Influence of Processing Methods on the Nutrient, Anti-Nutrient, Mineral Compositions and Functional Properties of Akee Apple (Blighia Sapida Konig) Seed and Aril Flour

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Abstract

Akee apple (Blighia sapida konig) is one of the popular small scale tropical fruits and it is an important crop. B. sapida may be eaten raw (without the pink raphe attaching the aril to the seed) or after cooking when it resembles scrambled eggs. Fruits like akee apple are novelties for many people except in the Savannah belt, in the localities where they grow, they are eaten and relished. In view of this, an investigation into the nutrients, anti-nutrients, mineral and functional properties of the aril and seeds flour of B. sapida was carried out using standard processing methods (germination and fermentation). The protein content of the samples differed significantly (p< 0.05). The protein value ranged from 17.10-18.77% where the akee fermented aril flour has the highest protein content. A significant difference (p< 0.05) was also established in the fat content of the samples and ranged between 22.10-25.13% where the akee germinated seed flour has the highest fat value and the akee apple raw seed flour the least. The carbohydrate value of the untreated sample was significantly higher (p< 0.05) than that of the treated samples (33.30-46.90%) while the energy value of the samples ranged from 406.17-469.25 Kcal where the akee germinated seed and akee fermented aril flours were the highest in energy value. Calcium was the most abundant mineral element in the samples (76.65-88.83/100g) and irons the least (1.10-1.40g/100g). The anti-nutritional factors were significantly reduced (p< 0.05) in germinated seed and fermented aril flours respectively. The results of the study indicated that germination and fermentation improved the nutrient value of the seeds and aril flour of B. sapida and the reduction in the anti-nutritional factors through processing methods could make the seeds more utilizable as human food, hence, both the seed and aril flour could find application in the formulation of weaning food and other food products.

Keywords

• Blighia sapida
• Relished
• Nutrient
• Anti-nutrient
• Germination
• Fermentation

INTRODUCTION

Throughout history, man has turned nature into various substances such as food, medicine and domestic aids which had played a vital role in the management of various diseases [1]. Akee apple (Blighia sapida), a member of sapindaceae (soapberry family), is a native of Tropical West Africa, including Nigeria and has been given various local names: Hausa (gwanja kusa), Fulani (feso), Yoruba (ishin) [2]. From its West Africa origin, akee apple has transverse the Atlantic ocean, making the Caribbean its home. Akee apple like other fruit trees such as citrus, cashew, guava, banana, mango provide fruit for human food [3]. B.sapida has been put into many medicinal uses [4]. The unripe fruit are pounded together and used as fish poisoning. B. sapida contains saponin and phytochemical studies on the plant showed the presence of steroid saponin which could be useful in the manufacturing of steroid drugs [5].

The akee apple fruits- bearing trees reaches 10-12 meter with a grayish, smooth trunk 1.8 meter in circumference and a dense crown of spreading branches. It flowers and bears fruits all the year round in some areas in Nigeria. In some other parts of West Africa countries, the tree fruits twice in a year (Feb-April & July-October). At maturity, the akee apple pod naturally splits open to reveal 3-cream-coloured fleshy, glossy, crispy arils attached to black, smooth, hard, shiny seeds. At this stage, akee arils are considered safe for consumption uncooked. The consumption of immature arils has been found to be hazardous causing hypoglycemia referred to Jamaica vomiting sickness (JVS) [6]. In some parts of Nigeria, especially, Oke-ogun areas of Oyo state of Nigeria, akee apple arils are often cooked with vegetable soup for its meat like texture. The arils are known to be rich in protein and fat respectively [7].

[8], Reported on the proximate composition and some
nutritively valuable minerals in the dehulled seeds and seed hull of *Blighia sapida*. The information on the proximate composition, anti-nutritional factors, mineral and functional properties of germinated and fermented seeds and arils of *B. sapida* is scanty. Processing methods, such as sprouting (germination) and fermentation has been reported to improve the nutritional and functional properties of plant seeds [9, 10]. For instance sprouting or germination has been reported to improve digestibility, bioavailability of vitamins, minerals, amino acids and proteins, and decrease anti-nutrients and starch of some foods [11-15], and thereby improve protein and mineral absorption. Hence, the present investigation is, therefore, to determine the nutrient, anti-nutrient, mineral profiles as well as the functional properties of germinated and fermented seeds and aril flour of ripe and naturally opened *Blighia sapida*. This type of information may improve the food composition tables of *B. sapida*.

**MATERIALS AND METHODS**

**Source of raw materials**

 Matured and naturally opened akee apple fruits used for this study were obtained from the department of Food Science and Technology, The Polytechnic Ibadan, Saki Campus. The seeds of akee apple were subjected to both germination and fermentation processes while the aril was subjected to fermentation only.

**Processing of raw akee seeds and aril flour**

Akee apple seeds and aril were sorted and cleaned. The cleaned seeds and aril were then oven dried at 60°C for 6 hours, milled and sieved through 0.4mm wire mesh. The flour was then packed in plastic container sealed with aluminum foil and stored at room temperature prior to analyses.

**Processing of germinated akee apple seeds flour**

The akee apple seeds were sorted and soaked in water for 10 hours. The seeds were spread on trays lined with cloth and kept wet by frequent spraying of water at every morning and evening for 4 days. The germinated akee apple seeds were washed, oven dried at 60°C for 6 hours, milled and sieved through 0.4mm wire mesh. The akee apple seed flour was packed in plastic container sealed with aluminum foil and stored at room temperature prior to analyses.

**Processing of fermented akee apple seeds and aril flour**

The akee apple seeds and aril were boiled for 1 hour as described by [16]. The boiled seeds and aril were fermented naturally for 4 days. The fermented seeds and aril were then oven dried at 60°C for 6 hours, milled and sieved through 0.4 mm wire mesh. The akee apple seeds and aril flour were packed in plastic container sealed with aluminum foil and stored at room temperature prior to analyses.

**Proximate analyses**

The moisture, protein, fat, ash and fibre contents of the samples were determined in triplicate using the method of [17]. The carbohydrate was determined by difference [18]. The food energy value was calculated using the Atwater factor 4 x protein, 4 x carbohydrates, and 9 x fat.

**Anti-nutritional factors analyses**

**Determination of tannin content:** Tannin content of akee apple seeds and aril flour were determined according to [19]. About 20 g of the flour samples were weighed and extracted with 10 ml of 1% HCl in methanol for 24 hours at room temperature with mechanical shaker. The solutions were then centrifuged at 1000rpm for 5 mins. 1 ml of the supernatant solution was mixed with 5 ml vanillin-HCl in methanol. The absorbance was read at 500nm after 20 mins. A stock of catechin solution was run simultaneously along with the sample as standard solution. The results were expressed as mg/100g dry weight.

**Determination of saponin:** Saponin was determined by the method described by [20]. 20 g of the samples were dispersed in 200mL of 20% ethanol. The suspension was heated over a hot water bath for 4 hr with continuous stirring at 55°C. The mixture was filtered and the residue re-extracted with another 200mL of 20% ethanol. The combined extracts were reduced to 40 mL over water bath at 90°C. The concentrate was transferred into a 250 mL separating funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 mL of n-butanol was added and the combined n-butanol extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the samples were dried in the oven to a constant weight and the saponin content was calculated.

**Determination of phytic acid:** Phytic acid of akee apple seeds and aril flour were determined according to the method of [21]. One gram of the material was ground and extracted with HNO3 by continuous shaking, filtered and made up to suitable volume with water. To 1.4 ml of the filtrate, 1 ml of ferric ammonium sulphate solution (21.6 mg in 100 ml water) was added, mixed and placed in a boiling water bath for 20 min. The contents were cooled and 5 ml of isomyl alcohol was added and mixed. To this, 0.1 ml ammonia solution was added, shaken thoroughly and centrifuged at 3000rpm for 10 min. The alcoholic layer was separated and the color intensity was read at 465nm against amyl alcohol blank after 15 min. Sodium phytate standards were run along with the sample. The results were expressed as mg phytic acid/100g dry weight.

**Determination of oxalate:** The titration method as described by [22] was followed. 1 g of sample was weighed into 100 ml conical flask. 75 ml 3M H2SO4 was added and stirred for 1 hr with a magnetic stirrer. This was filtered using what man No 1 filter paper. 25 ml of the filtrate was then taken and titrated while hot against 0.05M KMNO4 solution until a faint pink color persisted for at least 30 sec. The oxalate content was then calculated by taking 1 ml of 0.05M KMNO4 as equivalent to 2.2 mg oxalate [18,23].

**Determination of trypsin inhibitor:** The trypsin inhibitor activities (TIA) were determined using the procedure of [24] which is based on the trypic hydrolysis of synthetic substrate, benzoyl- DL-arginine p-nitroanilide (BAPA). 1 g of finely ground and sieved samples of akee apple seeds and aril flour was defatted

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for 3 h using n-hexane. The samples were mixed with 50 ml of 0.01M NaOH and the pH was adjusted to 9.5 using 0.1M NaOH or 0.1 MHCl. The mixture was macerated in warrring blender for 2 min and centrifuged for 10 min at 1,000rpm. The extract from the sample was diluted with distilled water to obtain a dilution whereby 1 ml extract produced trypsin inhibitor activity of between 40-60%. Such dilution was used. The sample dilution was used with BAPA substrate and trypsin solution at 37°C. The reaction was allowed to take place in water bath for 10 min and their absorbance read at 410nm against the sample blank.

Trypsin inhibitor activity (TIA) was calculated as

\[ TIA = \left( \frac{2.632 \times D \times A_1}{S} \right) \text{ mg pure trypsin/g sample} \]

\[ D = \text{Dilution factor} \]

\[ A_1 = \text{Change in absorbance (pure trypsin and sample extract)} \]

\[ S = \text{Sample mass} \]

MINERAL ANALYSES

Two grams of oven dried samples were weighed into a 125 ml Erlenmeyer flask which has been previously washed with acid and distilled water. Four milliliters of perchloric acid, 25 ml of concentrated HNO3, and 2 ml of concentrated H2SO4 were added under a fume hood. The contents were mixed and heated gently at low heat on a hot plate until dense white fumes appeared. It was finally heated strongly for half a minute and then allowed to cool. Fifty milliliters of distilled water was added and then boiled for a minute at medium heat. The solution was allowed to cool and filtered completely with a wash bottle into a 100 ml Pyrex volumetric flask, and then made up to mark with distilled water. The mixture was macerated in warrring blender for 2 min and centrifuged for 5 minutes at room temperature. The mixture was quickly but carefully transferred to measuring cylinder and the foam volume was measured. The volume of foam formed was then recorded as foam capacity in percentage.

\[ \% \text{ Foam Capacity (FC)} = \frac{V_s - V_b}{V_b} \times 100 \]

Where:

\[ V_s = \text{volume after whipping} \]

\[ V_b = \text{volume before whipping} \]

The method of [29] was employed for the determination of least gelation concentration (LGC). For each of the flour sample, dispersion of 2, 4, 6, 8, 10…...20% weight by volume (w/v) was prepared in 5ml of distilled water in test tubes and heated in boiling water for 1h. The heated dispersions were cooled. The least gelation concentration was the one at which the sample did not fall down or slip when the test tube was inverted.

DATA ANALYSIS

The software package used for the statistical analysis was the version 17 of the SPSS while all the analyses were carried out in three replicates and the standard error mean were calculated. The data were evaluated for significance differences (p< 0.05) in their means using Analysis of Variance (ANOVA). Differences between means were separated using Duncan’s Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Nutrient compositions of akee apple seeds and aril flour are presented in Table (1). The moisture content of akee fermented seed flour was the highest (8.90%) while that of the akee raw seed flour was the lowest (7.83%). These values were within the range reported by other investigators [30-32]. However, investigator have shown that low moisture content of food samples is a desirable phenomenon, since the microbial activity is reduced, because low moisture content in food sample increased the storage periods of food products [33] while high moisture content in foods encourage microbial growth, hence, food spoilage [34]. The protein content of the samples varied between 17.10% for akee raw seed flour (ARS) and 18.57% for akee fermented seed flour (AFS). The increase in protein content of the germinated and fermented flour sample may be due to synthesis of enzymes or compositional changes following the degradation of other constituents [35]. Many authors also reported that during fermentation, microflora enzymes hydrolyzed bonds among bond protein-anti nutrient and enzymes to release free amino acid for synthesis of new protein [36]. Our data, regarding the effect of germination on the proximate composition of akee apple seed and aril flour agree with [37] who reported increase in crude protein of germinated brown rice. According to him, total nitrogen, total non-protein nitrogen, protein nitrogen, true protein nitrogen increases with sprouting. [38] assumed that the increase was due to synthesis of enzymes proteins (for example proteases) by germinating seed. A further explanation was made by [39] where they noted that protein synthesis occurred during imbibitions and that hormonal changes play an important role in achieving the completion of germination.

Fat content varied from 22.10-25.13%. Fat contents of germinated and fermented akee seed and aril flour were found to be significantly higher than the raw sample (p< 0.05). The
Table 1: Nutrient compositions of the akee apple seed and aril flour (% DW basis).

<table>
<thead>
<tr>
<th>Samples/nutrient</th>
<th>moisture</th>
<th>Crude protein</th>
<th>Crude fat</th>
<th>Crude fibre</th>
<th>Total ash</th>
<th>CHO</th>
<th>Energy (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARS</td>
<td>7.83a</td>
<td>17.40d</td>
<td>22.10*</td>
<td>2.53a</td>
<td>3.37c</td>
<td>46.90d</td>
<td>456.10d</td>
</tr>
<tr>
<td>AGS</td>
<td>8.43b</td>
<td>17.87c</td>
<td>25.13a</td>
<td>2.17c</td>
<td>3.50b</td>
<td>42.90c</td>
<td>469.25b</td>
</tr>
<tr>
<td>AFS</td>
<td>8.90b</td>
<td>18.57c</td>
<td>23.61b</td>
<td>2.40b</td>
<td>3.10b</td>
<td>42.89b</td>
<td>458.83c</td>
</tr>
<tr>
<td>ARA</td>
<td>8.10c</td>
<td>17.10b</td>
<td>22.73d</td>
<td>2.30d</td>
<td>3.30d</td>
<td>33.30b</td>
<td>406.17c</td>
</tr>
<tr>
<td>AFA</td>
<td>8.23d</td>
<td>18.77a</td>
<td>23.13c</td>
<td>2.10c</td>
<td>3.57d</td>
<td>44.20b</td>
<td>460.05d</td>
</tr>
</tbody>
</table>

ARS - Akee raw seed flour; AGS - Akee germinated seed flour; AFS - Akee fermented seed flour; ARA - Akee raw aril flour; AFA - Akee fermented aril flour.

Values are means ± Standard error mean of triplicate determinations.

Means with different superscripts on the same column are significantly different at 5% level of significant.

Table 2: Anti-nutrient compositions of akee apple seed and aril flour (mg/100g).

<table>
<thead>
<tr>
<th>Samples/ANFS</th>
<th>Tanin</th>
<th>Saponin</th>
<th>Phytic acid</th>
<th>Trypsin inhibitor</th>
<th>Oxalate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARS</td>
<td>14.67a</td>
<td>18.50a</td>
<td>21.33b</td>
<td>0.57a</td>
<td>10.23c</td>
</tr>
<tr>
<td>AGS</td>
<td>12.17c</td>
<td>15.53b</td>
<td>17.52a</td>
<td>0.30b</td>
<td>6.33c</td>
</tr>
<tr>
<td>AFS</td>
<td>10.11d</td>
<td>14.45c</td>
<td>18.10c</td>
<td>0.40b</td>
<td>8.53c</td>
</tr>
<tr>
<td>ARA</td>
<td>13.33b</td>
<td>13.50d</td>
<td>35.50a</td>
<td>0.40c</td>
<td>17.33c</td>
</tr>
<tr>
<td>AFA</td>
<td>10.15d</td>
<td>9.54e</td>
<td>18.00d</td>
<td>0.20e</td>
<td>12.33b</td>
</tr>
</tbody>
</table>

ARS - Akee raw seed flour; AGS - Akee germinated seed flour; AFS - Akee fermented seed flour; ARA - Akee raw aril flour; AFA - Akee fermented aril flour.

Values are means ± Standard error mean of triplicate determinations.

Means with different superscripts on the same column are significantly different at 5% level of significant.

Table 3: Mineral compositions (mg/100g) of akee apple seed and aril flour.

<table>
<thead>
<tr>
<th>Samples/Minerals</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Sodium</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Zinc</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARS</td>
<td>80.00d</td>
<td>24.00a</td>
<td>22.50a</td>
<td>60.33c</td>
<td>90.80d</td>
<td>1.09b</td>
<td>1.40b</td>
</tr>
<tr>
<td>AGS</td>
<td>85.00c</td>
<td>26.00c</td>
<td>24.55b</td>
<td>63.00b</td>
<td>93.55c</td>
<td>1.00c</td>
<td>1.20c</td>
</tr>
<tr>
<td>AFS</td>
<td>88.83c</td>
<td>28.67a</td>
<td>25.00</td>
<td>65.00c</td>
<td>95.65c</td>
<td>1.05e</td>
<td>1.10e</td>
</tr>
<tr>
<td>ARA</td>
<td>76.65a</td>
<td>24.50d</td>
<td>20.50</td>
<td>53.00b</td>
<td>84.00b</td>
<td>1.47c</td>
<td>1.50c</td>
</tr>
<tr>
<td>AFA</td>
<td>86.67b</td>
<td>27.00b</td>
<td>24.30</td>
<td>58.00b</td>
<td>94.50b</td>
<td>1.33c</td>
<td>1.10c</td>
</tr>
</tbody>
</table>

ARS - Akee raw seed flour; AGS - Akee germinated seed flour; AFS - Akee fermented seed flour; ARA - Akee raw aril flour; AFA - Akee fermented aril flour.

Values are means ± Standard error mean of triplicate determinations.

Means with different superscripts on the same column are significantly different at 5% level of significant.

Table 4: Functional properties of akee apple seed and aril flour.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Packed bulk density (g/ml)</th>
<th>Loose bulk density (g/ml)</th>
<th>Water absorption capacity (g/g)</th>
<th>Oil absorption capacity (ml/g)</th>
<th>Foam capacity (%)</th>
<th>Least gelation conc (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARS</td>
<td>0.65a</td>
<td>0.39a</td>
<td>1.35a</td>
<td>1.30a</td>
<td>12.20a</td>
<td>14.17a</td>
</tr>
<tr>
<td>AGS</td>
<td>0.65a</td>
<td>0.38a</td>
<td>1.35a</td>
<td>1.15a</td>
<td>14.17a</td>
<td>12.20a</td>
</tr>
<tr>
<td>AFS</td>
<td>0.64a</td>
<td>0.39a</td>
<td>1.45a</td>
<td>1.20a</td>
<td>15.17a</td>
<td>11.50a</td>
</tr>
<tr>
<td>ARA</td>
<td>0.65a</td>
<td>0.39a</td>
<td>1.35a</td>
<td>1.25a</td>
<td>12.50a</td>
<td>11.50a</td>
</tr>
<tr>
<td>AFA</td>
<td>0.64a</td>
<td>0.39a</td>
<td>1.30a</td>
<td>1.20a</td>
<td>11.63a</td>
<td>11.63a</td>
</tr>
</tbody>
</table>

ARS - Akee raw seed flour; AGS - Akee germinated seed flour; AFS - Akee fermented seed flour; ARA - Akee raw aril flour; AFA - Akee fermented aril flour.

Values are means ± Standard error mean of triplicate determinations.

Means with different superscripts on the same column are significantly different at 5% level of significant.

observed increase in fat content may be due to increase activities of lipolytic enzymes during fermentation which hydrolysed fat component to fatty acids and glycerol [40]. [41] Also reported increase in the fat content of fermented millet in ogi production. Similarly, the increase in fat value of germinated sample could be due to non-conversion of free fatty acids to carbohydrate during germination [42]. The fibre content of akee apple germinated and fermented seed and aril flour was significantly lower to the raw sample and this could be due to hydrolysis and leaching into the fermenting medium or the microflora used it for metabolism [43]. The energy value of the sample ranged between 406.17-469.25Kcal with the akee germinated seed flour having the highest energy value and the akee raw aril flour the least. Energy value of food is a function of protein, fat and carbohydrate, hence the observed increase in energy value in germinated and fermented samples may be due to the increase in fat content of the sample [44].

Anti-nutritional compositions of akee apple seed and aril...
flour were shown in Table (2). There was significant reduction in the anti-nutritional content of the akee apple seeds and aril flour; for example the tannin content ranged between 10.11 to 14.67mg/100g on dry weight basis. Tannin content observed in the samples were lower than those reported for groundnut seed flour 450.00mg/g [Fasayiro et al, 2006], sorghum flour 280.00mg/g [45] and Cajanus cajan 550.05mg/g [46]. Tannins are the oligomeric higher molecular of polyphenols compound occurring naturally in plants. Due to their binding ability with protein and carbohydant, tannin can inhibit digestive enzymes and reduces the bioavailability of proteins [45]. The saponin content was also reduced through processing. The value ranged between 9.54 and 18.50mg/100g. The value observed was high compared to 5.20mg/g reported for raw seeds of M. utilis [47]. Saponin has both beneficial and adverse effects on human health. Apart from their hypocholesterolemic properties [48], saponin also shows hemolytic activity by reacting with the steroids of erythrocyte membrane [49]. The phytic acid and trypsin inhibitor observed were also significantly reduced and scientific studies have established that processing methods such as cooking, dehulling, soaking, fermentation and germination improve the nutritional quality of food products by reducing or eliminating the anti-nutrient composition of food products [50-52].

The mineral composition of akee apple seed and aril flour is shown in Table (3). The most abundant mineral element in the sample was potassium while Zinc and Iron were the least. In comparison, the mineral composition of akee fermented seed flour sample was higher in calcium, magnesium, phosphorus and potassium than the akee raw seed flour. Similarly, the mineral composition of the akee fermented aril flour was higher in calcium, magnesium, phosphorus and potassium than the akee raw aril flour. It was summarily observed in this study that germination and fermentation processing methods improved the mineral composition of the flour samples. This observation could be due to bio-synthesis and activities of micro-organisms during germination and fermentation [53].

The functional properties of akee apple seed and aril flour as influenced by processing methods are presented in Table (4). Results shows that there was no significant difference (p< 0.05) in the packed and loose bulk density of the samples. The packed bulk density values were observed to be 0.64g/ml and 0.65g/ml while the loose bulk density is 0.38g/ml and 0.39g/ml respectively. The bulk and loose densities obtained were higher to that reported by [54] for commercially sold soybean flour (0.38g/ml) but lower to the values for African bread fruit wheat flour blends (0.75g/ml) reported by [55]; bambara groundnut (0.60g/ml) reported by [56] and sorghum toasted soya beans blends (0.68g/ml) reported by [57]. The functional properties of food materials are very important for the appropriateness of the diet, particularly for the growing children [58]. The bulk density value is of important in packaging. The lower loose bulk density implies that less quantity of the food samples would be packaged in constant volume thereby ensuring an economical packaging. However, the packed bulk density would ensure more quantity of the food samples being packaged, but less economical. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding [59]. The high bulk density of akee apple seed aril flour indicates that they would serve as good thickeners in food products.

Water absorption is important for certain product characteristics, such as the moistness of the product, starch retrogradation and subsequent products scaling [60]. The water absorption capacity of the samples was found to be 1.30g/g and 1.45g/g. The value obtained was higher to the value reported by Nwabueze et al, 2001) for raw breadnut flour (1.25g/g). With respect to water absorption capacity [16] reported that the microbial activities of food products with low water absorption capacity would be reduced, hence the shelf life of such products would be extended. The oil absorption capacity of the samples ranged between 1.20-1.30ml/g. Oil absorption is an important property in food formulation because fats improves the flavor and mouth feel of foods [61] and are as well important due to their storage stability especially in development of oxidation rancidity. The foam capacity of akee apple seed and aril flour ranged between 11.40-14.17%. The formability of flour samples has been shown to be related to the amount of nature protein present in the flour [62] and nature protein gives higher foam stability than the denatured protein [63]. Fermentation and germination may have caused surface denaturation of the of the akee apple seed and aril proteins and reduced surface tension of the molecules which gives the raw akee apple seed and aril flour good formability than the germinated and fermented samples.

The least gelation concentration of the flour samples ranged from 10-12%. The values observed were much lower than the value reported for African yam bean flour (16-20%) reported by [64] and winged bean flour (16-16%) reported by [65], [66] have associated the variation in gelling properties to the ratio of different constituents such as protein, lipids and carbohydant in different legumes. Gelation properties are interrelated to water absorption capacities [67], hence, the high water absorption capacity recorded by the flour sample could explained the high gel formation capacity of the samples.

CONCLUSION

This study established that germination and fermentation improved the nutrient value , especially the protein, fat and mineral content of akee apple seed and aril flour while the anti-nutritional factors were also significantly reduced, hence, making the seeds flour of akee apple to find a new application in food products.

REFERENCES


