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Quality Characteristics of Cassava-Ackee-Groundnut Composite Cookies

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Abstract Cookie, a popular baked product, could be prepared from non-wheat flour because of its negligible gluten requirement. Developing nutritious cookies from indigenous crops can create an avenue for adding value to neglected protein-rich food sources such as ackee fruit arils and groundnut while enhancing cassava flour utilization by gluten intolerants or celiac disease patients. The objective of this study was to develop cassava-ackee-groundnut composite cookies and evaluate their nutritional and sensory properties. Seven composite flours (F1-F7) were used for the cookies along with 100% cassava flour as control. Proximate composition and mineral contents (Ca, P, Na and Mg) were determined by standard methods. Eighty consumers evaluated the acceptability levels of the cookies on a 9-point hedonic scale; 1 (dislike extremely), 5 (neither like nor dislike) and 9 (like extremely). The most preferred cookies, F1 and F7, with more than 52% cassava flour substitution, ratios of (48.33: 38.33: 13.33) and (45: 35: 20) for cassava flour, aril meal and groundnut meal, respectively, were quantitatively described by thirteen trained panellists. The composite cookies had high mean ranges of 35.5-39.9%; 1.9-3.1%; 6.7-8.3%; 509.1-579.7 Kcal/100g, 0.07-0.11% and 0.26-0.35% for fat, fibre, protein, calculated energy, phosphorus and sodium, respectively. All the samples were acceptable (mean scores above 5). F1 and F7 were more intense in colour (brownish), less crisp and less hard with a well perceived groundnut aroma and taste than wheat and cassava cookies. The developed cookies could therefore constitute a first step in the development of an improved snack to meet the population needs and generate business opportunities.

Keywords: *cassava, ackee arils, groundnut, cookies, nutrients, sensory properties*

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1. Introduction

Food availability and costs, eating occasions and motivations (hunger, pleasure, location, food culture, the environment, etc.) are some factors that cause people to snack nowadays [1].

Snacks can be as diverse as beverages, savoury or sweet foods and cookies are one of such products [2,3]. Snacks are often regarded as foods with poor nutrient intakes and nutritional excesses leading to energy imbalance and weight gain [1]. However despite this negative perception, they have also positive aspects such as the improvement of the triglyceride and cholesterol concentrations and the blood pressure as well [4]. Processed snacks as convenient foods [5] may also find used in nutrition interventions [6] to address challenges such as hunger, constipation and several nutrient deficiencies among populations. They may be a good option to adding value to local crops. The processing stages undergone by these commodities and the resulting convenient finished products may help promote their consumption among the population.

Cassava root constitutes a major staple crop among the roots and tubers consumed in Africa, [7]. It has a high carbohydrate content of about 80% [7,8] and are traditionally processed into flours, granulated products, pastes and starch [9]. On industrial basis, the cassava flour can be used in extruded snacks for its expansion property, in mild processing conditions as thickeners, in processed complementary food as filler and in the confectionary and biscuit industries as binding agents [10]. However, in spite of these benefits, cassava roots have the least protein-energy ratio among other staple food crops; the most common cultivars have a protein content of about 1% [11,12].

Ackee (*Blighia sapida)* is an underutilized multipurpose fruit tree species native from West Africa [13]. Although, parts of the tree have applications in traditional medicine, fishery, livestock feed [14], the nutrient-dense edible arils from the ripe fruits have not been much explored in West African diets as compared to the other areas. For instance, it constitutes a popular ingredient of the Jamaican cuisine [15] and also a cheap source of proteins. Moreover, the arils have a large export market as canned and frozen products in the US, UK and Canada [15]. Where as in West Africa, they are sun dried and locally sold on rural markets [16]. Thus, ackee aril potential to improve nutrition as crop remains untapped in West Africa.

Groundnut is a valuable ingredient of the diets in the developing countries and a major cash crop throughout the sub-Saharan Africa [17]. It is a good source of antioxidants, proteins and fats [18,19,20].

The focus of the present work was to evaluate the nutritional and sensory properties of cookies develop from cassava, ackee aril and groundnut composite flour.

2. Materials and Methods

2.1. Material Sources

Ripe ackee fruits were harvested at mature stages from 5 to 9 [15] between mid-February and mid-April 2015 from trees located on KNUST campus Kumasi and in Accra. Mature (12 months) cassava roots (*Otuhia variety*) and groundnut seeds (*Yenyawoso variety*) were obtained from Crops Research Institute of the CSIR, Fumesua, Ghana.

2.2. Methods

2.2.1. Ackee Aril Processing

The inner yellowish fleshy arils were carefully separated from the black seeds and the pink membrane and washed with potable water. The cleaned arils were boiled at 100°C for 30 min and dried at 60 °C for 18 h in a Beveilinging Conventional Oven Dryer (Model: DMV 1250, Holland). The dried arils were ground using a kitchen grinder (Heavy duty electric Grinder, Model MG182/00), packaged in airtight polyethylene bags and stored at 4°C.

2.2.2. Cassava Flour Processing

The roots were washed with potable water, peeled and grated with a locally made cassava grater. The mashed cassava was pressed to remove water and dried at 70°C for 5 hours. The obtained grits were milled with the kitchen grinder, sieved with 450 µm mesh, packaged in airtight polyethylene bags and stored at room temperature.

2.2.3. Groundnut Processing

Groundnut kernels were roasted, ground, packaged in polyethylene bags and stored at 4 °C.

2.2.4. Experimental Design

Seven composite flour blends made from cassava flour, ackee aril and groundnut meals along with whole cassava flour (control C) were used for the cookie preparation as shown in Table 1. The mixture design was created using Minitab 17 (Minitab Inc., Philadelphia, U.S.A).

Table 1. Flour composition

Blend	Cassava Flour (CF) (%)	Ackee Meal (AM) (%)	Groundnut meal (GM) (%)	Total Flour (%)
C	100	0	0	100.00
F1	48.33	38.33	13.33	99.99
F6	46.67	41.67	11.67	100.01
F4	55	35	10	100.00
F5	45	45	10	100.00
F7	45	35	20	100.00
F3	46.67	36.67	16.67	100.01
F2	51.67	36.67	11.67	100.01

2.2.5. Cookie Preparation

The cookies were prepared according to the recipe used by [21] with however reduced amounts of butter and sugar (Table 2). The preparation followed three stages: creaming, mixing and baking. Butter and granulated sugar were mixed together with a hand mixer Wilko SKU 228910 at a medium speed until formation of a light and fluffy cream. Egg (whole) was added and then the milk powder. Flour, baking powder and salt were finally added to the mixture and all was mixed evenly to form dough. The dough was cut into pieces and rolled on a flat rolling board to a uniform thickness of 0.4 cm using a wooden rolling spin. Circular pieces of about 4.5 cm diameter were cut and placed on a baking tray. tray with spacing of about 2.5 cm.

They were baked at 100-140°C for 10 min in a kitchen oven. The cookies were then cooled on at room temperature and packaged in zip lock bags.

2.2.6. Chemical analyses of the Cookies

Proximate analysis

The proximate compositions were determined according to the standard method of [22]. Crude protein was calculated by multiplying the total nitrogen by factor 6.25 and carbohydrate was obtained by subtracting all the proximate other parameters from 100%.

Mineral analysis

The mineral contents of the cookies were determined according to AOAC method [23]. Calcium and magnesium contents were determined by titration using ethylenediaminetetraacetic acid (EDTA) and phosphorus was determined using vanadomolybdate method with absorbance reading at 430 nm in a colorimeter (Jenway 6051, model PFP7).

Table 2. Recipe ingredients

Ingredients (g)	Samples/Formulation							
	C	F1	F2	F3	F4	F5	F6	F7
Flour	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Butter	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Sugar	30.6	30.6	30.6	30.0	30.6	30.6	30.6	30.0
Milk powder	10.0	10.0	10.0	10.0	10.0	10.00	10.0	10.0
Baking powder	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Egg	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
Total ingredient	211.5	211.5	211.5	211.5	211.5	211.5	211.5	211.5

Sensory analyses

Consumer preference / acceptability test

The composite samples and cassava cookies (control) were presented for evaluation to 80 untrained panellists. Aroma, crispness, taste, texture and overall acceptability were the assessed attributes. The panellists were asked to score their preference and general acceptability using a 9 point hedonic scale with 9 being like extremely and 1 dislike extremely. The composite cookies were coded and divided into 2 groups of 3 and 4 samples respectively. Each batch was served with the control in a monadic sequential mode to avoid panellists' fatigue.

Quantitative and descriptive analysis test

Selection was done among the composite cookie samples based on high protein contents, low fat contents and high sensory mean scores. The selected composite samples and two controls (cassava and wheat cookies) were described and quantified by 13 trained panellists from Food Research Institute, Accra, Ghana. The panellists had about 2 hours and 30 minutes of training session to select and agree on the meaning of the sensory descriptors for cookies used in this study. A mock evaluation using a 15 cm line-scale anchored at both ends was done for the reference product (wheat cookies) to strengthen the judges' discriminative abilities. Coded samples with three digit numbers were served in a monadic display to allow proper assessment by the judges in the final evaluation.

Statistical Analysis

Analysis of variance (one-way ANOVA) at 5% significance level and multiple comparisons with Fisher's LSD test was done with IBM SPSS Statistical Software version 20.

3. Results and Discussion

3.1. Proximate Composition and Energy Content of the Cookies

Significant differences ($p < 0.05$) were found among samples for each proximate parameter and the energy level.

3.2. Moisture content

Biscuits and cookies require low moisture content for a desired texture that is short, brittle and crumbly [24]. Moisture contents ranged from 5.8% to 7.5%. Contents of samples F1 and F2 had both the lowest content (5.8±0.2%) while, the highest one (7.5±0.2%) was for sample F7 followed by that (6.7±0.2%) of C (100% cassava cookies) (Table 3). The samples were within the acceptable range of 5-14% moisture [21]. Moisture content is also related to cookie stability since low moisture content contributes to prevention against microbial spoilage [25].

3.3. Crude Protein Content

Protein contents of the cookies varied between 3.6% and 9.1% (Table 3). Whole cassava cookies had the lowest content of 3.6±0.3% while samples F7, F6 and F3 had the highest ones (9.1±0.3 %, 8.3±0.2 % and 8.2±0.1 % protein respectively). In terms of flour composition, F7 contained maximum amount of groundnut (20%) while F6 had high ackee aril quantity (41.67 %) and F3 received also high amount of groundnut (16.67 %). Thus, protein content increased in the developed cookies with the substitution of cassava flour by ackee aril and groundnut. Similarly, an increase in protein content of composite biscuits from 5.85% to 8.35% as cassava flour was replaced by proportion of cashew apple powder up to 25% has been previously reported [21]. Relatively high protein content is desirable for any food products as proteins supply amino acids to many biological processes in the body [26]. Thus, the composite cookie's range of 6.7-9.1% protein obtained in the study is appreciable even with regard to the recommended daily allowance (RDA) of 65g protein per adult [27].

3.4. Crude Fat Content

Fat contents ranged from 18.8 % to 39.9 % (Table 3). Cassava cookies and sample F4 had the lowest values of fat contents of 18.8±0.6 % and 35.3±0.9 % while, F5 and F3 had the highest ones of (39.9±0.5 % and 37.8±0.4 % respectively). From the flour composition, Sample F5 received high amount of ackee aril (45 %), F3 had high quantity of groundnut (16.67%) while F4 had maximum cassava flour (55%). This suggests that addition of more ackee aril and groundnut in the flour results in high fat content in the cookies. Hence, the range of 35.5-39.9 % fat recorded by the composite cookies seems a bit high with regard to the levels of fat reported by others i.e. 6.23-36.78 %, 14.45-16.57 %, and 21.64-23.27 % [25,28,29]. However, it remains acceptable for cookies.

Table 3. Proximate composition of Cassava-Ackee aril-Groundnut Composite Cookies

Formulation	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Ash (%)	Crude Fibre (%)	Carbohydrate (%)	Energy (kCcal/100g)
C	6.7 ± 0.2^{a}	3.6 ± 0.3^{a}	18.8 ± 0.6^{a}	2.7 ± 0.0^{a}	1.3 ± 0.2^{a}	74.9 ± 0.4^{a}	276.4 ± 5.7^{a}
F1	5.8 ± 0.2^{b}	8 ± 0.1^{b}	35.5 ± 0.5^{b}	3.6 ± 0.1^{b}	2.6 ± 0.2^{b}	53.0 ± 0.6^{b}	538.0 ± 4.5^{b}
F2	5.8 ± 0.2^{b}	7.4 ± 0.0^{c}	35.9 ± 0.2^{b}	1.9 ± 0.1^{c}	2.8 ± 0.3^{bc}	54.7 ± 0.1^{c}	529.0 ± 2.4^{b}
F3	6.5 ± 0.3^{abc}	8.2 ± 0.1^{b}	37.8 ± 0.4^{c}	1.9 ± 0.0^{c}	3.1 ± 0.2^{c}	52.0 ± 0.5^{bf}	566.2 ± 5.9^{c}
F4	6.0 ± 0.2^{bc}	6.7 ± 0.3^{d}	35.3 ± 0.9^{b}	1.7 ± 0.1^{d}	3.6 ± 0.3^{d}	56.3 ± 1.0^{d}	509.1 ± 12.6^{d}
F5	6.2 ± 0.3^{c}	7.3 ± 0.1^{c}	39.9 ± 0.5^{d}	3.3 ± 0.0^{e}	2.7 ± 0.1^{bc}	49.5 ± 0.3^{e}	561.4 ± 1.7^{c}
F6	6.2 ± 0.2^{b}	8.3 ± 0.2^{b}	37.4 ± 0.2^{c}	2.1 ± 0.2^{f}	2.6 ± 0.4^{b}	52.2 ± 0.1^{bf}	562.7 ± 3.3^{c}
F7	7.5 ± 0.2^{d}	9.1 ± 0.3^{e}	37.5 ± 1.0^{c}	2.1 ± 0.1^{f}	1.9 ± 0.2^{e}	51.3 ± 1.0^{f}	579.7 ± 11.6^{e}

The values are means ± SD of three independent determinations. The means with the same superscripts in a column are not significantly different ($p > 0.05$).

Table 4. Mineral contents of Cassava-Ackee aril-Groundnut Composite Cookies

Samples	Minerals			
	Phosphorus (%)	Calcium (%)	Magnesium (%)	Sodium (%)
C	0.070±0.00^{a}	0.081±0.00^{a}	0.048±0.00^{a}	0.170±0.01^{a}
F1	0.070±0.00^{a}	0.046±0.00^{b}	0.028±0.00^{b}	0.300±0.00^{bc}
F2	0.070±0.00^{a}	0.052±0.00^{c}	0.031±0.00^{c}	0.317±0.01^{b}
F3	0.090±0.02^{b}	0.054±0.00^{c}	0.033±0.00^{c}	0.290±0.01^{c}
F4	0.110±0.02^{c}	0.052±0.00^{c}	0.031±0.00^{c}	0.293±0.01^{c}
F5	0.100±0.000^{bc}	0.252±0.00^{d}	0.151±0.00^{d}	0.307±0.01^{bc}
F6	0.100±0.00^{bc}	0.070±0.00^{e}	0.043±0.00^{e}	0.353±0.01^{d}
F7	0.090±0.02^{b}	0.044±0.00^{b}	0.026±0.00^{b}	0.263±0.02^{e}

The values are means ± S.D of three independent determinations. The means with the same superscripts in a column are not significantly different (p> 0.05).

3.5. Ash Content

Ash contents varied between 1.7 % and 3.6 %, whole cassava cookies having 2.7 % (Table 3). [29] reported a range of 2.68-6.33 % ash for composite cookies with 2.15 % ash for 100 % cassava flour cookies as control. [21] reported 2.05-2.87 % ash with the control (100 % cassava cookies) having 1.82 %. Ash contents recorded in the present study are therefore within common ranges for composite cookies.

3.6. Crude Fibre Content

Crude fibre contents ranged from 1.3 % to 3.6 % (Table 3). Cassava cookies had the lowest content (1.3±0.2 %) while F4 content was the highest (3.6±0.3 %). The other composite cookies ranged from 1.9 % to 3.1 %. These values are close to those of [21] who reported fibre contents between 1.3 % and 2.5 % with 1.3 % for 100% Cassava flour. The fibre contents the developed cookies though low in respect of the recommended daily allowance RDA of 20-35 g/ day for adults could easily contribute to meet that of the children (5 g/ day) [30,31]. Dietary fibre intake is necessary because of its health benefits against chronic constipation and risks of other chronic diseases such as diabetes and obesity [31].

The composite cookies were all significantly different (p<0.05) from the cassava cookies (control) which had the highest carbohydrate content of 74.9±0.4 % (Table 3). Among the composite cookies, sample F4 and F2 had the highest contents of 56.3±1.0% and 54.7±0.1% respectively) and also the highest amount of cassava flour (55%, 51.67% respectively). Similar results have been reported by [32] with whole cassava cookies having 82% carbohydrate and cookies from composite flour ranging between 55.10% and 60.62%. Carbohydrate content of the cookies reduced significantly as cassava flour was substituted by other flours. These cookies could therefore serve as carbohydrate-restricted snacks advocated in obesity and diabetes management [33].

3.7. Calculated Metabolised Energy Levels (CME)

The energy levels were between 276.4 Kcal and 579.7 Kcal per 100 g of cookies (Table 3). All the samples made from the composite flours had higher energy levels than the whole cassava flour cookies (276.4±5.7 Kcal/100 g) with significant differences between them. Sample F7 had the highest energy level of 579.7±11.6 Kcal/100 g among all followed by F3 which had a level of 566.2±5.9 Kcal/100 g. These samples contained high protein contents of 9.1±0.3 % and 8.2±0.1 % respectively, and relatively high fat contents of 37.5±1.0 % and 37.8±0.4% respectively but low carbohydrate contents (54.8±0.4% and 55.1±0.6%) and hence, the highest energy values. These results suggest that when it comes to higher levels of energy in the developed cookies, fat is the main contributor followed by protein, carbohydrate contributing the least.

3.8. Mineral Contents

As essential elements in human nutrition, minerals are required in several metabolic activities of the body and thus involved in human health and disease states [34,35,36]. The mineral contents of the composite cookies were significantly different (p<0.05) from that of the control.

The phosphorus contents of the samples were between 0.070 % and 0.110% with the lowest content of 0.070±0.00% for 100% cassava cookies, samples F1 and F2 (Table 3). Samples F4, F5 and F6 had the highest contents (0.110±0.017%, 0.100±0.000% and 0.100±0.000% respectively). Phosphorus is the second most common mineral in the body after calcium [36]. It is involved in several important metabolic processes that take place in the body such as bone and teeth formation and maintenance, body fluid buffers, ATP synthesis, etc. Some recommended daily allowances (RDA) of phosphorus are 800 mg/day for children around 1-10 years, adults of 25 years old and 1200 mg /day for adolescents and young adults between 11 years and 24 years [37]. The phosphorus level of developed cookies is valuable in meeting the recommended intake especially that of children [37, 38].

Calcium contents of the cookies ranged from 0.04% to 0.25% (Table 3). Sample F5 had the highest content (0.25±0.00%) followed by the cassava cookies (0.08±0.002%). Sample F7 had the lowest calcium content of 0.04±0.000% followed by F1 (0.046±0.002%). These values are greater than those obtained by [39] who recorded calcium content range of 0.01-0.08% or 10-80 mg/100 g for wheat biscuits fortified with citrus peel powder. Calcium is one the most common minerals needed by the body along with phosphorus and magnesium as it is involved in biological processes such as bone and teeth formation and maintenance, muscle contraction, nerve regulation, membrane permeability, etc [36]. The calcium daily intake should be between 400 mg/100 g and 1300 mg/100 g for the entire population including children [40]. The frequent consumption of these composite cookies as normal snack can contribute to reach these levels.

Magnesium contents were between 0.026% and 0.151% (Table 3). Sample F5 had more magnesium (0.151±0.000%) than the others and sample F7 had the least (0.026±0.000%). [41] had a low magnesium range of 0.031-0.042% for wheat-soya bean composite cookies. [39] reported very low values from 0.01% to 0.02%. Magnesium is widely found in plant and animal foods. It plays important metabolic and physiological roles in the body as a key constituent of several enzyme systems as well as a constituent of the bones and teeth [36]. RDA values of magnesium range between 54 mg/100 g and 260 mg/100 g for people aged from 1 year old to above 65 years old [40]. Magnesium contents of the developed composite cookies were close to these values. Thus, these cookies can greatly contribute to meet the magnesium requirement of the population.

Sodium levels varied between 0.170% and 0.353% (Table 4). Sample F6 had more sodium (0.353±0.006%) and whole cassava cookies (control) had less (0.170±0.010%). The contents of the remaining composite cookies ranged between 0.263% and 0.317%. These results indicate that consumption of the cookies is safe with regard to sodium intake. The suggested safe amount of sodium is around 2400 mg/day [37]. Sodium is important for the body as it involved in nerve, muscle and fluid balance regulations [42]. Table salt (NaCl) is the main form in which dietary sodium is consumed [43].

Salt intake is recommended below 2400 mg/day because high consumption of salt is shown to positively correlate with high blood pressure [44]. Thus, the sodium contents of the developed composite cookies are safe for the entire population.

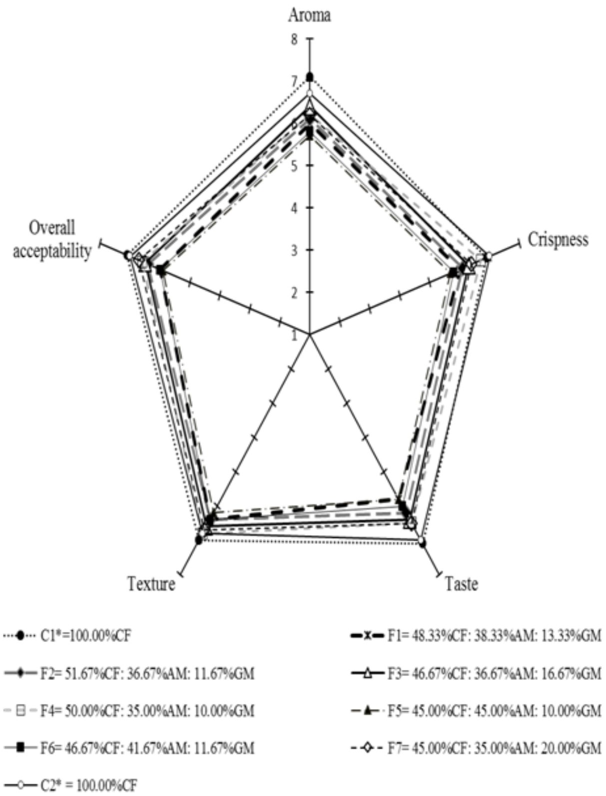
3.9. Sensory Properties of the Cookies

3.9.1. Consumer Preference and Overall Acceptability Mean Scores

The mean scores for consumer preference in terms of aroma, crispness, texture, taste and the overall acceptability for all the cookie samples are presented in Figure 1.

3.9.2. Aroma Preference

The aroma preference mean scores for all samples ranged between 5.7 and 7.1 (Figure 1). The two servings of the control (100% cassava flour cookies) C1 and C2 had the highest mean scores of 7.1 and 6.7, respectively which were not significantly different ($p > 0.05$) from each other. These values were followed by that of sample F3 (6.4) and sample F7 (6.2). They had less cassava and ackee aril (46.67% and 45%, respectively) and more groundnut meal (16.67% and 20%, respectively). However, the results show that the aroma of all samples were liked by the panel with mean scores above 5.5. Thus, aroma as key attribute which may cause acceptance or rejection by the consumer even before tasting the food [45,46], had rather contributed to the acceptance of the composite cookies among the consumers.



The values are means ± SD of eighty independent determinations. * C1 and C2 are serving of the same control.

Figure 1. Web plot of consumer preference of the composite cookies and control

3.9.3. Crispness Preference

Preference mean scores of crispness ranged between 5.7 and 7.0 (Figure 1). Serving C1 and C2 recorded the highest means with no significant difference ($p>0.05$) from each other (6.9 and 7.0 respectively). Samples F4 and F7 were more preferred in terms of crispness among the composite samples with mean scores of 6.7 and 6.4 respectively. They contained high and low amounts of cassava (50 % and 45 %) respectively and also low and high quantities of groundnut (10 % and 20 %) respectively in their flour compositions with both the same low ackee aril quantity (35 %). Crispness is a desirable feature for cookies [29]. The mean scores of likings above 5.5 for the composite cookies indicate that the levels of supplementation of cassava by ackee arils and groundnut were not detrimental to how the consumers perceived the crispness of the cookies.

3.9.4. Taste Preference

Taste mean scores ranged between 5.8 and 7.1, the lowest mean score being for sample F5 and the highest value for cassava cookies (Figure 1). Samples F4 and F7 had the most preferred taste with mean score of 6.5 among the composite cookies. Although, their flour compositions were at the opposite from one another with more cassava (50%), less groundnut (10%) and more groundnut (20%), less cassava (45%) respectively and a constant amount of ackee aril in both.

Taste is one of the important sensory characteristic of food [46] this is because food is intended for consumption. Composite cookie tastes were appreciated (mean scores above 5.5) even though preference scores were lesser than those obtained by cassava cookies (control). Addition of groundnut and ackee aril in the flour probably altered the taste of cassava in the cookies but, the levels of supplementation used still contributed to the acceptance of the composite cookie.

3.9.5. Texture Preference

Preference mean scores for texture ranged between 6.2 and 7.0, cassava serving C1 having the greatest value while, sample F5 the least (Figure 1). Samples F7 and F4 had the highest preference mean scores (6.7 and 6.8 respectively) among the composite cookies. Texture as attribute recorded higher mean scores (above 6) compared to the other (aroma, crispness, and taste). This suggests that texture of the composite cookie was really pleasant to the panellists because texture is a key attribute to the acceptance of cookies.

3.9.6. Overall Acceptability

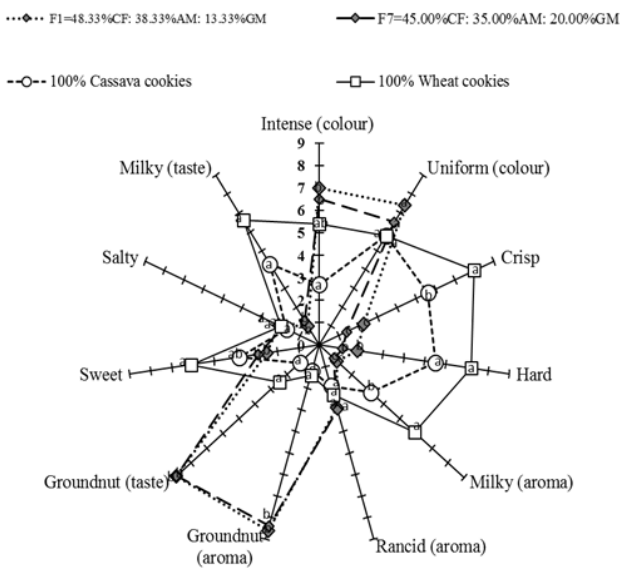
The overall acceptability mean scores recorded by the samples ranged between 5.9 and 7.1 Sample F5 had the lowest overall acceptability mean (5.9±1.8) followed by sample F6 with mean score of 6.0. Cassava cookies (C1 and C2) had the highest values (7.1 and 7.0, respectively). Among the composite cookies, sample F7 was most appreciated with mean score of 6.7 followed by sample F4 with mean score 6.4. These composite samples in terms of flour composition received cassava and groundnut proportions at the opposite with ackee aril remaining the same in both. This suggests that the level of ackee aril seems appropriate for maintaining sensory quality of the cookies.

3.10. Quantitative and Descriptive (QDA) Mean Scores of Selected Cookies

Criteria such as relatively high mean scores of preference, relatively high protein contents and low fat contents were used to select two samples (F7 and F1) among the composite samples for further sensory evaluation.

The quantitative and descriptive profiles of samples F1 and F7 along with controls (wheat and cassava cookies) are shown below. Significance differences ($p<0.05$) were found among samples for the sensory attributes except for the colour uniformity and rancid aroma.

Colour intensity mean scores ranged between 2.7 and 7.0 while, the means for the colour uniformity varied between 5.8 and 7.4. Sample F1 was more intense (7.0±3.5) and uniform (7.4±2.7) in colour than the others (Figure 2). Indeed, sample F1 which contained more cassava flour (48.33 %), more ackee aril (38.33 %) and little groundnut meal (13.33 %) than sample F7 (45 %, 35 %, 20 %) was actually more brownish. This may be due to more oil coming from the ackee arils which was a yellow colour [47].



The values are means ± S.D of thirteen independent determinations. The means with the same superscripts on an axis are not significantly different ($p>0.05$).

Figure 2. Web plot of the QDA profile of F1, F7 and controls

Sample F1 was more crispier (2.3±2.4) than F7 (1.4±1.8) but less crisp than cassava cookies (5.6±2.2) and wheat cookies developed using wheat flour instead of cassava flour (8.0±2.0) (Figure 2). The low levels of crispness of F1 and F7 could be attributed first of all to their relatively high fat contents (35.5% and 37.5%, respectively), for fats play important roles in cookie making. Lubrication of the dough and its shortening when the fat level is high, produce cookies with tender and friable texture [48]. It could also be due to their relatively high moisture contents of 5.8% and 7.5% respectively. According to [49], water activity negatively correlated with the loss of crispness in ice cones where, water activity is a measure of the free water from the total moisture content. They found that the water activity range of 0.42-0.45 was the critical zone that coincided to total loss of crispness in the cones. It has been reported that the water contents of some types of cookies ranging from 5.9% up to 11.7% had their water activity values falling between 0.51 and 0.65 [50]. Thus, a reduction of moisture content in the developed cookies may impart some amount of crispiness for enhanced preference.

In terms of hardness, sample F1 was harder (1.8±0.9) than F7 (1.1±3.2) with no significant difference ($p>0.05$) between them. However, they were less hard than wheat cookies (7.2±2.2) and cassava cookies (5.5±1.7). Hardness, in some instances can be related to crispness, since the evaluation of both attributes requires biting through the sample that is application of force to the food. Reduction of moisture may thus also help to adjust the hardness of the composite cookies.

Both, sample F1 and F7 had little milk aroma (1.1±1.1 and 0.9±1.0 respectively) than wheat (5.9±2.8) and cassava cookies (3.2±1.9). This could be caused by the presence of groundnut and ackee aril which aromas may have suppressed that of the milk. Both composite cookies had more of rancid aroma of 3.0±3.3 and 2.9±2.8 than wheat and cassava cookies (2.3±3.0 and 1.9±2.3 respectively).

The rancid aroma may be attributed to fat oxidation which is a potential problem in cookies because of their high fat content. However, rancidity in cookies can also be solved by the use of an appropriate packaging. Groundnut aroma was only detected in sample F1 and F7 (8.6±2.1 and 8.4±1.8) however with no significant difference (p>0.05). Wheat and cassava cookies were sweeter in taste (6.1±2.4 and 3.8±2.8) than that of F7 and F1 (2.9±2.1 and 2.5±2.2). Salt was detected very low in all cookies with no significant difference (p>0.05). Milk taste was detected very low in F1 and F7 (1.0±1.0 and 1.3±1.1) as compared to wheat and cassava cookies (6.6±2.9 and 4.3±3.3). Generally, the profile shapes exhibited by the composite cookies were very different to those of wheat and cassava cookies pointing out the novelty of the developed cookies.

4. Conclusion

The composite cookies presented better nutrient contents than the cassava cookies. They were accepted by panellists in terms of aroma, crispness, taste and overall acceptability although; cassava cookies recorded the highest preference mean scores. The sensory profiles of samples F1 and F7 selected among the composite cookies were very different from those of wheat and cassava cookies as they were more intense in colour (brownish), less crisp and less hard with well perceived groundnut aroma and taste. Therefore, the present work efficiently combined cassava flour; ackee aril and groundnut meals to develop acceptable improved cassava cookies which can be consumed as snack by most groups of the population.

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