PEER-REVIEWED RESEARCH PAPER

Use of Cowpea (*Vigna Unguiculata*) as Substitute for Wheat Flour in the Preparation of Snacks

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Abstract

Cowpea is an important protein staple food commonly used in Ghana. However, its utilisation in snack foods in Ghana is limited. Quiche Lorraine, a delicious French snack now adopted in Ghana, is quite unpopular due to its high cost, thus making it a snack for the rich in society. This study was therefore conducted to produce an affordable local version of Quiche Lorraine by substituting commonly used wheat flour with cowpea flour. Non-dehulled and dehulled cowpea flours were used to replace wheat flour at 25%, 50% and 100% levels to obtain the new product, named Kum-allory. *Proximate and sensory evaluations were conducted on the products using experimental and descriptive designs respectively. One hundred untrained teenagers were selected purposively from a Senior High School in Takoradi for the acceptability test. The nutrients composition of both the uncooked and cooked samples were also determined according to the methods of the AOAC (2004). Data was analysed using the ANOVA of the Minitab Statistical package. Results indicated lower fat, but higher crude protein contents in the new product. The overall acceptability of the control product was significantly (P < 0.001) better than the 25% and 50% cowpea-based products, but was similar to the 100% cowpea inclusion products. The formulation cost of the new products, were about 47% lower than for the control products. The new product could be commercialised to help combat protein-malnutrition among the vulnerable groups in society.*

KEYWORDS: **COWPEA; PROXIMATE ANALYSIS; CONSUMER TEST; SENSORY EVALUATION; SNACK FOODS**

Introduction

The development of new food products in today's food industry is progressively becoming interesting, due to ever changing trends and competitive products. Dollar and Kraay (2001), realized that urbanisation, women in the labour force, new food processing and storage technologies are contributing factors to changes in food consumption and dietary patterns for many people. Owing to the fast-paced nature of urban living, there is a high demand for convenience and snacks among urban dwellers. These lifestyle changes, according to Haddad et al. (2003) have adverse effect on the health status of people in developing countries over a long period of time. For this reason, consumers are expecting newer and healthier products that are an alternative to home-made foods.

A study by Edema et al.(2005), has indicated that the consumption of snacks containing trans-fat has increased in Ghana. These snacks dough are chiefly made with wheat flour which is largly imported, since they are not produced locally (Seibel, 2011). This importation is achieved at higher costs, resulting in depreciation of the local currency, hence the need for locally available staples for use in place of wheat flour. One of such potential staples is cowpea.

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Cowpea (*Vigna Unguiculata L. Walp*) are popularly called “beans” in Ghana. It is a grain legume that serves as a major source of protein among low income earning families in the country and hence forms a major staple food crop in sub-Saharan Africa (Boye et al., 2010). It is grown all over the world, though perceived to have originated from Africa (Dugje et al., 2009).

In Ghana, there are lots of cowpea varieties on the local market. They also come in different colours, such as red beans, black-eyed beans, black beans and cream-coloured beans. The seeds are boiled alone or in combination with rice (*Waakye*), and plantain (*Red-Red*). Cowpea is also used in the preparation of street foods popularly called *koose* or *akara* (cowpea fritters) and *tubani* (steamed cowpea batter). Others use it in soups and stews (Appiah et al., 2012; Seibel, 2011). The nutritious nature of cowpea requires that alternative uses are scouted to improve its utilisation.

This study was designed to determine the effects of replacing wheat flour with cowpea flour in snack foods, on cost of formulation, proximate composition and consumer acceptability of the products.

Review of Related Literature

Origin and domestication of cowpea

Cowpea is a grain legume, commonly referred to as “beans” in Africa and “niebe” in Francophone countries as reported by Appiah et al., 2012. In Ghana, *beans* is a common name for all types of legumes except soya. Moreover, the crop is also named locally amongst the ethnic groups in the country:

- *yor* by Gas
- *edua* or *eduwa* by Akans
- *ayi* by Ewe, and
- *waakye* among the Hausas.

Several researchers have reviewed works on the origin of cowpea. Allen (1983) reported that, cowpea was introduced from Africa to the Indian sub-continent around 2000 to 3500 years ago. Another study by Taiwo (1998) also stated that cowpea originated from Africa, and later to East and West Africa and Asia. Kitch et al. (1998) reviewed the species *unguiculata* to be a West African Neolithic domesticated whose progenitors were the wild weed species, namely, *dekindtiana* and *meusensis*.

In Ghana, cowpea is equally popular and is grown largely in the three Northern regions. For instance, the Upper West and Northern regions recorded 75,969 and 105,841 metric tonnes of cowpea respectively (Ministry of Food and Agriculture, 2011). Other areas of production include the Brong Ahafo and some parts of the Volta regions. The most popular cowpea varieties available in Ghana include *Nhyira*, *Tona*, *Hewale*, *Asontem*, *Asetenapa* and *Videza*.

As a legume grain, cowpeas are rich and low-cost sources of protein and other nutrients (Egounlety & Aworh, 2003). In addition, the crop is rich in dietary fibre and carbohydrates. Minor compounds include lipids, polyphenols, and bioactive peptides (Rochfort & Panozzo, 2007).

Processing of cowpea grains

Cowpea passes through several processes before they are used in food preparations. These processes include cleaning, drying, sorting, splitting and milling under conditions which assure a minimum degree of mechanical damages (Uebersax et al., 1991). Other steps like dehulling and roasting may be included, depending on its intended use. Table 1 shows the processing methods.

Table 1 Processing of Cowpea Grains

Process	Description
Cleaning	Cleaning can be done by running the grains over gravity tables or hand picking dead matters, leaves, weevils, diseased grains and any other unwanted materials (Uebersax et al., 1991).
Sorting	The cleaned cowpea is graded according to their seed size, using separators. Another, by forcing air through the gravity table, products of the sought-after size are effectively separated out, while outsized product and foreign material fall below into a separate area.

Process	Description
Dehulling or Decortication	The process of removing seed coat of legume before use. Dehulling, can be done manually or mechanically, depending on the type or quantity of the grain involved. According to Akinjayeju and Enude (2002), the outcome of dehulling helps improve the functional attributes such as appearance, texture, cooking quality, palatability and digestibility of their products. Traditionally, dry beans are soaked in water to loosen the seed coat, decorticated by either manual rubbing or stirring the wet beans in a mortar and floating off the seed coats in water, and then grinding to a paste either on a stone, in a mortar, with an electric blender or in a commercial plate mill (Dolvo et al., 1975) as reported by Singh (2016).
Milling	Once dehulling has been completed, the grains are milled, mostly with plate mills (Phillips & et al., 2003). This is a critical step in legume processing.
Sieving	The sieving process removes the undesirable deposit. For dry-milled cowpea flour, sieving helps to achieve different ranges of particle sizes. Wet sieving can be done using cheese-cloth or muslin cloth while dry sieving can be done with different kinds of local or standard sieves. (Fasoyiro et al., 2012).
Processing undehulled grain into flour	Undehulled or hulled cowpea splits are either ground dry into flour or ground wet into a batter for other food uses, often in combination with cereals and millet. The properties of the product, such as mouth feel, texture, and others are impacted by the composition of the flour, the fineness of the grinding and the cooking conditions (Singh, 2016). In the preparation of flour from undehulled cowpea, the addition of seed coat to produce acceptable product has been a challenging factor, particularly with respect to texture and flavour (Alobo, 1999).

Utilisation of cowpea in Ghana

Cowpea is a multifunctional crop, it serves as a source of food for man and livestock, and serving as a valuable and dependable revenue-generating commodity for farmers and grain traders (Langyintuo et al., 2003; Singh, 2002). In Ghana, the crop is consumed in the various stages of development other than the legumes. The stages include the fresh green leaves, dry leaves, green pods, green beans and dry grains. The most common is the dry grains, which contain significant nutritional value. It is either cooked whole or milled into flour for use (Timko et al., 2007).

Cowpea has found utilisation in various ways, in both the traditional and modern food processing in the world. In Ghana, most cowpeas are cooked with vegetables, spices, and palm oil to produce a thick soup, stews and sauces that accompany the basic staple, notably rice, cassava, yam, or ripe fried plantain. The seeds are also decorticated, ground into flour or paste, mixed with chopped onion and spices, and is either deep-fried (*koose*) or steamed (*tubani*). Some are ground or crushed into meal that is used from bean salads to buns, fritters, and stand-alone vegetarian dishes. Cowpeas are easy to prepare and provide far more nutrition than many other legume species.

The nutritional value of cowpea

Cowpea has a nutritional profile that suits all ages. The nutritional value of cowpea is in the composition of its grain. According to Boukar et al. (2010), the grain provides cholesterol-free protein up to around 30% in some varieties, fibre, magnesium, potassium, B vitamins, and resistant starch. Another study by Rochfort, and Panozzo (2007), revealed that cowpea provides a good source of protein (18%–35%), which was evident in culinary traditions, where cowpeas were used as an important complementary dietary item to grain-based meals.

Health benefits of cowpea

Cowpeas are not only versatile and delicious, but also important for human health, offering a number of health benefits when consumed. Many researchers have revealed that cowpea is effective at binding and lowering blood cholesterol in the body (Bazzano et al., 2001; Winham & Hutchins, 2007.). Further, Vitamin B1 (thiamine) and various flavonoids found within cowpea have recently gotten some great attention for their role, as they can help reduce inflammation and promote normal heart functioning (Anderson et al., 1984). Regular consumption of cowpea and other legumes is reported to have the ability to reduce serum cholesterol, improve diabetic therapy, and provide metabolic benefits that aid in weight control.

The antioxidant effects of cowpeas are of particular interest to the natural health community, because cowpeas are highly associated to lower levels of chronic illness and cancer. (Bazzano et al., 2001; Winham & Hutchins, 2007). Evidence shows that legume based ingredients have been recently used to develop functional breads intended to evade cardiovascular disease (Nilufer et al., 2008; Vittadini & Vodovotz, 2003)

Dietary fibre is one of the best solutions for a wide range of stomach issues, such as constipation or diarrhoea, however, cowpea can help to absorb water and loosen up the stool, bulking up bowel movements and stimulating peristaltic motion. According to Howarth et al. (2001), soluble fibre and resistant starches in cowpea may help suppress appetite and manage blood sugar as compared to other sources of carbohydrates. According to the report, cowpea exhibit a low glycemic index (GI) and produce a relatively flat blood-glucose response.

Economic importance of cowpea

Cowpea is versatile, providing food for human and feed for livestock. Additionally, the crop is an income generating commodity for farmers, small and medium-scale enterprises.

It is documented that cowpea forms a major component of tropical farming systems because of its ability to improve marginal lands through nitrogen fixation as cover crop (Sanginga et al., 2003). The crop is drought tolerant and its relatively early maturity and nitrogen fixation characteristics fit very well to the tropical soils where moisture and low soil fertility is the major limiting factor in crop production (Hall, 2004; Hall, et al., 2002).

The full economic potential of cowpea will only be realized if other value-added products, especially those targeted at the ever-growing urban population, are introduced. For example, converting cowpea flour into cost effective snack products and baby food might bring about a rise in the price of the commodity, which will also bring higher returns to the producer (Appiah et al., 2012).

Consumer acceptability test

Consumer acceptability test requires relatively larger sample size between 75-150 consumers (Jones et al., 1955). This is to ensure greater confidence regarding the interpretation of the results. Samples are prepared properly. Facilities are well designed and labelled, white or off-white colour more preferable. Good lighting and ventilation should be controlled. Temperature is also controlled to obtain the same temperature for all samples. Volume served should be equal for all samples. For experimental design considerations, samples are labelled with random 3-digit codes to avoid bias (Jones et al., 1955).

Materials and Methods

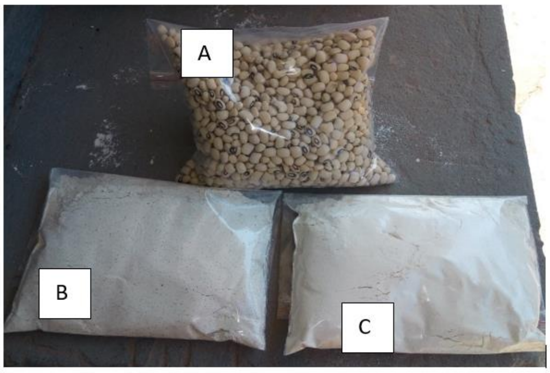
Study area

The product preparation and sensory evaluations were conducted in Takoradi, in the Western region, Ghana. The proximate analyses of the samples were, however, conducted at the Nutrition laboratories of the School of Agriculture, University of Cape Coast.

Materials used for the study were purchased from a local market in Takoradi. The items purchased included cowpea grains (black-eyed variety), wheat flour (soft), chicken, fresh chilli pepper, carrot, sweet pepper, tomatoes, eggs, onion and salt.

Cowpea flour preparation

The cowpea was examined to ensure it was disease-free, and was then sieved to remove foreign particles, to ensure wholesomeness. The cleaned seeds were divided into two portions and treated as follows: The first portion was manually dehulled by pounding with a little water for about 20 minutes. This was followed by a vigorous hand-rubbing to separate the seeds from the seed coat, then the seed coats were detached from individual seeds. The dehulled seeds were spread on a clean table and sun-dried for 12 days till the grains were bone-dried. The second portion was milled in the dry state, using a locally fabricated attrition, and was then passed through a 250 μm mesh sieve to obtain fine cowpea undehulled and dehulled flours, as shown in Figure 1.



A. Cowpea grains B. Undehulled Cowpea Flour (UCF) C. Dehulled Cowpea Flour (DCF)

Figure 1 Whole Cowpea Grains and Flours

Products preparation

In the preparation of *Kum-Allory*, flours of the undehulled and dehulled cowpeas were beaten separately with a wooden ladle till a smooth, foamy and light consistency batter was obtained. The pastes were used to substitute for wheat flour at 25%, 50% and 100% levels to obtain the new formulation for the base of the product. Five to ten millilitres of water was added to the mixtures to attain the appropriate consistencies. The batter mixtures were then poured into already labelled patty tins of approximately 4cm thickness. Each mixture was filled with toppings of vegetables, chicken flakes, chicken stock or well-seasoned egg for binding. Formulations were baked in a hot oven at temperatures of 175ºC for 20mins, cooled, packed in zip-lock bags and stored at ambient temperature for further use.

In the preparation of the Quiche Lorraine products, half fat to flour was rubbed-in to obtain a fine-crumbs texture. A soft pastry dough was formed with 15ml cold water, wrapped in a polythene and allowed to stand for 30 minutes. Vegetables, chicken and custard were prepared ready as toppings. The dough was rolled and lined in muffin tins of approximately 4cm thickness. The dough was filled with the toppings and seasoned eggs for binding. The mixture was baked in a hot oven at temperature of 175ºC for 30mins, cooled, packed in zip-lock bags and stored at ambient temperature for later use.

Proximate composition

The ash, moisture, crude fibre, crude protein, fat, minerals and carbohydrate contents of the flours, were determined according to the methods proposed by the AOAC (2004).

Sensory evaluation of products

One hundred teenagers (aged between 14 and 19 years) were purposively selected from students of a Senior High School in Takoradi. The non-random purposive sampling technique was used in an attempt to sample participants who were interested in the study (Amedahe, 2002). Criteria for selection included the following:

1) participants were to be at least 14 years of age
2) participants should not be allergic to any of the ingredients used in the study, and
3) they were to be available for the period required to conduct the evaluation.

The assessment was in two sessions; mid-morning and late afternoon. This is because the number of product samples were quite large (eight samples) for the participants to evaluate at a time, as that could result in sensory fatigue (Meilgaard et al., 1999). Adequate and uniform lighting and ventilation were ensured in the evaluation hall. Movements and other sources of distraction were also controlled. In the first session, the undehulled samples were assessed. Participants were made to sit in a way that their responses were not influenced by other panellists. The products were chopped into smaller sizes, and wrapped in coded aluminium foils, and were presented to the panellists for evaluation.

Each panellist was provided with a glass of water to rinse and neutralize their mouths after tasting each product.

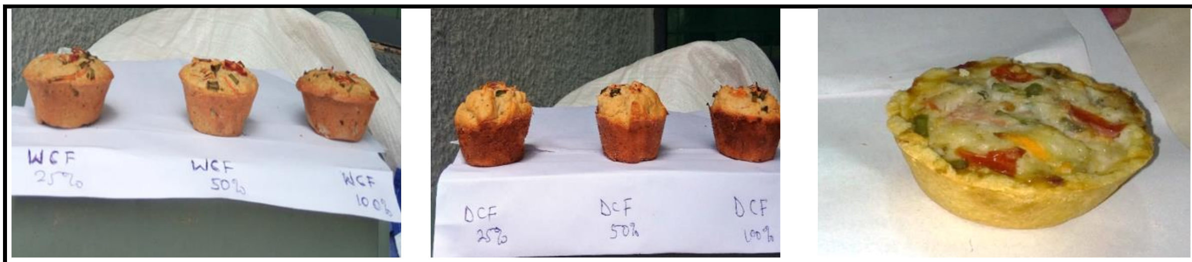
The panellists were then asked to evaluate the products using a 7-point hedonic scale, where 1 represented *dislike extremely* and 7 *like extremely*. The attributes evaluated include colour, taste, flavour, texture, appearance and overall acceptability.

Statistical analysis

Data collected were subjected to analysis using one-way ANOVA of the Minitab Statistical Package. Independent *T*-tests were used to separate and compare the group means. Significant differences were accepted at probability level of 0.05.

Results and Discussion

Physical characteristics of the products



Undehulled cowpea products Dehulled Cowpea Products Control (wheat based product)

Figure 2 Physical Appearance of *Kum-Allory* and Quiche Lorraine Products

Table 2 Proximate Analysis of the Nutritional Composition of the Cooked (Processed) Samples of Cowpea

Parameter (%)	Control	25% U	50% U	100% U	25% D	50% D	100% D	SED	Sig.
Dry Matter	33.07^{d}	47.38^{bc}	44.66^{c}	44.15^{c}	55.12^{a}	48.86^{b}	37.16^{d}	1.01	***
Crude Protein	23.90^{d}	27.39^{c}	28.03^{bc}	31.51^{a}	29.84^{ab}	24.85^{d}	31.41^{a}	0.69	***
Ash	1.61^{d}	2.34^{bc}	2.82^{a}	2.75^{ab}	2.90^{a}	1.93^{cd}	2.39^{b}	0.12	***
Crude Fibre	2.75^{d}	4.45^{a}	2.43^{e}	3.57^{b}	4.27^{a}	3.03^{c}	2.89^{cd}	0.07	***
Ether Extract	17.46^{a}	3.24^{cd}	3.05^{d}	3.02^{d}	3.86^{b}	3.72^{bc}	3.86^{b}	0.15	***
CHO	49.61^{d}	60.27^{b}	61.37^{b}	56.18^{c}	57.50^{c}	64.18^{a}	56.48^{c}	0.55	***
Ca	0.64^{ab}	0.51^{b}	0.50^{b}	0.61^{ab}	0.64^{ab}	0.73^{a}	0.65^{ab}	0.05	**
Mg	0.12^{d}	0.12^{d}	0.13^{cd}	0.12^{d}	0.17^{bc}	0.17^{b}	0.23^{a}	0.01	***

*= $P < 0.05$; ***= $P < 0.001$; Sig.= Significance level
25% U = 25% Undehulled; 50% U = 50% Undehulled; 100% U = 100% Undehulled;
25% D = 25% Dehulled; D = 50% Dehulled; 100% D = 100% Dehulled
SED = Standard Errors of Differences
Means in a row with similar superscripts are not significantly different ($P < 0.05$; $P < 0.001$)

Table 3 **Sensory Evaluation Result for Samples Made From Undehulled Cowpea**

Parameter	604 100% U	704 50% U	804 25% U	904 (control)	SED	Sig. Level
Colour	4.61^{b}	4.85^{b}	4.89^{b}	6.12^{a}	0.21	***
Taste	5.26^{b}	5.11^{bc}	4.68^{c}	6.06^{a}	0.22	***
Texture	4.92^{b}	4.81^{b}	4.84^{b}	5.57^{a}	0.22	**
Aroma	4.88^{b}	4.69^{b}	4.91^{b}	5.96^{a}	0.20	***
Attractiveness	5.02^{b}	5.10^{b}	5.27^{b}	6.09^{a}	0.21	***
Acceptability	5.37^{b}	5.14^{b}	5.21^{b}	6.31^{a}	0.20	***

** = P < 0.01; *** = P < 0.001
SED = Standard Errors of Differences
Means in a row with similar superscripts are not significantly different.

Table 4 **Sensory Evaluation Result for Samples Made of Dehulled Cowpea Products**

Parameter	304 (control)	204 100% D	404 25% D	504 50% D	SED	Sig. Level
Colour	5.17^{b}	5.74^{a}	5.49^{ab}	5.46^{ab}	0.20	***
Taste	5.57^{a}	4.59^{b}	4.68^{b}	4.53^{b}	0.25	***
Texture	4.89	5.26	5.26	4.99	0.22	NS
Aroma	5.72^{a}	5.40^{ab}	5.13^{b}	5.36^{ab}	0.21	***
Attractiveness	5.51	5.86	5.65	5.61	0.20	NS
Acceptability	5.95^{a}	5.51^{ab}	5.33^{b}	5.25^{b}	0.22	***

NS: Not Significant, *** = (P < 0.05), SED = Standard Errors of Differences
Means in a row with different superscripts are significantly different.

Table 5 **Costs of Producing Quiche Lorraine (control) and *Kum-Allory* Products**

	Quiche Lorraine (control) Cost of Production		*Kum-Allory* Cost of production	
Items	**Quantity**	**GhȻ**	**Quantity**	**GhȻ**
Wheat flour cowpea flour (kg)	1	15.0	1	9
Shortening (g)	450	7.0	-	-
Chicken (g)	500	22.5	200	9
Vegetables (g)	250	25.0	100	10
Eggs (each)	8	8.0	5	5
Custard or stock (ml)	500	5.5	30	5
Spices (g)	30	7.5	20	5
Fuel/ power	-	6.0	-	6
Other cost		20.0		20
Total cost		**116.5 GhȻ**		**69 GhȻ**
Net Weight finished product (kg)		1.630		1.835
Cost GhȻ per Kg.	**116.50/1.630 =**	**71.50**	**69/1.835 =**	**37.60**

Source: Field data, 2017. ($1 US = 5.00 Gh Cedis). GhȻ is The Ghanaian cedi is the unit of currency of Ghana.

Discussion

Physical characteristics of *Kum-Allory* products

It can be realised from Figure 1 that the shape and appearance of the products were similar to the control products. The UCF samples appeared and felt like it was a cup cake, because particle cohesion was weaker than for the other samples. This might have influenced panellists' preference for such products. This appearance was due to its foaming ability when whipped at appropriate viscosity, in a similar way as cake products do. Several studies have reported that the functional properties of cowpea give its products the attractive round shape, golden brown crust and spongy texture (Hung, & Kaveh, 1988; Okaka & Potter, 1979). Dehulling of the grains is reported to result in refined cotyledons with products exhibiting good appearance, texture, and cooking qualities (Singh, 2016).

The control products appeared gummy and dumpy when broken, but the cowpea based products patted spongy and crumby like cake touch. The particle cohesion of the 100% cowpea products were relatively weaker due to lower particle cohesion, and this made them quite delicate, compared to the other products.

Proximate composition of products

The moisture content of the cowpea products ranged between 48.36 and 54.93%. The crude protein content of the *Kum-Allory* products was significantly ($P < 0.001$) higher than that of the Quiche Lorraine products. Similarly, the protein content of the products made with undehulled flours (50% and 100%) were higher than the dehulled counterparts.

Table 2 also indicates that, the ash content in the *Kum-Allory* (undehulled and dehulled) products were significantly ($P < 0.001$) higher than that of the control. Comparatively, the mean scores of the ash content in the products made with (50% and 100%) undehulled flours were higher than that of the dehulled products, except for products with 25% dehulled flour which was significantly higher ($P < 0.001$) than that of the undehulled flour products.

From Table 2, crude fibre content of the products was significantly ($P < 0.001$) higher than the mean score of the control. Comparatively, there was no significant difference ($P > 0.05$) in the mean score of the crude fibre content in the 25% undehulled and dehulled products. However, there was significant difference ($P < 0.001$) in the crude fibre content (50% and100%) of the undehulled and dehulled products respectively. The results of the current study are consistent with findings of Olayiwola et al. (2013) who reported a significantly ($P < 0.05$) higher contents of crude fibre of cowpea flour (10.79%, 10.56% and 10.36%) for all recipes compared with the control recipe (100% cocoyam flour).

Table 2 also revealed that the mean score of the fat content in the control product reduced significantly ($P < 0.001$) from 17.5% to 3.2% in the cowpea based products. Excessive intake of dietary saturated fats has been associated with the development of hypertension, cardio-vascular diseases, obesity, cancers of the colon, breast and prostate (Bruhn et al., 1992; Jiménez-Colmenero et al., 2001). It is observed in the same table that carbohydrate content of the cowpea-based products was significantly ($P < 0.001$) higher than that of the control. However, the carbohydrate content increased significantly in the 25% and 50%, but reduced in the 100% products respectively. This result suggests that carbohydrate content in the cowpea products decreased with an increase in inclusion rates of the cowpea flour. The calcium content of the cowpea-based products was significantly ($P < 0.01$) lower than that of the control products. Comparatively, there was significant difference ($P < 0.01$) in the levels of calcium content of 25%, 50% and 100% undehulled products. Similar observations were made in the dehulled products. This result suggests that calcium content in cowpea products fluctuates with an increase in an inclusion of cowpea flour.

Sensory evaluation

The results of the sensory evaluation of the undehulled cowpea products, are presented in Table 3. It was realised that the colour liking was significantly ($P < 0.001$) lower in *Kum-Allory* than the Quiche Lorraine products. The taste, aroma, texture, flavour, attractiveness and acceptability ratings of the control product was significantly ($P < 0.001$) higher than the experimental products. These differences could be explained by the lower fat content of the cowpea-based products (Table 2).

Results on the sensory evaluation of dehulled cowpea products is presented in Table 4. The mean scores ranged from 4.53 to 5.95. Among these samples, sample 504 had the lowest sensory value ranged (4.53-5.61) while the highest sensory value was reported in the sample 304, similar to the control sample (4.89–5.95). The results indicated that there are significant ($P < 0.05$) differences in the colour, taste, aroma and acceptability, whilst it was observed that there is no significant ($P > 0.05$) difference in texture and other parameters of the dehulled cowpea samples. The similarity in the rating of the products is an indication that the products were similar in appearance and taste, and therefore, when such products are in the market, consumers would not select against them.

Costs of producing Quiche Lorraine and *Kum-Allory* products

The costs of producing the products are presented in Table 5. It is obvious from the results that the cowpea-based product is much cheaper, compared to the control products. The total cost of producing about 1.835 kg of *Kum-Allory* was GhȻ 69.00, whiles that of producing 1.630 kg of Quiche Lorraine products was GhȻ 116.50. It implies that the unit cost of the new product which is GhȻ 37.6 is lesser than the per unit cost of the control (GhȻ 71.50).

Shelf-life of the new product

The new products, prepared from the flours of whole and dehulled cowpea have a short shelf life outside the refrigerator. It is therefore concluded that the product cannot stay outside the refrigerator for more than 24 hours (280°C), but could stay for a week under refrigerated (4°C) condition.

Conclusions and Recommendations

From the result obtained, it can be concluded that wheat flour can successfully be substituted with 100% cowpea flour snack products without adverse effects on acceptability, but with reduced costs, up to about 47% in the cowpea-based products. Also, cowpea-based products had higher yields during production, thus higher quantities of batter were obtained, compared with the wheat flour products which will result in high profit. Above all, the cowpea-based products were higher in crude protein, with lower fat contents, hence, an ideal product for diabetics and cardiovascular patients.

It is recommended that consumer education on health benefits of consuming cowpea-based products, to help alleviate protein malnutrition among rural folks, especially women and children. Snack producers should adopt *Kum-Allory* product, and commercialize it for reduced production costs for improved profit margins.

Author Biographies

Patience Darko *holds a Bachelor of Education in Home Economics (Food and Nutrition) from University of Education, Winneba. Ms Darko has taught for the past 15 years and is currently teaching at Archbishop Porter Girl's Senior High School, Takoradi. She is an MPhil student near completion and she teaches in Home Economics (Food and Nutrition) at the University of Cape Coast. Her areas of interest are Nutrition and Health Education.*

Professor Sarah Darkwa *is a professor of Food Science at the University of Cape Coast where she has taught courses in Food Science since 2000. She has been a professor for the past 22 years. Professor Darkwa served as a Head of Department of VOTEC (2010-2013) and is currently the Vice Dean of the Faculty of Science and Technology Education, University of Cape Coast, Ghana.*

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References

Akinjayeju, O., & Enude, O. T. (2002). Effects of dehulling on some properties of cowpea (vigna unguiculata walp. L.) *Flours. Italian Journal of Food Science, 14*(1).

Allen, D. J. (1983). *The pathology of tropical food legumes*. John Wiley and Sons, Chichester.

Alobo, A. P. (1999). Production and organoleptic assessment of akara from bambara groundnut (Voandzeia subterranea (L.) Thouars). *Plant Foods for Human Nutrition (Formerly Qualitas Plantarum), 53*(4), 313-320.

Amedahe, F. K. (2002). Fundamentals of educational research methods. *Mimeograph, UCC, Cape Coast*.

Anderson, J. W., Story, L., Sieling, B., Chen, W. J., Petro, M. S., & Story, J. (1984). Hypocholesterolemic effects of oat-bran or bean intake for hypercholesterolemic men. *The American Journal of Clinical Nutrition, 40*(6), 1146-1155.

AOAC. (2004). *Official methods of chemical analysis of the Association of Official Analytical Chemists*. AOAC.

Appiah, F., Asibuo, J. Y., & Kuma, P. (2012). Physicochemical and functional properties of bean flours of three cowpeas (Vigna unguiculata L. Walp) varieties in Ghana. *African Journal of Food Science 5*(2),100-104

Bazzano, L., He, J., & Ogden, L. (2001). Legume consumption and risk of coronary heart disease in US men and women. NHANES I Epidemiologic Follow-up Study. *Archives of Internal Medicine, 161*(21), 2573-2578.

Boukar, O., Massawe, F., Muranaka, S., Franco, J., Maziya-Dixon, B., & Fatokun, C. (2010, September). Evaluation of cowpea germplasm lines for minerals and protein content in grains. In *World Cowpea Research Conference: Improving Livelihoods in the Cowpea Value Chain through Advancement in Science*.

Boye, J., Zare, F., & Pletch, A. (2010). Pulse proteins: Processing, characterization, functional properties and applications in food and feed. *Food Research International*, *43*(2), 414-431.

Bruhn, S. L., Pil, P. M., Essigmann, J. M., Housman, D. E., & Lippard, S. J. (1992). Isolation and characterization of human cDNA clones encoding a high mobility group box protein that recognizes structural distortions to DNA caused by binding of the anticancer agent cisplatin. *Proceedings of the National Academy of Sciences, 89*(6), 2307-2311.

Dollar, D., & Kraay, A. (2001). *Growth is good for the Poor*. The World Bank.

Dolvo, E. F., Williams, C. E., & Zoaka, L. (1975). Cowpeas. Home preparation and use in W. Africa. *International Development Research Centre, IDRC-055e, Ottawa.*

Dugje, I. Y., Omoigui, L. O., Ekeleme F., Kamara, A. Y. & Ajeigbe, H. (2009). *Farmer's guide to cowpea production in West Africa*. International Institute of Tropical Agriculture (IITA).

Edema, M. O., Sanni, L. O., & Sanni, A. I. (2005). Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. *African Journal of Biotechnology*, *4*(9).

Egounlety, M., & Aworh, O. C. (2003). Effect of soaking, dehulling, cooking and fermentation with rhizopus oligosporus on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (Glycine max merr.), cowpea (Vigna unguiculata l. walp) and groundbean (Macrotyloma geocarpa harms). *Journal of Food Engineering, 56*(2-3), 249

Fasoyiro, S., Yudi, W., & Taiwo, K. (2012). Processing and utilization of legumes in the tropics. In Ayman Amer Eissa (Ed.), *Trends in vital food and control engineering*. ISBN: 978-953-51-0449-0

Haddad, L., Alderman, H., Appleton, S., Song, L., & Yohannes, Y. (2003). Reducing child malnutrition: How far does income growth take us? *The World Bank Economic Review, 17*(1), 107-131.

Hall, A. E. (2004). Breeding for adaptation to drought and heat in cowpea. *European Journal of Agronomy*, *21*(4), 447-454.

Hall, A. E., Ismail, A. M., Ehlers, J. D., Marfo, K. O., Cisse, N., Thiaw, S., & Close, T. J. (2002). Breeding cowpea for tolerance to temperature extremes and adaptation to drought. In C. A. Fatokun, S. A. Tarawali, B. B. Singh, P. M. Kormawa, & M. Tamò (Eds.) *Challenges and Opportunities for Enhancing Sustainable Cowpea Production. International Institute of Tropical Agriculture* (pp. 14-21).

Howarth, N. C., Saltzman, E., & Roberts, S. B. (2001). Dietary fiber and weight regulation. *Nutrition Reviews, 59*(5), 129-139.

Hung, H., & Kaveh, M. (1988). Focussing matrices for coherent signal-subspace processing. IEEE *Transactions on Acoustics, Speech, and Signal Processing, 36*(8), 1272-1281.

Jiménez-Colmenero, F., Carballo, J., & Cofrades, S. (2001). Healthier meat and meat products: their role as functional foods. M*eat science, 59*(1), 5-13.

Jones, L. V., Peryam, D. R., & Thurstone, L. L. (1955). Development of a scale for measuring soldiers' food preferences. *Food Research, 20*, 512-520.

Kitch, L. W., Boukar, O., & Murdock, L. (1998). *Farmer Acceptability Criteria in Breeding Cowpea*. Cambridge University Press, (pp. 24-31).

Langyintuo, A. S., Lowenberg-DeBoer, J., Faye, M., Lambert, D., Ibro, G., Moussa, B., Kergna, A., Kushwaha, S., Musa, S., & Ntoukam, G. (2003). Cowpea supply and demand in West and Central Africa. *Field Crops Research, 82*, 215-231.

Meilgaard, M., Civille, G. V., & Carr, B. T. (1999). Attribute Difference Tests. In Sensor Evaluation Techniques, 3rd Edition, CRC Press, Boca Raton, Florida. 119pp.

Ministry of Food and Agriculture. (2011). *Statistics, Research and Information Directorate*. MOFA & SRID.

Nilufer, D., Boyacioglu, D., & Vodovotz, Y. (2008). Functionality of soymilk powder and its components in fresh soy bread. *Journal of Food Science, 73*, 275– 81.

Okaka, J. C., & Potter, N. N. (1979). Physicochemical and functional properties of cowpea powders processed to reduce beany flavour. *Journal of Food Science, 44,* 1235-1240

Olayiwola, I., Folaranmi, F., Adebowale, A. R. A., Oluseye, O., Ajoke, S., & Wasiu, A. (2013). Chemical, mineral composition, and sensory acceptability of cocoyam-based recipes enriched with cowpea flour. *Food Science & Nutrition, 1*(3), 228-234.

Phillips, R. D., McWatters, K. H., Chinannan, M. S., Hung, Y., Beuchat, L. R., Sefa-Dedeh, S., Saki-Dawson, E., Ngoddy, P., Nnanyelugo, D., Enwere, J., Komey, N. S., Liu, K., Mensa-Wilmot, Y., Nnanna, I., Okeke, C., Prinyawiwatkul, W., & Saalia, F. K. (2003). Utilization of cowpeas for human food. *Field Crops Research, 82*, 193–213.

Rochfort, S., & Panozzo, J. (2007). Phytochemicals for Health, the Role of Pulses. *Journal of Agricultural and Food Chemistry, 55*, 7981-799.

Sanginga, N., Dashiell, K., Diels, J., Vanlauwe, B., Lyasse, O., Carsky, R. J., Tarawali, S., Asafo-Adjei, B., Menkir, A., Schulz, S., Singh, B. B., Chikoye, D., Keatinge, D., & Rodomiro, O. (2003). Sustainable resource management coupled to resilient germplasm to provide new intensive cereal-grain legume livestock systems in the dry savanna. *Agriculture, Ecosystems and Environment, 100*, 305–314.

Seibel, W. (2011). Future of flours—composite flours. www.muehlenchemie.de/ downloads-future-of-flours/fof_kap_16.pdf

Singh, B. B. (2002). Recent genetic studies in cowpea. In: Challenges and Opportunities for Enhancing Sustainable Cowpea Production. Fatokun, C. A., Tarawali, S. A., Singh, B. B., Kormawa, P.M., & Tamo, M. (Eds.), *International Institute of Tropical Agriculture,* (pp. 3–13).

Singh, R. J. (2016). *Plant cytogenetics*. CRC press.

Taiwo, K. A. (1998). The Potential of Cowpea as Human Food in Nigeria. *Technovation,18*,469-481. http://dx.doi.org/10.1016/S0166-4972(98)00015-7

Timko, M. P., Ehlers, J. D., & Roberts, P. A. (2007). Cowpea. In C. Kole (Ed.), *Pulses, sugar and tuber crops* (pp. 49-67). Physica-Verlag.

Uebersax, M. A., Ruengsakulrach, S., & Occena, L. G. (1991). Strategies and procedures for processing dry bean. *Food technology* (USA).

Vittadini, E., & Vodovotz, Y. (2003). Changes in the physicochemical properties of wheat-and soy-containing breads during storage as studied by thermal analyses. *Journal of Food Science, 68*(6), 2022-2027.

Winham, D., & Hutchins, A. (2007). Baked bean consumption reduces serum cholesterol in hypercholesterolemic adults. *Nutrition Research*, *27*(7), 380-386.