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Formulation and Proximate Composition of Chips Produced from Ackee Aril-Wheat Flour Composites.

Joycelyn Anima Osei[1], Owusu Kyeremateng[2], Martha Wunnam Alhassan[3] and Jacob Agbenorhevi[4]

[1]Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana[1]Email:sweetjoy50@gmail.com

[2]Lecturer, Department of Agro-Processing, Faculty of Applied Sciences, Wenchi, Methodist University College, Ghana[2]Email: danokyeremateng@gmail.com

[3]Lecturer, Department of Food Science and Technology, University for Development Studies, Tamale, Ghana [3]Email: alhassan.martha@yahoo.com

[4] Lecturer, Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana [4]Email: jkagbenorhevi@yahoo.com

[3]**Correspondence:**alhassan.martha@yahoo.com

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Abstract

Ackee aril *(Blighiasapida)* is an underutilized, multipurpose fruit tree species native to West Africa. The fleshy arils of the ripened fruits are edible while the seeds and capsules of the fruits are used for soap making. The utilization of this fruit will contribute tremendously to reducing, if not eliminating the food insecurity in West Africa. The aim of the present study was to assess the potential of ackee aril as a partial replacement to traditional wheat in baked products. The objectives of this research were to evaluate the

proximate composition of the ackee aril-wheat flour composites and to assess the suitability and acceptability of ackee aril composite chips at different levels of ackee aril flour substitution. Four composites or blends of chips were prepared in the proportions: 80:20, 60:40, 50:50 and 40:60 and wheat were used as control. The flour blends were used to bake chips after which the proximate composition and sensory attributes of the chips were examined. Results of proximate analysis showed significant increase ($p \leq 0.05$) in protein (10.2 – 16.9%), fat (2.1 – 20.2%) and fibre (0.5 – 3.7%) contents and significant decrease in carbohydrate (72.3 – 48.1%) contents with increase in ackee aril flour. There was no significant difference in the ash content of the test samples. Sensory evaluation results showed that all chips samples had high rating for all evaluated attributes. The closeness of values obtained for all chips samples to the control sample indicate a high level of acceptance of the WF-AF chips.

Keywords: composite, proximate composition, sensory attributes.

INTRODUCTION

Despite the increase in production of agricultural foods, Africa's food and nutrition insecurity status is growing worse (Frimpong, 2013). This is as a result of the underutilization of most native crops one of which is ackee aril *(Blighiasapida)*.This food insecurity situation could lead to a rise in malnutrition and nutritional deficiencies. Ghana and most developing countries are the largest importers of American red winter wheat (David, 2006; Edema *et al*., 2005). This implies that these countries are totally dependent on foreign countries for their bakery products. There is therefore a high dependency on imported wheat which can result in huge economic losses to the nation. Ghana like most other West African countries is endowed with ackee fruits. However, it is underutilized as the amount consumed is currently relatively low. One reason for this is the limited knowledge of its use especially in local food industries in Ghana.

The ackee *(Blighiasapida*) fruit is an African native crop introduced to the Caribbean by British slave traders. It belongs to the family *Sapindaceae* and grows to a height of 10 to 12m at maturity. The fleshy arils of the ripened fruits are edible and the oil extracted from the ackee seeds also has pesticide properties (Williams et al 1994, Khan and Gumbs 2003). Although the fleshy aril of the ackee fruit is not popularly eaten in Ghana, it is cultivated in the country for several nonfood uses: immature fruits are used to make soap; the wood from the tree is termite resistant and used for building; extracts from the poisonous seeds are taken to treat parasites and are sometimes used as a fish poison; topical ointment made from crushed ackee leaves is applied to the skin to treat headaches and ulcers. The leaves are also good as a fodder for goat.

Ackee is very nutritious. It is high in fatty acids and rich in protein, potassium, iron and vitamin C. A large percentage of the ackee (arils) consists of lipids, 51-58% by dry weight (Odutuga et al 1992). The major fatty acids found are linoleic, palmitic and stearic acids. 55% of the fatty acids present in acheeis linoleic acid (Lancashire 2006) which is an essential fatty acid and important for membrane development in the eye and brain.

Wheat flour is one of the major conventional ingredients in pastry making due to its gluten fraction which is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated by yeast during fermentation (Mepba et al., 2007). However, in tropical countries, wheat

production is limited and importation of wheat flour to meet local demand is a necessity (Giami *et al*., 2004).

Due to the high cost, geographical scarcity and high demand of wheat flour, efforts are been directed toward the provision of alternative source of flour. Attempts have been made by many researchers to complement wheat flour with non-wheat flour for pastry product (Okaka and Isieh, 1990, Onweluzo et al., 1995). Pacheco–Delahaye and Testa (2005) maintain that wheat can be mixed with other cereals and plants with high starch content which could constitute a locally available and less costly nutrient source in addition to enriching the dietetic fiber sources. These mixtures are referred as 'composite flour' and they have used to develop bread (Torres and Pacheco–Delahaye, 2007). Composite flours have therefore become the subject of numerous studies. Attempts have been made by many researchers to complement wheat flour with non-wheat flour for pastry product (Okaka and Isieh, 1990, Onweluzo et al., 1995).

In Ghana the major source of partial substitute for wheat in bread and pastry making are cassava, sorghum and millet. With increasing demand of bakery products which has led to importation of wheat, there is the need to source for locally processed flour from vegetables and fruits which can be used in partial substitution for wheat in the production of bakery products for consumption and industrial uses.

Increase utilization of Ackee aril in Ghana will significantly contribute to the reduction in food insecurity. This will ultimately result in a reduction in malnutrition and nutritional deficiencies. One way of increasing the utilization of Ackee aril, is through in food industries in the formulation of food, especially as a relatively cheaper replacement of wheat in the manufacture of pastries. However, due to its unique properties, wheat cannot be completely replaced by Ackee in the manufacture of pastries but can only be partially replaced by Ackee.

The aim of this study was to assess the potential of Ackee as a partial replacement to traditional wheat in the production baked food products. The objectives of the study were to evaluate the proximate composition of the ackee aril-wheat flour composites and to assess the suitability and acceptability of ackee aril composite chips at different levels of ackee aril flour substitution.

METHODOLOGY

Source of material

The *Blighiasapida* (ackee fruit) that served as sample for analysis was collected from ackee trees scattered at the Agogo Hospital which is located in Kumasi, Ashanti Region. Only the fleshy pulp (aril) of ackee fruits opened naturally was harvested for analysis. Wheat flour, hydrogenated fat, nutmeg, onion and salt were purchased from the Asafo market, Kumasi.

Processing of ackee aril flour

The edible portions (aril) of *Blighiasapida* were removed from the pulp using a knife after which it was solar dried for 2 weeks. The dried sample was milled with a hammer mill into flour and soaked in hexane in flour to solvent ratio of 1:10 w/v. The flour was soaked with the hexane in a sealed airtight container for 5 days at room temperature. The hexane was decanted after the 5 days period and dried in a solar dryer to expel the residual solvent. The ackee aril flour was milled again and sieved through a metal sieve of 160 μm pore size. The flour was sealed in polythene bags in airtight containers and kept in a refrigerator at 4 ºC until ready for analysis.

Flour blends for chips preparation

The flour blends from wheat and ackee aril flour was done as shown in Table 1. The negative control sample was 100% wheat flour. Each sample was blended in a high speed blender to get a unified composite mix. Each of the flours was sieved through a metal sieve of 160 μm pore size prior to blending.

Table 1: Wheat-ackee aril composites for chips production

Flour blend sample	Ackee aril flour (%)	Wheat flour (WF) (%)
A	0	100
B	20	80
C	40	60
D	50	50
E	60	40

Proximate analyses

Analysis of composited wheat-ackee aril flour for chips was carried out according to AOAC (2005) based on the formulation as shown in Table 1 as follows:

Moisture: About 2.0 g of mixed flour of wheat and ackee aril was weighed and transferred into a previously weighed glass crucible and placed in a hot air oven to dry at 105 °C until a constant weight was obtained. Samples were cooled in a desiccator, weighed, and returned to the oven to dry to constant weight. Measurements were taken in triplicate. Loss in weight was calculated as percentage moisture (AOAC, 2005).

Ash: About 2 g of mixed flour of wheat and ackee aril in a pre-weighed porcelain crucible was combusted in a muffle furnace at 600 °C for 2 h. The crucibles containing ash were cooled and re-weighed. Loss in weight was calculated as percentage ash content (AOAC, 2005).

Crude fat: The mixed flour of wheat and ackee aril used for moisture determination was transferred into a paper thimble, labeled and put into a thimble holder for the crude fat determination. About 200 mL of hexane was poured into a pre-weighed 500 mL round bottom flask and assembled on a semi-continuous soxhlet extractor and refluxed for 16 h. The hexane was recovered after removing the paper thimble from the thimble holder and the flask containing the fat was heated for 30 min in an oven at 103 ^{o}C to remove the residual hexane. The flask containing the fat was re-weighed after being cooled in a desiccator. The increase in weight was calculated as percentage crude fat (AOAC, 2005).

Protein: The protein determination of mixed flour of wheat and ackee aril was carried out by the Kjeldahl method in three steps: digestion, distillation and titration.

Digestion: About 2 g of mixed flour of wheat and ackee aril was weighed into a digestion flask and mixed with 25 mL concentrated H_2SO_4, selenium catalyst and few anti-bumping agents. The flask and its content were digested by heating in a fume chamber till the colour of the solution turned clear.

***Distillation*:** After the digestion has been completed the digestion flask was allowed to cool and the solution was transferred into a 100 mL volumetric flask and the volume made up to the 100 mL mark with distilled water. The distillation apparatus was flash out with water and 10 mL of digested sample

was transferred into the distillation apparatus. The solution was neutralize with 18 mL NaOH and boiled under distillation water in a steam generator. Circulation was allowed for about 10 min. A conical flask was filled with 25 mL of 2 % boric acid and 3 drops of mixed indicator (methylene blue and methylene red) added. The conical flask and its content were placed under the condenser in a position where the tip of the condenser was completely immersed in solution for 10 min and end of condenser washed with distilled water.

Titration: The nitrogen content was then estimated by titrating the ammonium borate formed in the conical flask with 0.1 M HCl solution. Titre values of the replicate samples were recorded and percentage nitrogen calculated (AOAC, 2005). A blank sample was run at the same time as the sample was being analyzed.

Crude fiber: The defatted mixed flour of wheat and ackee aril of about 2.0 g was weighed and transferred into a flat bottom flask and 200 mL of 1.25 % H_2SO_4 was added. The flask was connected to condenser over a hot plate and refluxed for 30 min after the first drop of condensate. Flask was disconnected from condenser and filtered through a clean cheese cloth. The residue was then washed with lots of boiling water until filtrate is no longer acidic by checking with blue litmus paper. The residue was transferred quantitatively back into the flask and 200 mL of 1.25 % NaOH was added and refluxed for 30 min. The content was filtered through cheese cloth and washed with boiling water until filtrate is no longer basic by checking with red litmus paper. The residue was transferred into a dry porcelain crucible and dried in an air oven at 105 °C for 4 h. The dried sample plus the porcelain crucible after cooling in a desiccator was weighed and recorded. It was then placed in a muffle furnace preset at 600 ^{o}C and combusted for 2h and re-weighed after cooling in a desiccator. The difference in weight was calculated as percentage crude fiber (AOAC, 2005).

Available carbohydrate: The available carbohydrate content present was determined by subtracting all the other proximate determinations from 100 % (AOAC, 2005). All values were expressed as means of triplicates for all the analysis.

Chips preparation Procedure

About 250 g of flour and 50 g of fat was mixed together by rubbing it with the finger tips. A tablespoon of blended onion and ½ tablespoon of nutmeg was added to the mixture of flour and fat and mixed again. About ½ tablespoon of salt was dissolved in water and added to the mixture to form dough. The dough was rolled on a cutting surface and cut into desired shapes and baked in a pre-heated oven for 15 min. After baking, chips were cooled and then packed in tray pans and labeled according to formulations with codes prior to sensory evaluations. This preparation procedure was applied to both the control (wheat only) and the wheat- ackee composites.

Sensory Evaluation

The five wheat-ackee composites that were made into chips were subjected to sensory evaluation. All the chips samples were evaluated on the following sensory attributes: appearance, taste, texture, aroma and overall acceptability. The each sensory attribute was evaluated on each sample using a 9-point hedonic scale with 1= disliked extremely, 2 = disliked very much, 3 = disliked moderately, 4 = disliked slightly, 5 = neither liked nor disliked, 6= liked slightly, 7= liked moderately, 8 = liked very much and 9 = liked extremely. Fifty panelists familiar with chips, who were neither sick nor allergic to baked products, were

involved in the assessment. The panelists were instructed to rinse their mouth with water after tasting each sample.

Statistical Analysis

The scores obtained from the sensory evaluation were subjected to analysis of variance (AVOVA) and Fisher's least significant difference (LSD) tests was carried out to ascertain significant effects at $P<0.05$ level of significance among treatments.

RESULTS AND DISCUSSIONS

Chemical Composition of Ackee Aril and Wheat Flour

Significant variation was observed when portions of the wheat flour were substituted with ackee aril flour. The range of moisture contents of the mixture samples ranged between 7.7 to 15.4 % as shown in Table 2.

Table 2: Chemical composition of wheat-ackee aril flour composites

Samples (%)	Moisture (%)	Fat (%)	Fibre (%)	Ash (%)	Protein (%)	Carbohydrate (%)
A=100 WF Control	12.8±0.0^{c}	2.1±0.1^{a}	0.5±0.0^{a}	2.0±0.0^{a}	10.2±0.2^{a}	72.3±0.1^{e}
B= 80:20 WF : AF	11.4±0.0^{b}	9.6±0.1^{b}	1.1±0.0^{b}	2.5±0.7^{a}	10.8±0.2^{a}	64.5±1.0^{d}
C= 60:40 WF : AF	15.4±0.0^{d}	14.8±0.4^{c}	1.3±0.1^{b}	3.5±0.7^{a}	13.6±0.6^{b}	51.5±0.3^{b}
D= 50:50 WF : AF	8.8±0.3^{a}	17.2±0.2^{d}	1.9±0.1^{c}	2.5±0.7^{a}	13.1±0.2^{b}	56.5±1.1^{c}
E= 40:60 WF : AF	7.7±1.0^{a}	20.2±0.2^{e}	3.7±0.1^{d}	3.5±0.7^{a}	16.9±0.3^{c}	48.1±0.1^{a}

Means in column with different superscripts are significantly different ($P < 0.05$)
WF=Wheat flour (100%); AF=Ackee flour (100%)

The fat, fibre and protein contents increased with increasing level of ackee aril flour substitution indicating nutrients enhancement with ackee aril flour substitution ranging from 2.1, 0.5 and 10.2% (0 % ackee aril flour substitution) to 20.2, 3.7 and 16.9 % (60 % ackee aril substitution) respectively. This could obviously be due to the significant quantity of protein in ackee fruit (Odutuga *et al*., 1992). This high protein content in wheat ackee aril mixes will be of nutritional importance in most developing countries, Ghana inclusive where many people can hardly afford high proteinous foods because of the cost. The moisture, fat and fibre contents as shown in Table 2 also assumed the same trend as the protein content due to the same reason while carbohydrate decreased with increasing level of ackee aril flour substitution supporting the claims of Abioye *et al.* (2011).

Sensory Evaluation of the Chips Sample

The results from sensory evaluation in Table 3 showed that all chips samples were generally accepted for all attributes evaluated as none scored below the minimum acceptable rating of 5 on the 9 point hedonic scale. Appearance or colour by physical examination ranged from 6.30 - 6.88 for chips while taste score ranged from 5.38 - 6.80 in chips. Texture, mouth feel and aroma score ranged from 6.44 -6.86, 5.72 – 7.02

and 6.30 – 6.70 respectively. Where there was equal mixes of wheat-ackee aril flour (50% WF: 50% AF) resulted in chips scoring lower value for all the sensory attributes tested with the exception of aroma. The control sample score a high value for all the sensory attributes examined with the exception of sample E which score 6.70 although this was not significantly different from the control.

The results of sensory evaluations reveal that chips produced from ratio 100:0 wheat-ackee aril composite flour are significantly different ($p \leq 0.05$) in appearance from chips made from ratio 80:20, 60:40 and 50:50 wheat-ackee aril composite flour, but there was not significantly different ($p \geq 0.05$) from 40:60 wheat-ackee aril composite flour.

Table 3: Sensory evaluation scores of chips samples produced from blends of wheat and ackee aril flour

Quality attributes	A	B	C	D	E
Appearance	6.88^{b}	6.46^{a}	6.40^{a}	6.30^{a}	6.60^{ab}
Taste	6.80^{c}	6.12^{b}	6.08^{b}	5.38^{a}	6.02^{b}
Texture	6.86^{b}	6.65^{ab}	6.74^{ab}	6.44^{a}	6.66^{ab}
Mouth feel	7.02^{c}	6.36^{b}	6.34^{b}	5.72^{a}	6.36^{b}
Aroma	6.58^{a}	6.30^{a}	6.52^{a}	6.52^{a}	6.70^{a}
Overall acceptability	7.28^{c}	6.64^{b}	6.72^{b}	6.18^{a}	6.68^{b}

Sample with mean values bearing the same letter of superscript in the same row are not significantly different ($p \geq 0.05$). Samples: A: 100% wheat flour, B: 80% wheat flour and 20% ackee aril flour, C: 60% wheat flour and 40% ackee aril flour, D: 50% wheat flour and 50% ackee aril flour, E: 40% wheat flour and 60% ackee aril flour.

A drop in taste was observed as the level of wheat flour was substituted with ackee aril flour. Chips from wheat flour substituted with ackee aril flour up to 20% down to 60% reduced the taste of the chips sample significantly. However, sample B, C and E were not significantly different from each other with the exception of sample D which recorded a lower value of 5.38 and was significantly different from all the other samples.

The values obtained for aroma of all the tested samples showed no significant difference which shows a high level of acceptance of the wheat-ackee aril chips by the panellists. There was no significant difference between sample A, B, C and E for the texture of chips as ackee aril flour substitute increases.

At 20% level of substitution of ackee aril flour for wheat flour, acceptance chips were obtained. However, chips produced with 20% ackee aril flour in the mixture had overall acceptability score of 6.64 which was not significantly different from the 40% and 60% level of substitution with a total score of 6.72 and 6.68 respectively. All the same, the control had a total score of 7.28 and significantly different from chips with 20%, 40%, 50% and 60% ackee aril flour in the mixtures.

Generally, closeness of values obtained for all wheat-ackee aril chips samples to the control sample indicate a high level of acceptance of the wheat-ackee aril chips, thereby improving the nutritional contents of chips as well as increasing the utilization of ackee fruit.

CONCLUSIONS

Apart from ackee aril being processed into paste, findings in this study have shown the potential for the production of bakery products such as cake and chips.

Substitution of wheat flour with ackee aril flour at levels of 20% to 60% resulted in notable increase in proximate composition. Protein, fat and fibre of the flour blends increased with increasing ackee aril flour contents while carbohydrate decreased simultaneously. The experiments produced chips of acceptable sensory qualities from all ratios of wheat-ackee aril flour that was used; therefore, these research findings have unveiled new windows for further utilization of ackee aril.

RECOMMENDATIONS

The following are further recommended based on the findings of this study:

1. Further research should be conducted to increase the value of these species and to make them more widely available to broaden the agricultural resource base and increase the livelihood options for rural communities.
2. Since the fruit of ackee mature in the rainy season, there should be efficient drying techniques to make storage of large quantities of aril easy.
3. Based on the significant differences in the proximate composition and sensory evaluation, the potential for innovative products with higher added values should be exploited to increase utilization of the species.

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