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Effects of cowpea fortification, dehydration method and storage time on some quality characteristics of maize-based traditional weaning foods.

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EFFECTS OF COWPEA FORTIFICATION, DEHYDRATION METHOD AND STORAGE TIME ON SOME QUALITY CHARACTERISTICS OF MAIZE-BASED TRADITIONAL WEANING FOODS

Afoakwa EO*, Sefa-Dedeh S† and E Sakyi-Dawson†

ABSTRACT

Fortification of cereal-based traditional foods with legume protein can improve their nutritional value. It is, however, important to find out the extent to which the addition of cowpea affects the desirable quality characteristics of traditional weaning foods prepared from fermented maize and also to assess the effect of dehydration method and storage time on the chemical, physico-chemical and functional properties of the products. A 3 x 2 x 4 factorial experiment with cowpea level, drying method and storage time as the respective variables was done. The traditional weaning food was prepared by steeping maize in water for 24 hours, mixed with cowpea and co-milled into a meal. A 50%-moisture dough was made with the addition of water and fermented for 24 hours. The product was dried using solar drier (40-60 °C for 72 hours) and oven drier (60 °C for 8 hours), and packaged in polypropylene bags prior to the analysis. Proximate analysis, pH, titratable acidity, fat acidity, water absorption and cooked paste viscosity were monitored over six months under tropical ambient conditions (28 °C, RH 85-100%). Cowpea addition caused only minimal changes in the studied indices with the exception of protein content, which increased from 10.54-14.34% and 10.71-14.42% with 20% cowpea level, respectively, for the solar and oven-dried products. Likewise, no major changes in proximate composition were detected during storage. The product pH and fat acidity increased with concomitant decreases in titratable acidity in the stored samples. The pH levels increased from 4.67 – 5.18 and 4.13 - 4.71, respectively, in the solar-dried and oven-dried products within the six months storage period whilst titratable acidity levels decreased slightly during storage of the product. The cowpea level, drying method and storage time showed comparable variations on the cooked paste characteristics measured. The application of cowpea fortification and dehydration to traditional weaning foods is, therefore, a viable option of promoting the nutritional qualities of traditional weaning foods with prolonged...
shelf life stability.

Key words: Cowpea fortification, dehydration method, storability, traditional weaning foods, chemical and functional properties.

FRENCH

Effets de l'enrichissement avec du niébé, la méthode de déshydratation et la durée de conservation sur certaines caractéristiques qualitatives des aliments de sevrage traditionnels à base de maïs

Resumé

L'enrichissement des aliments traditionnels à base de céréales par adition de protéines végétales (légumineuses) est susceptible d'améliorer leur valeur nutritionnelle. Cependant, il est essentiel de connaître l'étendue des effets de l'adjonction du niébé sur les caractéristiques qualitatives souhaitables des aliments traditionnels de sevrage préparés à partir du maïs fermenté. Il est également important d'évaluer l'incidence que la méthode de déshydratation et la durée de conservation ont sur les propriétés chimiques, physico-chimiques et fonctionnelles des produits. Une expérience factorielle 3 x 2 x 4 a été faite avec comme variables respectifs la concentration de niébé, la méthode de déshydratation et la durée de conservation. L'aliment de sevrage traditionnel a été préparé de la manière suivante : on a laissé tremper du maïs dans l'eau pendant 24 heures, ensuite ce maïs a été mélangé aux niébés. Ce mélange a été broyé et réduit en farine. L'adjonction d'eau à cette farine a donné une pâte moelleuse (50% d'humidité) qu'on a laissée fermenter pendant 24 heures. Le produit a été séché en utilisant le séchoir solaire (40-60 °C pendant 72 heures) et dans un four de séchage (60 °C pendant 8 heures), et emballé dans des sachets en polypropylène avant d'être analysé. L'analyse de la composition, le pH, l'acidité titrable, l'acidité grasse, l'absorption de l'eau et la viscosité de la pâte cuite ont été suivis sur une période de six (6) mois dans les conditions tropicales ambiantes (28 °C, RH 85-100%). L'adjonction de niébé n'a pas causé de changements importants dans les indices étudiés, à l'exception de la teneur en protéines. Celle-ci a augmenté car elle est passée de 10,54 à 14,34% et de 10,71 à 14,42% avec une concentration de niébé de 20% respectivement pour les produits soumis au séchage solaire et ceux dont le séchage a été effectué au four. Il en est de même pour la composition globale : aucun changement important n'a été détecté pendant la conservation. Le pH du produit et l'acidité de la matière grasse ont augmenté tandis que le taux d'acidité titrable a diminué dans les échantillons conservés. Les concentrations du pH ont augmenté : elles sont passées de 4,67 à 5,18 et de 4,13 à 4,71 respectivement pour les produits séchés au soleil et ceux séchés au four pendant une période de six mois, tandis que les taux d'acidité titrable ont légèrement diminué pendant la conservation des produits. La concentration de niébé, la méthode de déshydratation et le temps de conservation ont montré des variations comparables sur les caractéristiques de la pâte cuite qui ont été mesurées. L'application de l'enrichissement avec du niébé et la méthode de déshydratation aux aliments de sevrage traditionnels est donc une option viable pour la promotion des qualités nutritionnelles des aliments de sevrage...
tradiotlions conservés pendant une longue période.

Mots-clés : enrichissement avec du niébé, méthode de déshydratation, aptitude à la conservation, propriétés chimiques et fonctionnelles, aliments de sevrage traditionnels.

INTRODUCTION

Maize processing in West Africa is based on traditional indigenous technology which utilizes local raw materials and in most cases, local equipment. These technologies are simple, with most of them having been developed through experience in the production of products of desirable quality. Common unit operations involved include steeping, sprouting, dehulling, milling, cooking (boiling, roasting, steaming) and fermentation [1, 2].

Maize is processed into a wide range of foods and beverages which are consumed as breakfast foods, main meals, or as snacks. One of such foods made from maize is known as Koko which is commonly fed to infants as a weaning food. It is prepared by soaking maize in water for 24 hours, after which the maize grains are washed and milled in a disc attrition mill. Water is added to the meal produced and made into dough which is fermented for 24 hours. The thin slurry is prepared by mixing a portion of the dough with water and this is cooked into porridge which is sweetened with sugar before it is given to children.

Traditional weaning foods are formulated based on local staples usually cereal grains such as maize, sorghum and rice, and roots and tubers such as yam and cassava [3]. These foods are eaten in large quantities and are expected to provide the bulk of the proteins needed for the children’s growth, but the quality of this protein leaves much to be desired. The result is the provision of foods with low nutritional value as they are not adequate sources of micro- and macro-nutrients [4]. During cooking, the starch in the staple foods binds water, requiring considerable amounts of water to bring the consistency of porridges prepared from them to levels suitable for child rearing. This lowers the energy and nutrient density of the porridge considerably and makes it difficult for infants fed these gruels to satisfy their nutritional requirements.

The use of legumes such as cowpeas has been successfully used to increase the nutritional value of weaning foods and as well several researches have been done towards the development of some high-protein weaning foods from local staples [5-7]. Cowpeas have high protein content and constitute the natural protein supplements to staple diets. Protein quality is synergistically improved in cereals-legume blends because of the lysine contributed by the cowpea and methionine contributed by the cereal [8].

The techniques commonly employed in weaning food developments include the formulation of high-quality protein foods and the enrichment of traditional foods by the incorporation of local staples. These processing technologies are traditional and facilitate the utilization of food by converting the local raw materials into diverse end products with desirable quality characteristics. However, most of these traditional weaning foods
are usually not stored, thus limiting their widespread use. In an attempt to
develop products with low moisture content to prolong their shelf-life,
Ghanaian fermented maize dough was dehydrated using a cabinet drier at
60 °C to develop a product with shelf life of at least 16 weeks [9]. In
another study, satisfactory results were obtained by dehydrating fermented Ogi (a Nigerian maize product) by drum-drying with no
significant changes in chemical composition and had prolonged storage
stability [10]. Studies on traditional weaning foods that can retain their
quality characteristics during storage is therefore important and deserves
in-depth investigation. The objective of this study was to evaluate the
effect of cowpea fortification, dehydration method and storage time on
the chemical and functional properties of traditional weaning foods.

.MATERIALS AND METHODS

Materials
Maize (Zea mays. L. cv Obatampa) and cowpea (Vigna unguiculata. cv
Amantin) were purchased from Ejura Farms in Accra, Ghana and used for
the study.

Preparation of cowpea-fortified weaning foods
Maize dough was prepared using the traditional method of first cleaning,
washing and steeping in water for 24 hours. Dehulled cowpea was added
to the maize at 10 and 20% concentration and the maize-cowpea blend
milled using a disc attrition mill (Agrico Model 2A, New Delhi) into a
meal. The meal was made into a 50% moisture dough and allowed to
ferment at room temperature for 24 hours to obtain the cowpea-fortified
fermented maize dough. The dough was then divided into two parts. One
part of it was dried in a solar drier (40-60 °C) for 72 hours and milled into
flour using a hammer mill (Christy and Norris Ltd, England), to pass
through sieve number 6 (Approx ASTM 35 and the flour packaged for
the storage studies. The other portion of the dough was dried using an
oven drier (Model OV-160, Gallenkamp, England) at 60 °C for 8 hours
and milled into flour using a hammer mill, to pass through sieve number
6 (Approx ASTM 35 and the flour packaged for the storage studies. The
samples were packaged in polypropylene bags and stored under tropical
ambient conditions (26-31 °C, R H 85-100%) for a period of 6 months.
Samples were analyzed after 0, 2, 4, and 6 months of storage for proximate analyses (moisture, fat, ash, protein and carbohydrate), pH and
titratable acidity, fat acidity, water absorption and cooked paste viscosity.

Experimental Design
A 2 x 3 x 4 factorial experimental design was used and the principal
factors were:
    i. Drying method: Solar drying and oven drying
    ii. Cowpea level : 0%, 10% and 20%.
    iii. Storage period: 0, 2, 4 and 6 months.

METHODS

Chemical analyses
The moisture, crude protein (N x 6.25), fat and ash contents were
determined by Association of Official Analytical Chemists' Approved
methods 925.10, 920.87, 920.85, 923.03 and 963.09, respectively [11].
Carbohydrate contents were determined by difference. The American Association of Cereal Chemists’ Approved Methods 02-01A was used for fat acidity determination [12].

**Water absorption capacity**
Flour water absorption was determined by suspending 5.0 g in 30 ml of water and mixing. The mixture was allowed to stand for 10 minutes and mixing repeated times over one hour period, centrifuge at 3000 rpm for 15 minutes. The supernatant was decanted and the centrifuge tube weighed. Water absorption was calculated as the increase in weight of the gel formed after decanting the supernatant.

**Cooked paste viscosity**
The cooked paste viscosity of slurries made from concentrations of 10% (dry matter basis) flour in 500 ml water were measured using Brabender Viscoamylograph (Brabender, Duisburg Germany) equipped with a 700 cmg sensitivity cartridge. The viscosity of the slurries were continuously monitored as they were heated from 25 °C at a rate of 1.5 °C per minute to 95 °C and held at 95 °C for 30 minutes, cooled to 50 °C at a rate of 1.5 °C per minute and then held for 20 minutes at 50 °C. The Brabender Viscoamylograph indices (pasting temperature, peak viscosity, viscosity at 95 °C and 95 °C-Hold, and viscosity at 50 °C and 50 °C-Hold) were measured.

**pH and Titratable Acidity**
Ten grams of sample was mixed in 100 ml of CO2 -free distilled water. The mixture was allowed to stand for 15 minutes, shaken at 5 minutes interval and filtered with Whatman No. 4 filter paper. The pH of the filtrate was measured using a pH meter (Model HM-30S, Tokyo, Japan). Ten (10) ml aliquots (triplicates) were pipetted and titrated against 0.1M NaOH to phenolphthalein end-point and the acidity was calculated as g lactic acid/100 g sample.

**Statistical analyses**
The data obtained from the determinations were statistically analyzed using Statgraphics (Graphics Software System, STCC, Inc. U.S.A.). Comparisons between sample treatments and the indices were done using analysis of variance (ANOVA) with a probability p<0.05.

**RESULTS**

Effect of cowpea addition, dehydration method and storage on the chemical composition

The moisture content of the formulated weaning foods showed no major differences between the various treatments. The solar- and oven-dried products had moisture contents ranging from 6.61% to 6.42% and 5.13% to 5.29% respectively after processing (Table 1). However, storage of the products caused slight increases in their moisture contents. The solar-dried products increased from 6.61% to 6.82% whereas the oven-dried products increased from 5.13% to 5.72% within the six months of storage (Table 1). Similar results were reported on the moisture content of some dehydrated fermented foods [2]. Analysis of variance (ANOVA) conducted on the data showed that all the variables (drying method, cowpea level and storage time) had no significant effect (p<0.05) on the
moisture content of the weaning foods (Table 2). The ash contents of the samples increased with increasing concentration of cowpea (Table 1). There were fluctuating levels of ash contents between 2.32% and 2.66% with all the different products in storage (Table 1). Statistical analysis showed that only cowpea level had significant effect (p≤0.05) on the ash contents of the products. Drying method and storage time did not significantly affect the ash contents of the products (Table 2). Likewise, increasing the cowpea concentration (10-20%) increased the protein content of the products from 10.54 to 14.34% and 10.71 to 14.42%, respectively, for the solar- and oven-dried products (Table 1). However, the six months of storage of the products caused no observable changes in their protein contents (Table 1). Analysis of variance conducted on the data indicated that drying method and storage time had no significant effects (p≤0.05) on the protein contents of the weaning foods (Table 2). Contrary to this, cowpea level significantly affected the protein contents of the traditional weaning foods. Decreasing trends were observed in the fat contents of the products with increasing cowpea concentration (Table 1). This may be due to the observation that maize contains higher levels of fat than cowpeas [7]. Trends observed during storage of the products indicated that no variations in fat content occurred in the stored products (Table 2). ANOVA conducted on the data indicated that the addition of cowpeas had significant effect (p≤0.05) on the fat content of the products (Table 2). Variations in carbohydrate content were observed with cowpea concentration. The data showed that the carbohydrate content decreased with increasing cowpea concentration (Table 1). This agrees with the observation that addition of cowpea decreases the carbohydrate contents of maize-based traditional foods [13, 14]. Statistical analysis on the data showed that only cowpea level significantly affected (p≤0.05) the carbohydrate content of the products. Drying method and storage time did not significantly affect the carbohydrate content (Table 2).

PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES

pH and titratable acidity
The formulated weaning foods had pH values ranging between 4.13 and 4.98 after processing. The acidic nature of the products was due to the production of lactic acid associated with maize dough fermentation [15]. The pH of the unfortified products increased from 4.67 to 4.98 and 4.13 to 4.26 with 20% cowpea levels respectively for the solar- and oven-dried products. Storage caused slight increases in pH in all the products (Figure 1) with concomitant decreases in titratable acidity (Figure 2). The pH levels increased from 4.67 – 5.18 and 4.13 - 4.71, respectively, in the solar-dried and oven-dried products within the six months storage period. Contrary to this trend, titratable acidity levels decreased slightly during storage of the products (Figure 2). This suggests that some of the acids produced during fermentation are lost during storage of the products. Analysis of variance conducted on the data showed that only the drying method significantly (p≤0.05) affected the pH and acidity levels of the weaning foods (Table 3).
Figure 1: Changes in pH of cowpea-fortified traditional weaning foods during storage

Figure 2: Changes in titratable acidity of cowpea-fortified traditional weaning foods during storage

FIGURES LEGEND
0% C-S: Unfortified solar-dried product
10% C-S: 10% cowpea-fortified solar-dried product
20% C-S: 20% cowpea-fortified solar-dried product
Fat acidity
Fat acidity increased from 204.20 – 214.95 (mg KOH/100 g dry sample) and from 198.64 – 210.65 (mg KOH/100 g dry sample) for the unfortified solar- and oven-dried products, respectively. The rate of increase in fat acidity levels with the oven-dried products during storage was, however, low as compared to those of the solar-dried samples which increased tremendously during storage (Figure 3). The drying method used for the preparation of the weaning foods also influenced the degree of increase during storage of the products since drying processes of food products determine their water activity during prolonged storage. The water activity, oxygen partial pressure and temperature in a pack have been observed to affect the rate of lipid oxidation on foods during storage [16]. Statistical analysis showed that the drying method, cowpea level and storage time significantly (p<0.05) affected the fat acidity of the products (Table 3).

![Figure 3: Changes in fat acidity of cowpea-fortified traditional weaning foods during storage](image)

**FIGURES LEGEND**
0% C-S : Unfortified solar-dried product
10% C-S : 10% cowpea-fortified solar-dried product
20% C-S : 20% cowpea-fortified solar-dried product
0% C-O : Unfortified oven-dried product
10% C-S : 10% cowpea-fortified oven-dried product
20% C-S : 20% cowpea-fortified oven-dried product

Water absorption
Process treatment of raw materials is known to affect their hydration properties [17]. During storage, the water absorption capacity of the
products showed variations over the storage period. In general, slight decreases in water absorption capacity were observed with storage time of the products. The oven-dried samples showed comparatively higher rates of decrease than the solar-dried products (Figure 4), which compares well with observations made when working on some solar-dried and oven-dried cowpea-fortified traditional foods [2]. Water absorption decreased from 205.27-183.62 (g/100 g dry sample) and from 198.80-156.24 (g/100 g dry sample), respectively, for the solar- and oven-dried products during the six months of storage. Water absorption characteristics are attributed to the protein and starch granules present in the samples as well as their arrangements, and the degree of packing of the granules determine the intermolecular spaces available at the surfaces of the products [18]. Statistics analysis indicated that the drying method and storage time had significant effects (p≤0.05) on the water absorption pattern of the products (Table 3). Cowpea level, however, had no influence on the changes observed on the products during storage.

![Figure 4](image)

**Figure 4: Changes in water absorption capacity of cowpea-fortified traditional weaning foods during storage**

**FIGURES LEGEND**

- 0% C-S : Unfortified solar-dried product
- 10% C-S : 10% cowpea-fortified solar-dried product
- 20% C-S : 20% cowpea-fortified solar-dried product
- 0% C-O : Unfortified oven-dried product
- 10% C-S : 10% cowpea-fortified oven-dried product
- 20% C-S : 20% cowpea-fortified oven-dried product

**Cooked paste characteristics**

The results showed that the pasting temperatures of the products were not affected by cowpea fortification, dehydration method and storage time (Table 4). This means that the fortified and unfortified products would take similar times to gelatinize during cooking. However, increasing cowpea concentrations led to increases in the viscosity of the products at
95 °C and 95 °C-HOLD. Since the viscosity at 95 °C and 95 °C-HOLD are indicative of the viscosity of products during cooking, the observed trend with cowpea addition suggests that cowpea fortification would slightly prolong the cooking times of the fortified products. Contrary to this trend, increasing cowpea concentration led to decreases in the viscosities at 50 °C and 50 °C-HOLD (Table 4). Storage caused only slight variations in the Brabender viscoamylograph indices with drying method and cowpea level after six months (Table 4). Statistical analysis on the data indicated that only the drying method used for the preparation of the weaning foods significantly (p≤0.05) affected the indices studied (Table 3). This significant change with drying method is attributed to the varying degrees of dryness brought about by the different drying methods used during the preparation of the products.

DISCUSSION

The moisture content of the formulated weaning foods showed no major differences between the various treatments. Even though slight variations were reported, the moisture changes in the products were not high enough to influence the product quality during the six months of storage. These variations might have resulted from the fortification of cowpeas to the weaning foods during formulation. Earlier studies reported that ash content of cowpeas is higher than that of maize [7]. Similar ash contents have been reported on fermented maize-cowpea blends [5]. During storage of the products, no remarkable changes in the ash content were observed. This explains that the ash content of cowpea-fortified traditional weaning foods therefore increase with cowpea concentration. On the contrary, the protein contents of the products showed variations with the addition of cowpeas. Initial studies on fermented maize revealed that the protein quality and quantity of the products improved considerably with cowpea fortification [7]. The use of cowpea as a fortifying agent has been reported to improve the protein content of cereal diets [2, 13, 14]. This explains that fortification of maize-based foods with cowpea increases their protein content. However, the six months of storage of the products caused no observable changes in their protein contents. Contrary to the trends observed for the protein contents, decreasing trends were observed in the fat contents of the products with increasing cowpea concentration. This may be due to the observation that maize contains higher levels of fat than cowpeas [7]. Therefore, increasing cowpea concentration in traditional weaning foods leads to decreases in their corresponding fat contents. Addition of cowpeas to cereal-based weaning foods, therefore, decreases the fat contents of the products. Storage time and drying method however had no significant effect on the product fat contents. Variations in carbohydrate content were also observed with cowpea concentration. However, during storage of the products, no major changes occurred in their carbohydrate contents within the six months of storage.

Cowpea fortification was observed to increase the pH and to decrease titratable acidity of the products. This means that slight increases in pH occurs during storage of cowpea-fortified fermented weaning foods resulting in the loss of acids in the products. This increase in pH and consequential decrease in acidity associated with storage of cereal-based foods have been reported [2, 14]. The statistical analysis showed no
significant effect with storage time on the pH and acidity of the formulated weaning foods, explaining that even though some acids were lost during storage of the products, their impact on the product quality was minimal and could not influence the storage quality of the weaning foods. The fat acidity levels of the products were observed to vary with the fortification with cowpea. Increasing cowpea concentration in the products decreased the fat acidity contents. It has been reported that cowpeas have low fat acidity levels ranging from 32.2 to 34.6% [2]. Hence, the addition of cowpea to maize-based products which have relatively high fat acidity levels tend to decrease the fat acidity of the cowpea-fortified products. Similarly, storage caused increases in fat acidity of the products (Figure 3). This observation might be due to the barrier effects of the different drying temperatures used in the preparation of the products. The water activity, oxygen partial pressure and temperature in a pack have been observed to affect the rate of lipid oxidation on foods during storage [16].

Water absorption capacity is an important index, which gives valuable information on the behaviour of weaning food products during reconstitution in hot or cold water. Addition of cowpeas improved the water absorption potential of the samples. This was probably due to the influence of added proteins in the products. Proteins are mainly responsible for the bulk uptake of water and to a lesser extent the starch and cellulose at room temperature. The gelatinization of starch and the denaturation of proteins that is the result of the application of heat treatment to cowpeas have been suggested to improve the water absorbing capacity of cowpea [14].

The Brabender viscoamylograph presents useful information on the hot and cold paste viscosity of starch based foods. Cowpea fortification at concentrations of 10% and 20% influenced some of the Brabender viscosity indices. The pasting temperatures of the stored products showed no observable variation during storage of the products. The peak viscosity and viscosity at 95 °C of the oven- and solar-dried samples showed slight fluctuations during storage with the different cowpea levels used. However, these observed changes did not affect the quality of the cooking characteristics of the weaning foods since the observed differences were not wide. The cooking qualities of the weaning foods studied were, therefore, not affected by storage time and cowpea level, which implies that the cooking characteristics of the products remained unchanged during storage.

CONCLUSION

The use of cowpea as a fortifying agent effectively increased the protein and ash contents of the weaning foods. No major variations in chemical composition and functional properties were noted with dehydration method and storage time. However, increases in pH and fat acidity occurred with corresponding decreases in titratable acidity and water absorption capacity during storage of the products. The cooked paste characteristics were not influenced by any of the studied indices. Dehydration and cowpea fortification can, therefore, be employed for the production of high protein maize-based traditional weaning foods that can be stored for longer periods of time.
ACKNOWLEDGEMENT

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Table 1
Effects of cowpea fortification, dehydration method and storage time on the proximate composition of traditional weaning foods

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Drying method</th>
<th>Cowpea level %</th>
<th>Storage time (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>Solar-dried</td>
<td>6.61</td>
<td>6.61</td>
</tr>
<tr>
<td></td>
<td>6.29</td>
<td>6.34</td>
<td>6.42</td>
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<tr>
<td></td>
<td>5.18</td>
<td>5.21</td>
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<tr>
<td></td>
<td>2.47</td>
<td>2.43</td>
<td>2.48</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>Solar-dried</td>
<td>2.64</td>
<td>2.69</td>
</tr>
<tr>
<td></td>
<td>2.42</td>
<td>2.44</td>
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<tr>
<td></td>
<td>2.49</td>
<td>2.52</td>
<td>2.46</td>
</tr>
<tr>
<td>Protein* (%)</td>
<td>Solar-dried</td>
<td>10.54</td>
<td>10.47</td>
</tr>
<tr>
<td></td>
<td>12.71</td>
<td>12.77</td>
<td>12.85</td>
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<tr>
<td></td>
<td>14.34</td>
<td>14.44</td>
<td>14.26</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>Solar-dried</td>
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<tr>
<td></td>
<td>4.32</td>
<td>4.26</td>
<td>4.47</td>
</tr>
<tr>
<td>Carbohydrate** (%)</td>
<td>Solar-dried</td>
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<td></td>
<td>73.43</td>
<td>73.24</td>
<td>73.07</td>
</tr>
</tbody>
</table>

*N x 6.25
** By difference
Mean values of replicates, on dry matter basis

Table 2
F-ratios of process variables of the proximate composition of cowpea-fortified traditional weaning foods

<table>
<thead>
<tr>
<th>Index</th>
<th>Drying method</th>
<th>Cowpea level</th>
<th>Storage time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>0.132</td>
<td>0.223</td>
<td>1.285</td>
</tr>
<tr>
<td>Ash</td>
<td>0.637</td>
<td>8.73*</td>
<td>1.162</td>
</tr>
<tr>
<td>Protein</td>
<td>8.842</td>
<td>788.243*</td>
<td>2.418</td>
</tr>
<tr>
<td>Fat</td>
<td>0.365</td>
<td>91.196*</td>
<td>0.571</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>2.763</td>
<td>160.974*</td>
<td>1.894</td>
</tr>
</tbody>
</table>
*Significant F-ratio at p<0.05

Table 3
Significant F-ratios of process variables of the physico-chemical and functional properties

<table>
<thead>
<tr>
<th>Index</th>
<th>Drying method</th>
<th>Cowpea level</th>
<th>Storage time</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>242.879</td>
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<td>Titratable acidity</td>
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<td>Fat acidity</td>
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<tr>
<td>Pasting temperature</td>
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<tr>
<td>Peak viscosity</td>
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<td>Viscosity at 95 °C</td>
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<tr>
<td>Viscosity at 95 °C-HOLD</td>
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<td>Viscosity at 50 °C</td>
<td>10.826</td>
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Significance at p<0.05

Table 4
Effects of cowpea fortification, dehydration method and storage time on the cooked paste characteristics of traditional weaning foods

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Drying method</th>
<th>Cowpea level %</th>
<th>Storage time (Months)</th>
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<td></td>
<td>0 10 20</td>
<td>0 2 4 6</td>
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<tr>
<td>Pasting temperature (°C)</td>
<td>Solar-dried</td>
<td>72.6 73.2 73.1</td>
<td>73.1 73.4</td>
</tr>
<tr>
<td></td>
<td>Oven-dried</td>
<td>73.2 73.8 72.9</td>
<td>73.0 73.8</td>
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<td>72.8 73.1 73.6</td>
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<tr>
<td></td>
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<td>73.4 73.4</td>
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<td>1120 1140</td>
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<td>1110 1130 1140</td>
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<tr>
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<td>1270 1240 1260</td>
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<tr>
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<td>910 920</td>
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<td>910 940 920</td>
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<td>Viscosity at 95 °C (BU)</td>
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<td>890 870 900</td>
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<tr>
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<td>2440 2440</td>
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<tr>
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<tr>
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<td>Solar-dried</td>
<td>0 2640 2610 2650</td>
<td>2640 2640</td>
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</table>
Viscosity at 50 °C- HOLD (BU)

<table>
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BU: Brabender Units

REFERENCES


12. AACC. Approved Methods of Analysis of the American Association of Cereal


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