. "Organoleptic Assessment of the Performance of Some Cultivars of Ipomoea batatas in the Development of Selected Snack Products". *Pakistan Journal of Nutrition* 10.10 (2011): 935-939.
12. J Low T., *et al*. "The potential impact of orange-fleshed sweet potato on Vitamin-A intake in sub-Saharan Africa". Paper presented at a Regional Workshop on Food Based Approaches to Human Nutritional Deficiencies: The VITAA Project, Vitamin A and Orange-fleshed sweetpotato in sub-Saharan Africa, Nairobi, Kenya.
13. C Hotz., *et al*. "A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women". *British Journal of Nutrition* 108.1 (2012): 163-176.
14. R Kapinga., *et al*. "Role of Orange fleshed sweet potatoes in disaster mitigation: Experiences from East and Southern Africa". *Africa crop science conference proceedings* 7 (2005): 1321-1329.
15. AW Mwanri., *et al*. "Nutrients and antinutrients composition of raw, cooked and sun- dried sweet potato leaves". *African Journal of Food Agriculture, Nutrition and Development* 11.5 (2011): 1-6.
16. PJ Ndolo., *et al*. "Development and promotion of orange-fleshed sweetpotato varieties in Western Kenya". In the Proceedings of the 13th ISTRC Symposium (2007): 689-695.
17. AA Olapade., *et al*. "Quality Attributes of Biscuit from Acha (*Digitaria exilis*) Flour Supplemented with Cowpea (Vigna unguiculata) Flour". *African Journal of Food Science and Technology* 2.9 (2001): 198-203.
18. AOAC. "Association of Official Analytical Chemists. Official Method of Analysis," 15th edition, Washington DC USA 2005.
19. JI Okoye., *et al*. "Production, proximate composition and consumer acceptability of biscuits from wheat/soybean flour blends". *Continental Journal of Food Science and Technology* 2 (2008): 6-13.
20. IA Ihekoronye and PO Ngoddy. "Integrated Food Science and Technology for the Tropics". Macmillan, London. 1985.
21. E Hacineza., *et al*. "A comparative study on the β-Carotene content its retention in yellow and orange fleshed sweet potato flours". *Association for strengthening Agricultural Research in Eastern and Central Africa* 17.41 (2012): 1- 6.
22. E Adu-Kwarteng., *et al*. "Rice grain quality: a comparison of local varieties with new varieties under study in Ghana". *Food Control* 14.7 (2003): 507-514.
23. OB Oluwole., *et al*. "Development and Production of Fermented Flour from Sweet Potato (Ipomea Batatas L.) as a Potential Food Security Product". *Journal of Food Science and Engineering* 2 (2012): 257-262.

24. SA Bingham., *et al*. "Dietary fiber in food and production against colorectal cancer in the European prospective investigation into cancer and nutrition (EPIC): An observational study". *Lancet* 361 (2003): 1496-1499.
25. JL Slavin., *et al*. "Dietary fiber and body weight". *Nutrition* 21.3 (2005): 411-418.
26. M Elleuch., *et al*. "Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: Review". *Food Chemistry* 124.2 (2011): 411-421.
27. C Nishida., *et al*. "The Joint WHO/FAO Expert Consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications". *Public Health Nutrition* 7.1A (2004): 245-250.
28. S de Pee., *et al*. "Lack of improvement in vitamin A status with increased consumption of dark-green leafy vegetables". *Lancet* 346.8967 (1995): 75-81.
29. B Vimala., *et al*. "Variability in 42 orange-fleshed sweet potato hybrids for tuber yield and carotene and dry matter content". *Geneconserve* 40 (2011): 190 -200.
30. EE Carey., *et al*. "Collaborative sweetpotato breeding in eastern, central and southern Africa," In: Program Report 1995-1996. International Potato Center, Lima, Peru, (1997): 49-57.
31. MC Bourne., *et al*. "Food texture and viscosity". 1st edn. Academic Press, New York. (1982): 19-22.
32. Y Mochizuki., *et al*. "Texture profile analysis: Current Protocols in Food Analytical Chemistry". (2001):
33. AA Sawant., *et al*. "Physical and sensory characteristics of ready-to-eat food prepared from finger millet based composite mixer by extrusion". *Agricultural Engineering International* 15.1 (2013): 100-105.
34. H Luyten., *et al*. "Crispy/crunchy crusts of cellular solid foods: A literature review with discussion". *Journal of Texture Studies* 35.5 (2004): 445-492.
35. JM Arimi., *et al*. "Effect of moisture content and water mobility on microwave expansion of imitation cheese". *Food Chemistry* 121.2 (2010): 509-516.
36. JW Low., *et al*. "A Food-Based Approach Introducing Orange-Fleshed Sweet Potatoes Increased Vitamin A Intake and Serum Retinol Concentrations in Young Children in Mozambique". *The Journal of Nutrition* 137.5 (2007): 1320.

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