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Preparation and characterization of *akara* and *senke* cakes made from cowpea flour paste

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Abstract

Despite commercial acceptability as diets in some West African and South American households, the bulk of the world's population does not consider akara and senke to be foods due to a lack of scientific proof demonstrating their intrinsic benefits and formulation processes. The focus of this study, therefore, was to prepare and characterize *akara* and *senke* developed from dehulled (DH) and undehulled (UDH) cowpea. Sample A (100% DH), Sample B (100% UDH), Sample C (25% UDH: 75% DH), Sample D (75% UDH:25% DH), Sample E (50% UDH:50% DH). Analysis was carried out using standard methods. Results showed that samples E and A had the highest and lowest values for oil absorption capacity (OAC), water absorption capacity (WAC), and loose-packed density (LBD), respectively. Protein (17.40%), carbohydrate (42.33%), and energy (541.72 kcal/g) were the highest for samples A, D, and C, respectively. The fat content (14.44%) was the lowest in sample D, while sample B had the lowest ash content (3.18%). While sample C had the highest *L* value (50.94), *a* (13.14) and *b* (-6.13) were the lowest in sample A. The sensory qualities showed that *senke* made from Sample E had the highest ratings (except for color) in all the sensory parameters. The average overall acceptability was 7.13, and statistical analysis revealed no significant ($p<0.05$) differences among the samples. Formulation of dehulled and undehulled cowpea flour paste as cakes has intrinsic nutritional benefits and their consumption should be encouraged globally.

Keywords: *Akara; color, cowpea; flour, formulation, particle density; proteins; senke*

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1. Introduction

Legumes, a family of "*Leguminosae*", consist of oil-containing seeds such as soybeans, peanuts, alfalfa, clover, mesquite, and pulses, including the edible grains, lentils, peas, and faba beans, amongst many other seeds (Annor, Ma, & Boye, 2014). Legumes have a special place in the human diet because they contain twice the protein of cereals (Carbonaro, & Nucara, 2022; Thompson, & Brick, 2016). Cowpeas (*Vigna unguiculate*), for instance, are highly nutritious legumes that provide much-needed protein, fiber, and B-vitamins to the diet, along with other nutrients such as calcium, magnesium, iron, potassium, phosphorus, and zinc (Polak, Phillips, & Campbell, 2015). The majority of the world's cowpeas (>90%) are grown in Sub-Saharan Africa, with West Africa accounting for the majority (83%) of the crop (Abdul Rahman, Larbi, Kotu, Marthy Tetteh, & Hoeschle-Zeledon, 2018). The cultivation of cowpea is predominant in many

West African countries (e.g., Benin, Burkina Faso, Cameroon, Nigeria, etc.). As a result, cowpea is a major food crop, and its cultivation offers West Africa a way to alleviate food poverty (Anago, Agbangba, Oussou, Dagbenonbakin, & Amadji, 2021). Several scholars have attested to the health-promoting benefits of pulses. Epidemiological reports affirmed that consumption of cowpea, for instance, guards against the development of various chronic diseases, especially gastrointestinal problems (Trehan et al., 2015), cardiovascular diseases, hypercholesterolemia (Jayathilake et al., 2018), obesity (Frota, Mendonça, Saldiva, Cruz, & Arêas, 2008), diabetes (Barnes, Uruakpa, & Udenigwe, 2015), and several forms of cancer (Khalid, & Elharadallou, 2013). Because of these outstanding research findings and their high nutritional value, pulses are highly craved as a component part of diets. Cowpeas are eaten daily in foods like soups, *moin-moin* (steamed cowpea paste) and *akara* (fried cowpea paste), among some natives of the Western region of Nigeria.

Akara (bean cake) is a traditional indigenous food consumed by many ethnic groups in Nigeria and other West African countries, as well as in some parts of South America (e.g., Brazil) (Ogundele, Ojubanire, & Bamidele, 2014; Rogério et al., 2014). They are made from wet-milled cowpeas, which are thoroughly whipped and mixed with important ingredients like pepper, salt, and onion to improve the digestibility and nutrients of the cowpea (Mofoluke, Ramota, Adeoye, Toyin, & Olusegun, 2013). Other essential but optional ingredients, such as fish or crayfish are added to induce aroma. *Akara* can be taken with carbohydrate-based foods such as garri, bread, and solid pap (Hussein, Ilesanmi, Aliyu, & Akogwu, 2020). It is worth mentioning that *Akara* can be made from different varieties of cowpea (Mbofung, Rigby, & Waldron, 1999; McWatters et al., 2001; Rogério et al., 2014). *Akara* plays a significant role in the Yoruba culture, one of the ethnic in Nigeria. It is customarily served to the aged and peculiarly renowned as food in many festivities such as naming, burial, and other traditional ceremonies (Mofoluke et al., 2013; Adedokun, 2006). Despite the acceptability of *akara* among some natives, it is however reported that many parameters influence the quality of fineness of *akara*. According to Linus-Chibuezeh and colleagues, evidence from their study showed that sieve aperture significantly influenced all the sensory parameters tested but significantly different in terms of overall acceptability (Linus-Chibuezeh, Okoye-Okeke, Adindu-Linus, & Iwe, 2021). Some scholars have also reported the effects of drying on color, texture, and sensory analysis of deep-fried balls (Bermudez, Paternina, & Hernandez, 2018; Hussein et al., 2020) whereas optimization of process conditions was emphasized in some few reports (Ibiwumi, Oluranti, & Olanrewaju, 2021).

Senke, a traditional meal in Nigeria, is prepared by either homogenizing a slurry of dehulled and undehulled cowpeas or by milling undehulled cowpea flour into a paste, which is then deep-fried in vegetable or palm oil. *Senke* can be eaten as a meal with pap, garri, and solid pap, much like its counterpart (*akara*) (Mofoluke et al., 2013). However, *senke* has not gained much commercial acceptance when compared with *akara* probably because of setbacks associated with its cooking procedures. Although the processing techniques of *akara* and *senke* are almost similar, several parameters such as reheating time, initial cooking time, and oil temperature dictate the acceptability of the end-product. According to Tan and colleagues in the study of the frying conditions of *akara*, the authors evidenced that the first cooking time should be greater than 50 seconds in the making of an acceptable *akara* while the optimized temperature should be within the range of 152-180 °C at a 75-minute initial cooking time (ICT) and 50 minutes reheating time (RT) (Tan, Hung, & McWatters, 1995). Nonetheless, Singh and co-workers affirmed that the particle size distribution of cowpea flour prior to making an *akara* sample also affects the quality of *akara*. The scholars indicated a reduction in the range of viscosity (48.2-54.2% of blended cowpea flour paste). Outstanding findings have been reported on the effect of holding time and milling method on the qualities of *akara* prepared from cowpea paste (Hung, & McWatters, 1990; Kethireddipalli, Hung, Mcwatters, & Phillips, 2002). Findings from past studies agreed that acceptable akara could be produced from cowpea flour provided the structure, particle size distribution (0.180-0.425 mm), and presence of the cell wall of the cowpea flour were taken into consideration during milling (Singh, Hung, Phillips, Chinnan, & McWatters, 2004; Vanchina, Chinnan, & McWatters, 2006). In parallel, only a few studies are present on the evaluation of inherent benefits of *Senke* (Dania, Oladebeye, Adejumo, & Olukoya, 2021), although existing studies reveal their potential when utilized as a substitute for wheat flour in the preparation of snacks (Darkwa, Teye, & Darko, 2021). The study of some researchers also provided an insight into *senke* nutritional benefits. Akinjayeju, and Bisiriyu (2004) observed that undehulled cowpea paste used in the preparation of "*moin-moin*" had a higher ash content than undehulled cowpea paste. The authors further observed that dehulling, on the other hand, changed some of the flours' amylograph pasting characteristics, such as maximum viscosity, consistency, and setback values (Akinjayeju, & Bisiriyu, 2004). The production process of *akara* has been simplified through improved techniques, one of which is the partial or complete replacement of the undehulled and dehulled cowpea flour for paste preparation.

Food processing, in a broad sense, refers to the transformation of raw food products to improve palatability, storability, preservation, and other human necessities. Food processing techniques aim to improve the properties and reveal the inherent chemical and physical compositions of foods, thereby expanding their applications for a variety of purposes. In general, recipes or food formulas, like food products, date back centuries. A formula or food formulation, which was previously only a list of ingredients, is now a set of instructions for preparing a specific product. Therefore, in order to elaborate food preparations, a precise register of all the ingredients, their proportions, and the sequence of operation is required since adequate nutrition is crucial to the maintenance of health at a high functional level (Botelho et al., 2018; Sadovoy et al., 2012). Regardless of the location of production, whether domestic or industrial, empirical or scientific understanding, the basic principle of processing or the culinary technique is essential for producing good products (Botelho et al., 2018). As a result, basic recipes for many foods and beverages, whether alcoholic or not, are now available to the public. Sensory characteristics were enhanced to improve product acceptance. The quantities of the ingredients were not accurately standardized. A plethora of reports outstandingly focused on characteristics such as swelling capacity, water and oil absorption capacities, density, emulsion, amongst many other appealing parameters to sidestep this setback. In addition, the color of flour, hydration qualities, cold and post-heating rheology, and gelling capabilities have all been investigated. In the assessment of the intrinsic properties of bread flour under cold and heating conditions, Fernandez and colleagues observed that bread flours have higher water-holding capacity (WHC) and water-binding capacity (WBC) values, as well as higher elastic modulus (G') and viscous modulus (G") values than wheat flours (Fernández-Peláez, Guerra, Gallego, & Gomez, 2021). In the report of Appiah and co-workers, the intrinsic evaluation of cowpea flour revealed that moisture, crude protein, crude fat, crude fiber, ash, carbohydrate, and dry matter were 9.15-9.83%, 26.53-29.00%, 2.50-3.99%, 2.95-3.22%, 4.24-4.80%, 50.95-53.98%, and 90.17-90.85%, respectively. Further analysis, according to the authors, revealed that the bulk density, water absorption capacity, and oil absorption capacity ranged between 0.69-0.80 g/cm^3, 1.89-2.15 ml/g, and 1.95 and 2.31 ml/g, respectively (Appiah, Asibuo, & Patrick, 2011). Apparently, milled products are most likely to have various qualities, resulting in different health advantages and probably some setbacks, which might limit their applicability (Hemdane et al., 2016). At present, a huge number of reports are available on the intrinsic characteristics of cowpea flour prior to its use in further processing. Nonetheless, little or no studies have emphasized the inherent benefits of the developed or formulated products from cowpea paste.

2. Objectives

The goal of this study is to examine the functional properties, proximate composition, energy content, color characteristics, and sensory attributes of *akara* and *senke* prepared from cowpea flour paste.

3. Materials and methods

3.1 Raw materials

Cowpeas were purchased at a local market in the Ilorin metropolis in Kwara State, Nigeria. The seeds were manually sorted by picking to ensure a clean grain was obtained. The samples were kept in an airtight container prior to further processing. Similarly, ingredients such as pepper and seasoning agents such as salt, onions, and Maggi were purchased from a local food vendor.

3.2 Sample preparation

The *akara* and *senke* samples were prepared in the food analysis laboratory of the Department of Home Economics and Food Science, University of llorin, Nigeria. 800 g of sorted cowpeas were washed, soaked in water for 1 h, dehulled, filtered, and wet milled. To achieve a better surface fineness of the slurry, homogenization was carried out for about 10 min. After this process, the seasoning agents and pepper were added. In the preparation of the undehulled cowpea slurry, the cowpea was soaked for about 1 h and wet-milled. The dehulled cowpea was mixed with the undehulled cowpea at different percentages to obtain three different samples (C, D, and E), while the undehulled (A) and dehulled (B) cowpea slurries served as the control. This is presented in Table 1. According to a past report, the recipes for *akara* and *senke* should be proportioned accordingly (Table 2) (Ogundele et al., 2014). However, in this study, slight modifications were made to the recipe. For the acceptability test, the *akara* and *senke* samples were submitted to sensory evaluation utilizing specified sensory qualities.

Table 1 Formulated samples of cowpea

Samples	Cowpea formulation	Common terms
A	100% dehulled cowpea	*Akara*
B	100% undehulled cowpea	*Senke*
C	25% undehulled cowpea and 75% dehulled cowpea	*Senke*
D	75% undehulled cowpea and 25% dehulled cowpea	*Senke*
E	50% undehulled cowpea and 50% dehulled cowpea	*Senke*

Table 2 Standard recipe for fried "*akara*" from cowpea blend (Ogundele et al., 2014)

Ingredients	Weight
Cowpea (dehulled or undehulled)	800 g
Onions	35 g
Pepper	40 g
Salt	1g
Palm oil	500 g
Seasoning	2g
Water	500 ml

3.3 Functional properties

3.3.1. Water absorption capacity (WAC)

According to Makanjuola and co-workers, WAC is determined based on a series of procedures. Using a mixer, 1 g of each flour sample was mixed with 10 ml of water for 30 s. The samples were then allowed to coagulate at room temperature for about 30 min. The supernatant was measured after this process, and the mass of water absorbed was calculated and expressed as percentages (Makanjuola, Ogunmodede, Makanjuola, & Awonorin, 2012).

3.3.2 Oil absorption (OAC)

10 ml of soybean oil and 1 g of the sample were combined in a container after being weighed. It was left for 30 min at 30 °C ambient temperature. For 15 minutes, the mixture was centrifuged at 3500–4000 rpm. The tube was reweighed after the supernatant was discarded. The grain's bulk is measured by its ability to absorb oil. A comparable process has been described in other publications (Kim, & Shin, 2022).

3.3.3 Bulk density

A 25 ml graduated cylinder containing 10 g of the sample was filled with it, and 30 mild touches were made on the bench top from a height of 5 cm to pack the cylinder. The bulk density is defined as the sample's weight per milliliter of sample volume (g/ml) (Amidon, Meyer, & Mudie, 2017).

3.4 Proximate composition

Standard procedure (AOAC, 2005) was used in determining the proximate composition. They are further explained in the following sub-sections.

3.4.1 Carbohydrate

By using a difference in accordance, the carbohydrate content was determined (AOAC, 2005). Monosaccharides, disaccharides, and polysaccharides are all components of carbohydrates. In nature, polysaccharides account for 90% of all carbs. For the qualitative color test, paper chromatography was employed, and the (Cu) test was performed to reveal the sample's varied carbohydrate compositions.

3.4.2 Moisture content (MC)

The moisture content was determined by measuring the weight of the samples before and after drying. Then MC was expressed using the formula below.

$$\%\text{MC}=\frac{\text{weight of dried sample}}{\text{weight of wet sample}}\ \text{X}\ 100$$

3.4.3 Crude protein

The Kjeldahl method was used to calculate the protein content. Two tablets of selenium catalyst and

12 mL of concentrated H_2SO_4 were put into a Kjeldahl digestion flask holding 1g of the material. For 45 minutes, the flask was initialized in the digester inside a fume cupboard to produce a clear, colorless solution. Boric acid, at 4%, was distilled into the digest. Up until the distillation was finished, a 20% sodium hydroxide solution was metered into the distillate. After that, 0.1-mol/HCL was added and the distillate was titrated until a violet color appeared, signifying the end point. The same processes used for the sample and the blank were carried out.

$$\frac{\text{(titre value of sample)-blank*0.01*14.007*6.25*100}}{\text{1000*weight of sample}}$$

3.4.4 Ash content

For the ash content determination, a muffle furnace is used, capable of maintaining temperatures of 500-600 °C. Water and volatiles are vaporized, and the sample is burned in the presence of oxygen in the air CO_2, and oxides of N_2.

$$\text{\%Ash (dry basis)} = \frac{\text{weight after burning-tare weight of crucible}}{\text{weight of original sample * dry matter coefficient}}$$

3.4.5 Fat content

The fat content was determined by organic solvent extraction. In this process, the sample is dissolved in a beaker, the weight of the beaker from the solution. The resulting weight is the fat sample.

$$\text{Weight of fat sample} = \text{(beaker + fat)} - \text{beaker}$$

$$\text{\% Fat on dry weight basis} = \frac{\text{weight of fat sample * 100}}{\text{weight of dried sample}}$$

3.5 Energy estimation

This was obtained based on the calculation of the conversion of protein, fat, and carbohydrate content into calorie units (Hartati, & Royanda, 2021).

3.6 Color test

Using a UV-visible recording Minolta Spectrophotometer Chroma Meter-3500d and the AC4806 Spectro Minolta CM-3500d software, color measurements in the CIELAB space were measured. After being removed from the zip lock nylon, the external color of the snack samples was measured and placed on a white sheet. A white tube constructed of barium sulphate that is utilized as a flawless white object and is 100% white makes up the standard. According to A. K. R. Choudhury (2014), the colorimeter uses the CIELAB color space, where 0 is black, 100 is white, positive values for the a (red-green) axis are red, negative values are green, and 0 is neutral. Positive values for the b (yellow-blue) axis are yellow, negative values are blue, and 0 is neutral. The color determination was carried out in duplicates.

3.7 Sensory evaluation

The *akara* and *senke* were evaluated for color, taste, texture, aroma, and overall acceptability according to the 9-point hedonic scale. Thirty (30) respondents from the Home Economics and Food Science Department, University of Ilorin, were made to assess the samples. The *akara* and *senke* were served on labelled plates and the panelists rated the *akara a*nd *senke*. The evaluation was carried out using the nine-point hedonic scale where 9=like extremely, 8= like very much, 7= like slightly, 6= like moderately, 5= neither like nor dislike, 4= dislike moderately, 3= dislike slightly, 2 = dislike very much, 1= dislike extremely.

3.8 Statistical analysis

All the experiments were carried out in duplicates. The data were analyzed using Statistical Package for Social Sciences (SPSS) version 24 software. A descriptive statistic was used to interpret the results obtained. Comparisons between sample treatment and the indices were done using analysis of variance (ANOVA) with a at a confidence interval of 95% ($p \leq 0.05$).

4. Results and discussion

4.1 Functional properties of cowpea composite flour

The functional properties of cowpea composite flour evaluated include water absorption capacity (WAC), oil absorption capacity (OAC), loose bulk density (LBD), and packed bulk density (PBD) (Table 1). WAC of flour is important in food preparation processes because it is linked to other functional and sensory properties. WAC denotes the volume of water required to create gruels of suitable consistency, such as those used for infant feeding (Kambabazi et al., 2022). The WAC of the composite flour in this study ranged between 1.02 - 2.52 g water/g flour (Table 3). This is in line with the WAC (1.6-2.53 g/ml) reported for treated and untreated cowpea flour in other experiment (Ilesanmi, & Gungula, 2016). Nonetheless, the WACs of most legume flours ranged from 1.12 g/g to 1.89 g/g (Du, Jiang, Yu, & Jane, 2014). Sample

A had the lowest WAC, while sample E had the highest value. WAC is dependent on hydrophilic components such as starch and protein in food samples, which may vary between flour samples. Thus, differences in WAC among the flour samples may be attributed to the variation in the flour composition. The low WAC of raw cowpea flour could be attributed to the weak association of the starch biopolymers (Makinde, & Abolarin, 2020), its physical form and structure, and several anatomical and compositional factors such as thickness, hilium size and coating characteristics of the seed (McWatters, Resurreccion, Fletcher, Peisher, & Andress, 1993). Importantly, the amylose and amylopectin of most starchy flours impart their characteristics and uniquely position them for a wide range of applications (Falua et al., 2022). Previous studies reported that the WAC of flours is associated with high starch or protein contents (Aidoo, Oduro, Agbenorhevi, Ellis, & Pepra-Ameyaw, 2022; Awuchi, Igwe, & Echeta, 2019; Falade, & Oyeyinka, 2015). It may be assumed that the pretreatment process and modification technique on cowpea do not affect their water absorption capacity. However, this statement may not be generally true for all treatment processes. The condition of the seed used influences their water absorption capacity, as Liu and colleagues demonstrated that heat-moisture treatment of germinated mung bean flour positively affected not only water absorption but also the textural properties and cooking loss of the noodles developed (Liu et al., 2018). Similarly, in the evaluation of WAC (%) of different flours, it was reported that potato flour had the highest value (752±21.68) compared with other flour sources such as wheat (140±12.25), rice (192±10.95), and green gram flour (196±11.40) (Chandra, 2013). Volume fraction of particles, protein quality, and water-loving components (e.g., polysaccharides) also influence the water absorption capacity of flour (Du et al., 2014; Sapirstein et al., 2018).

The OAC content of legume flour is critical for improving mouth texture and retaining the flavor of foods (Iwe et al., 2016). Capillarity interaction is used in the oil absorbing mechanism, which allows the absorbed oil to be retained. According to Dui and co-workers, the hydrophobic proteins in flour are essential for oil absorption (Du et al., 2014). The OAC of the composite flour samples ranged from 4.01 to 4.71 g oil/ g flour (Table 1). There were significant ($p<0.05$) differences in the OAC of the flour samples. The flour mixtures of sample E flour had the highest OAC, while sample A flour had the lowest OAC. The reason for the variation in OAC is unclear. However, it appears that the presence of the hull contributes to the increased OAC of the flour. OAC represents the emulsifying ability of food and is considered an important functional property in food ingredients. According to the findings of Moutaleb, Amadou, Amza, and Zhang (2017), cowpea flour paste that was enhanced with sweet potato had an oil absorption capacity range between 1.67 - 2.04g/g (Moutaleb et al., 2017). The value recorded in this study is also higher than those obtained for oil absorption capacity (0.93 g/g -1.38 g/g) of ten different legumes (Du et al., 2014). The main chemical components of this product that improve its ability to absorb water are the proteins and carbohydrates derived from cowpeas (Hamid, Muzaffar, Wani, Masoodi, & Bhat, 2016; Wani, Sogi, Wani, & Gill, 2013). Similar to this, it has been claimed that a decrease in the crystalline structure of starch and an increase in amylose leaching and solubility can be linked to an increase in water adsorption capacity (Kaushal, Kumar, & Sharma, 2012). Furthermore, Kinsella and Melachouris stressed the role of hydrophobic proteins in most legume flours and posited that they essentially demonstrate a superior binding of lipids (Kinsella, & Melachouris, 1976). Therefore, legume flours with higher OAC contain a high amount of available non-polar side chains in their protein molecules (Du et al., 2014).

The bulk density of flour, especially legume-derived, is crucial in the formulation of weaning foods. As previously reported, lowering the bulk density of the flour is probably beneficial to the formulation of weanling food (Milán-Carrillo et al., 2000). The packed bulk density (PBD) of the composite flours was significantly higher than their LBD counterpart (Table 1). Sample A had the lowest value of LBD, while sample E flour had the lowest PBD. Akubor and colleagues obtained a packed bulk density was between 0.57 g/mL – 0.64 g/mL for cowpea and plantain flour blends (Akubor et al., 2003), a value that is lower when compared with PBD in this study. Notwithstanding, a much higher range of values was reported for loose bulk density (0.64 – 0.73 g/mL) and packed bulk density (0.84 – 0.94 g/mL) for dehulled cowpea flour (Makinde, & Abolarin, 2020). Previous research reported that high LBD and PBD indicate greater compactness of particles and indicates that such samples will require a more economical package (Falade, & Oyeyinka, 2014). Increased bulk density increases the sinkability and dispersibility of powdered particles (Ekwu et al., 2005). In addition, higher bulk density lowers the paste thickness of cowpea flour, and the better ease of dispensability of cowpea flour paste makes higher bulk density desirable. This observation is in consonance with research carried out on the physicochemical and functional characteristics of three varieties of cowpea in Ghana (Appiah et al., 2011). In the present study, the PBD were significantly different.

Table 3 Functional properties of *akara* and *senke* from cowpea flour

Samples	WAC (g/mL)	OAC (g/mL)	LBD (g/mL)	PBD (g/mL)
A	$1.02^{d}\pm0.02$	$4.01^{e}\pm0.01$	$0.39^{e}\pm0.07$	$0.73^{c}\pm0.01$
B	$1.22^{c}\pm0.02$	$4.23^{d}\pm0.04$	$0.51^{c}\pm0.00$	$0.77^{b}\pm0.07$
C	$1.23^{c}\pm0.04$	$4.62^{b}\pm0.02$	$0.46^{d}\pm0.00$	$0.76^{b}\pm0.07$
D	$1.32^{b}\pm0.02$	$4.42^{c}\pm0.02$	$0.53^{b}\pm0.01$	$0.79^{a}\pm0.00$
E	$2.52^{a}\pm0.57$	$4.71^{a}\pm0.01$	$0.56^{a}\pm0.00$	$0.72^{c}\pm0.01$

Values are mean±standard deviation (S.D.) of duplicate determination. Means with same superscript within same column are not significantly ($p<0.05$) different. WAC-Water absorption capacity; OAC-Oil absorption capacity; LBD-Loose bulk density; PBD-Packed bulk density.

4.2 Proximate composition

The proximate composition of the *akara* and *senke* samples is presented in Table 4. The moisture contents of the samples ranged from 21.17% to 25.73%. The moisture content of the samples was within the range of 21-26%. However, samples C, D, and E had slightly lower moisture contents, while sample B had the highest moisture content (25.73%). Mcwatters et al., (1993) reported a higher moisture content (27.64-31.64%) for *akara* prepared from undehulled cowpea compared to dehulled cowpea. Moutaleb and colleagues obtained much lower moisture content values (7.33-9.75%) in the formulation of cowpea with sweet potato (Moutaleb et al., 2017). Variation in moisture content may be attributed to different processing methods employed as well as the cowpea variety used in the respective studies (Ngoma et al., 2018; Olopade, Akingbala, Oguntunde, & Falade, 2004; Shafaei, Masoumi, & Roshan, 2016). Moisture content is a good indicator of the water content, stability, and susceptibility to microbial infection in foods (Uyoh, Ita, & Nwofia, 2013). When compared with another cake made from cowpea flour paste (*moinmoin*) with an approximately 14% moisture content (Otunola, & Afolayan, 2018), the storage stability of *akara* and *senke* in this study may be lesser.

Protein (17.40%) and fat (18.78%) contents of *akara* produced from Sample A were higher than *senke* prepared from sample B (protein: 15.25%; fat: 16.23%). Higher fat content of sample A compared with the other samples could be due to the light spongy structure of the dehulled sample, which was porous, thus accounting for greater oil absorption during frying (Thanatuksorn, Kajiwara, & Suzuki, 2009). Protein contents appears to be reduced with the increasing content (from 25% to 75% undehulled cowpea). The protein contents of the samples in this study are within the range reported for *akara* from cowpea (14.36 % -23.7%) while some scholars reported that protein content decreased from 21% to 19% of cowpea/maize flour blends as the level of maize substitution increased from 0% to 40% (Akusu, & Wordu, 2017). Furthermore, Uyoh and colleagues obtained about 27% protein content in a prepared *moinmoin* cake (Uyoh et al., 2013). This is quite higher than the protein contents of *senke* and *akara* in this study. Although cowpea seeds are reported to have high protein content (24%), processing techniques such as milling alters protein content of food products (Ertop, Bektaş, & Atasoy, 2020; Oghbaei, & Prakash, 2016).

Ash (3.18% -4.16%) and fiber (1.09% - 2.23%) contents of the samples were generally low and were significantly different from each other (Table 4). Carbohydrates calculated by difference ranged between 32.70% and 42.33% (Table 4). The carbohydrate content of Sample A was lower (32.70%) than that of Sample B (undehulled: 38.53 %) and increased in samples C, D, and E. There were significant differences in the estimated energy values, which ranged between 491.56 kcal/g and 541.72 kcal/g (Table 4). *Akara* and *Senke* samples are relatively good sources of energy when consumed in appropriate quantities.

Table 4 Proximate composition of cowpea *akara and senke*

Samples	Moisture (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)	CHO (%)	Energy (kcal/g)
A	$25.07^{b}\pm0.03$	$18.78^{b}\pm0.02$	$3.85^{c}\pm0.02$	$2.23^{a}\pm0.02$	$17.40^{a}\pm0.07$	$32.70^{e}\pm0.06$	$504.34^{b}\pm0.42$
B	$25.73^{a}\pm0.1$	$16.23^{c}\pm0.02$	$3.18^{e}\pm0.01$	$1.09^{e}\pm0.07$	$15.25^{d}\pm0.01$	$38.53^{c}\pm0.04$	$496.19^{d}\pm0.03$
C	$21.17^{e}\pm0.00$	$23.02^{a}\pm0.07$	$4.16^{a}\pm0.02$	$1.77^{b}\pm0.01$	$15.69^{c}\pm0.07$	$34.21^{d}\pm0.04$	$541.72^{a}\pm0.21$
D	$24.37^{c}\pm0.02$	$14.44^{e}\pm0.02$	$3.37^{d}\pm0.01$	$1.18^{d}\pm0.02$	$14.33^{e}\pm0.07$	$42.33^{a}\pm0.04$	$491.56^{e}\pm0.37$
E	$22.30^{d}\pm0.02$	$15.28^{d}\pm0.01$	$4.02^{b}\pm0.01$	$1.36^{c}\pm0.07$	$15.75^{b}\pm0.08$	$41.30^{b}\pm0.01$	$500.72^{c}\pm0.04$

Mean ± standard deviation of duplicate determination. Means with same superscript within same column are not significantly (p<0.05) different.

4.3. Color parameters

Color characteristics are essential in industrial applications as it directly affect the final product, acceptance, and quality (Hongbété et al., 2009). The objective data for the color of *akara* and *senke* prepared from dehulled, undehulled, and mixtures of the two are presented in Table 5. *Senke* from undehulled cowpea (Sample B) had a lower *L* value (49.09) compared with other counterparts, with a *L* range of 50.49-51.29. In this present study, the *L* value is far lower when compared with the findings of McWatters et al., (1993). The author reported a higher *L* value (67.4) for cowpea flour-based *akara*. Generally, the low *L* values may have accounted for the brownness tendency of both *akara* and *senke* samples during frying. The positive *a* value (redness) of sample A (11.29) was similarly lower than that of sample B (13.14). This indicates that sample B was lighter and displayed more redness than sample A. The higher *a* value of the samples B, C, D, and E may be associated with the increased concentration of pigments due to the presence of the seed coat, which significantly affected the appearance of the samples. The implication of the color results is that with the exception of sample A, samples B, C, D, and E, are not very different. Plahar et al., (2006) reported a *L* value range of 38.25-53.69 while *a* and *b* range were 14.94-16.33 and 24.90-35.24, respectively for *akara* prepared from non-decorticated cream cowpea (Plahar, Hung, McWatters, Phillips, & Chinnan, 2006). Also, scholars such as Plahar and colleagues observed that *akara* made from non-decorticated cream cowpeas with the same level of saponin was darker (lower *L*) and browner (lower hue angles) than *akara* made from decorticated black-eyed cowpeas (Plahar et al., 2006). The scholars further observed that the flour generated by the non-decorticated cream cowpeas was darker than the flour produced by the decorticated cream cowpeas, which could further contribute support the formation of darker *akara*. The variation in the *L* values could be attributed to the influence of processing methods and the variety of grains.

Table 5 Color parameters of *akara* and *senke* produced from dehulled and undehulled cowpea

Samples	*L*	*a*	*b*
A	$49.91^{b}\pm3.42$	$11.29^{b}\pm0.73$	$-6.13^{b}\pm4.50$
B	$49.09^{ab}\pm0.52$	$13.14^{b}\pm0.47$	$-2.44^{ab}\pm0.65$
C	$51.29^{a}\pm0.45$	$11.72^{b}\pm0.11$	$-2.62^{ab}\pm0.60$
D	$50.94^{a}\pm1.11$	$11.75^{a}\pm0.22$	$-0.35^{a}\pm1.70$
E	$50.49^{a}\pm2.49$	$11.32^{b}\pm0.43$	$-0.26^{a}\pm2.80$

Values expressed as the mean ± standard deviation. Means with the same superscript within the same column are not significantly different (P<0.05).

4.4. Sensory evaluation

The mean sensory scores of *akara* and *senke* are presented in Table 6. In general, there were no significant (p<0.05) differences among the samples for all the quality parameters assessed. The respondents considered Sample E to be more appealing in terms of color (7.13), taste (6.90), texture (6.63), aroma (6.83), and overall acceptability (7.13). The removal of the seed coat did not substantially affect the sensory properties of the samples. The results from this study is line with the findings of Akusu and Wordu (2017). However, an acceptability range of 3.96 and 4.46 was obtained for cowpea flour formulated with soybeans (Ogundele et al., 2014). The responses of the sensory panel to the quality of the samples may be attributed to the processing conditions, such as germination and dehulling, as well as the source and species of the grain.

Table 6 Mean sensory scores of akara and senke production from dehulled and undehulled cowpea

Samples	Color	Taste	Texture	Aroma	Overall
A	$6.84^{a}\pm1.19$	$6.68^{a}\pm1.25$	$6.42^{a}\pm1.39$	$6.26^{a}\pm1.46$	$6.52^{a}\pm1.29$
B	$7.13^{a}\pm1.04$	$6.70^{a}\pm1.58$	$6.60^{a}\pm1.43$	$6.77^{a}\pm1.43$	$6.97^{a}\pm1.35$
C	$6.90^{a}\pm0.94$	$6.86^{a}\pm1.33$	$6.17^{a}\pm1.67$	$6.24^{a}\pm1.38$	$6.76^{a}\pm1.27$
D	$6.70^{a}\pm1.37$	$6.87^{a}\pm1.14$	$6.33^{a}\pm1.24$	$6.30^{a}\pm1.34$	$6.76^{a}\pm1.14$
E	$7.13^{a}\pm1.14$	$6.90^{a}\pm1.21$	$6.63^{a}\pm1.25$	$6.83^{a}\pm1.23$	$7.13^{a}\pm1.07$

Values expressed as mean ± standard deviation. Means with same superscript within same column are not significantly different ($p<0.05$)

5. Conclusion

Akara and *senke* were prepared from dehulled and undehulled cowpeas, respectively. The functional properties of dehulled cowpea, undehulled cowpea, and their mixtures were significantly different. The densities (LBD and PBD) were less than 1g/cm^{3} while a value range of 1.02 to 2.52 and 4.01 to 4.71 was obtained for water and oil absorption capacities, respectively. All the proximate compositions (protein, moisture, fat, ash, moisture, and carbohydrate content) were present in the cakes. The protein and fat contents of *akara* prepared from dehulled cowpea flour paste were higher than those of the undehulled. Nonetheless, the mixture of dehulled and undehulled cowpeas in an equal ratio is more acceptable than other samples. Since the cakes made from dehulled and undehulled cowpeas have intrinsic nutritional benefits, both could be encouraged in local diets.

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