

Physico-functional and sensory properties of cowpea flour based recipes (*akara*) and enriched with sweet potato

Abstract

Cowpea and sweet potato were used for their nutritional and functional properties; thus the objective of this study was to determine the physico-functional and sensory properties of cowpea flour based recipes (*akara*) and incorporated with sweet potato. Moisture, protein, fat, ash, and carbohydrate were in the range of 7.33 to 9.75, 11.66 to 20.98, 1.51 to 3.49, 2.48 to 2.73, and 65.38 to 76.28% respectively. Water and oil absorption capacities ranged between 1.64 and 2.52 and, 1.67 and 2.04 g/g, respectively. Bulk density and water solubility ranged between 0.86 and 0.90 g/mL, and 1.19 to 2.01 g/100g respectively. Lowest swelling power was recorded for cowpea flour while the highest value was observed for the composite cowpea-sweet potato (50-50%) flour. The overall acceptability of the *akara* sensory properties was the 90-10% composite. The results indicated that the addition of sweet potato in making *akara* had significant effect on its properties

Keywords: cowpea flour, sweet potato, *akara*, functional properties, sensory evaluation

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Introduction

Cowpea (*Vigna unguiculata*) is popularly grain legume referred to as 'beans' in West Africa. It is nutritious and provides protein, vitamins, and minerals. Cowpea grain contains about 25% protein, making it extremely valuable where many people can't afford proteins from animal sources such as meat and fish.^{1,2} Cowpea flour has been used as a nutritious ingredient in fried and baked products, as well as comminuted meat products, such as chicken nuggets and meatballs.³⁻⁶ Sweet potato (*Ipomoea batatas L.*) is an important source of calories for the people of the developing nations; is the seventh most important food crop grown in around 111 countries with 80% of the world production came from China, where the roots of sweet potato are used as food or as raw material for starch and noodle manufacture.^{7,8}

Functional properties constitute the major criteria for the adoption and acceptability of proteins or starch in the food systems.^{4,9} The suitability of cowpea flour enriched with sweet potato flour as food systems of making *akara* a traditional popular West African recipe made from cowpea paste, is dependent on their functional properties, such as foaming, water and oil absorption capacities, as well as thermally induced gelling.¹⁰ The quality of various products made from cowpea flour in different parts of world which are dependent on the functionality of cowpea flour; as influenced by processing technique, cowpea variety, particle size distribution of the flour, ingredients and the hydration pattern of the flour mixture.^{2,10}

Previous research revealed the possibility of utilizing sweet potato in noodles and other wheat-based baked foods, the production of sweet potato and cowpea blend will increase their consumption for better nutritional status of all age groups and economical perspective.^{11,12} The consistency, dispensability, frying characteristics and sensory

properties of *akara* reconstituted from cowpea flour enriched with sweet potato are yet to be explored. Therefore the objective of this work was to investigate the functional properties and organoleptic taste of cowpea flour based recipes (*akara*) enriched with sweet potato.

Materials and methods

Materials

The cowpea variety TN 5-78 was obtained from a seed production company "Entreprise Semencière Alheri" (Niamey, Niger), and the sweet potato flour was purchased from local market (Wuxi, China). All other reagents were of analytical grade.

Methods

Proximate composition analysis: The proximate composition (moisture, protein, fat and ash) of the cowpea flour and composite cowpea-sweet potato flours were determined by standard method.¹³ The carbohydrate was obtained by difference (100-moisture, protein, fat and ash). All the experiment was carried out in triplicates.

Functional properties

Water absorption capacity: One gram of sample was mixed with 10 mL distilled water for 30 s. The samples were then allowed to stand at room temperature for 30 min after which they were centrifuged at 3000 rpm for 10 min. The volume of supernatant was noted in a 10 mL graduated cylinder.¹⁴

Oil absorption capacity: Sample (0.5 g) was taken and mixed with 3 mL of distilled water or refined soybean oil. The slurry was

centrifuged at 3000rpm for 5min. The pellet was drained for 30min and the gain in weight per unit weight was reported as water or oil absorption capacity (g/g).¹⁴

Bulk density: A known weight of the cowpea flour or composite cowpea-sweet potato flour was added to a graduated measuring cylinder. The cylinder was gently tapped and volume occupied by the sample was determined. Bulk density was reported as weight per unit volume (g/mL). All the experiments were performed in triplicate.

Swelling power: The swelling volume was determined as described by Mbofung & Waldron¹⁵ but with slight modifications. The cowpea or composite cowpea-sweet potato sample (1 g) was placed in a graduated cylinder and mixed with distilled water (10mL), then kept at room temperature for 24 h. The swelling volume was calculated by dividing the total volume of the swollen sample and the original dry weight of the sample.

Water solubility: Water solubility of different flours samples was determined as by slightly modifying the method of Anderson et al.¹⁶ Flour sample (2.5g) was dispersed in 30mL of distilled water, using a glass rod, and cooked at 90°C for 15min in a water bath. The cooked paste was cooled to room temperature and transferred to tared centrifuge tubes, and then centrifuged at 3000g for 10min. The supernatant was decanted for determination of its solid content into a tared evaporating dish and the sediment was weighed. The weight of dry solids was recovered by evaporating the supernatant overnight at 110°C. Water solubility was calculated as followed:

$$WS(g/100g) = \left(\frac{\text{Weight of dissolved solids in supernatant}}{\text{Weight of flour sample}} \right) \times 100$$

Wettability: The time to moisten completely 1g of the flour after it is suspended in distilled water determines the wettability of the cowpea or cowpea-sweet potato blend sample was determined by the method of Okezie & Bello.¹⁷

Sensory evaluation: The sensory panel consisted of students of the school of Food Science and Technology, Jiangnan University, Wuxi, China were used to evaluate sensory characteristics of *akara* fortified with sweet potato flour. The 9 point hedonic scale (from dislike extremely to like extremely) was used to evaluate appearance, texture, flavor and overall acceptability.

Statistical analysis: Statistical analysis of data was performed using IBM-SPSS Inc. software (version 20.0). One-way analysis of variance (ANOVA) was used to determine significant differences between means, with the significance level taken at (P<0.05). Duncan test was used to perform multiple comparisons between means.

Results and discussion

Proximate composition

Proximate composition of cowpea-sweet potato composite is presented in Table 1. Moisture content of different cowpea-sweet potato ratio was in the range of 7.33% to 9.75%. Protein and fat contents varied from 11.66–20.98% and 1.51–3.49% respectively. Ash and carbohydrate contents varied from 2.48–2.73% and 65.38–76.28% respectively. It was observed that no significant (P<0.05) differences for the moisture and ash contents. However, significant (P<0.05) variation was found in protein, fat and carbohydrate contents. Naturally, the more the potato ratio the more the carbohydrate contents, similarly the more the cowpeas ratio the more the protein contents. Similar trends were reported with the work of Iwe, van Zuilichem, Ngoddy, and Lammers¹² where proximate composition of soy flour mixt with sweet potato four contributed about 72% protein in the raw mixture, and about 71% protein in the extruded mixture. The variations in the proximate composition could be attributed to the nature of two composites one was source of protein and the other one rich in starch.

Table 1 Proximate composition of cowpea-sweet potato composite

Cowpea-sweet potato (%)	Moisture	Protein	Fat	Ash	Carbohydrate
100-0	7.33±0.62 ^a	20.98±0.09 ^f	3.49±0.06 ^f	2.68±0.36 ^a	65.38±0.20 ^a
90-10	8.19±0.56 ^a	18.97±0.24 ^a	2.55±0.06 ^e	2.71±0.33 ^a	67.53±0.06 ^b
80-20	9.11±0.26 ^a	17.62±0.23 ^d	2.37±0.07 ^d	2.52±0.03 ^a	68.40±0.03 ^c
70-30	9.75±0.37 ^a	15.76±0.08 ^c	2.06±0.08 ^c	2.73±0.35 ^a	69.76±0.07 ^d
60-40	7.88±0.99 ^a	14.17±0.04 ^b	1.83±0.07 ^b	2.48±0.02 ^a	73.65±0.01 ^a
50-50	8.04±1.41 ^a	11.66±0.06 ^a	1.51±0.03 ^a	2.50±0.07 ^a	76.28±0.01 ^f

Water and oil absorption capacity

The ability of cowpea and sweet potato flour to absorb water is an important functionality that influences the quality of *akara* product that is required different mixture ratio. However, this result showed that no significant differences (P<0.05) were found among the samples (Table 2). The major chemical compositions that enhance the water adsorption capacity of this product are cowpea source of proteins and the carbohydrates present in both cowpea and sweet potato.^{18,19} On the other hand, the functional properties of *akara* systems blend broadly depend on the water-cowpea-sweet potato interactions. It has been said that the increase in the water adsorption capacity can be associated with the increase in the amylose leaching and solubility,

and loss of starch crystalline structure.²⁰ In the other hand the lower water adsorption capacity in some flours may be due to less availability of polar amino acids in flours.² Oil absorption capacity is another important functional property of flours, since it plays an important role in enhancing the mouth feel and retaining the flavor, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorption is desired.⁴ The oil absorption capacity for the cowpea was ranged from 1.67 to 2.04 with no significant difference (P<0.05) among the different cowpea-sweet potato ratio samples (Table 2). The recipe *akara* is a product from deep oil frying making oil absorption capacity one of the fundamental function for its quality.

Table 2 Functional properties of cowpea-sweet potato composite

Cowpea-sweet potato (%)	Water absorption capacity (g/g)	Oil absorption capacity (g /g)	Bulk density (g/ mL)	Water solubility (g/100g)
100-0	1.64±0.50 ^a	1.90±0.01 ^a	0.89±0.01 ^a	2.01±0.03 ^b
90-10	2.09±0.01 ^a	1.76±0.04 ^a	0.90±0.00 ^a	1.93±0.12 ^b
80-20	2.16±0.07 ^a	1.89±0.13 ^a	0.88±0.01 ^a	1.33±0.14 ^a
70-30	2.51±0.85 ^a	2.04±0.64 ^a	0.89±0.01 ^a	1.25±0.25 ^a
60-40	2.52±0.03 ^a	1.98±0.01 ^a	0.86±0.01 ^a	1.23±0.27 ^a
50-50	2.45±0.24 ^a	1.67±0.02 ^a	0.88±0.01 ^a	1.19±0.01 ^a

Bulk density

There was a significant ($P<0.05$) difference among the cowpea flour and composite cowpea-sweet potato flours. The bulk density for different flours varied from 0.88 to 0.90 g/ml (Table 2). The addition of different percentage of sweet potato flour to cowpea flour had no significant effect on the bulk density values ($P<0.05$) (Table 2). Indeed, higher bulk density of cowpea-sweet potato flours suggest the suitability of the composite in providing bulk to akara product and it help to reduce paste thickness which is an important factor in akara making. Moreover, higher bulk density is desirable for greater ease of dispensability of cowpea-sweet potato flours. This result corroborate with the work of Appiah & Asibuo² in the research of physicochemical and functional properties of bean flours of three cowpea varieties in Ghana.

Water solubility

The water solubility is related to the presence of soluble molecules of different flours, the cowpea flour had the highest value (2.01) with significant ($P<0.05$) difference when compared with other blends (Table 2). It was observed that with an increase in the amount of sweet potato flour, the water solubility of blends decreased. The decrease in water solubility with the addition of sweet potato flour is of significance since it gives an indication that sweet potato flour addition can created a matrix whereby the amount of soluble materials such as starch and amino acids which can be easily digestible become insoluble in water. Contrary to Kaushal & Kumar et al.,²⁰ work where the increase of taro flour in the soluble components in blends. This might be due to fact that the starch in sweet potato interact with protein in cowpea to create insoluble materials that leads to decrease the water solubility Figure 1.

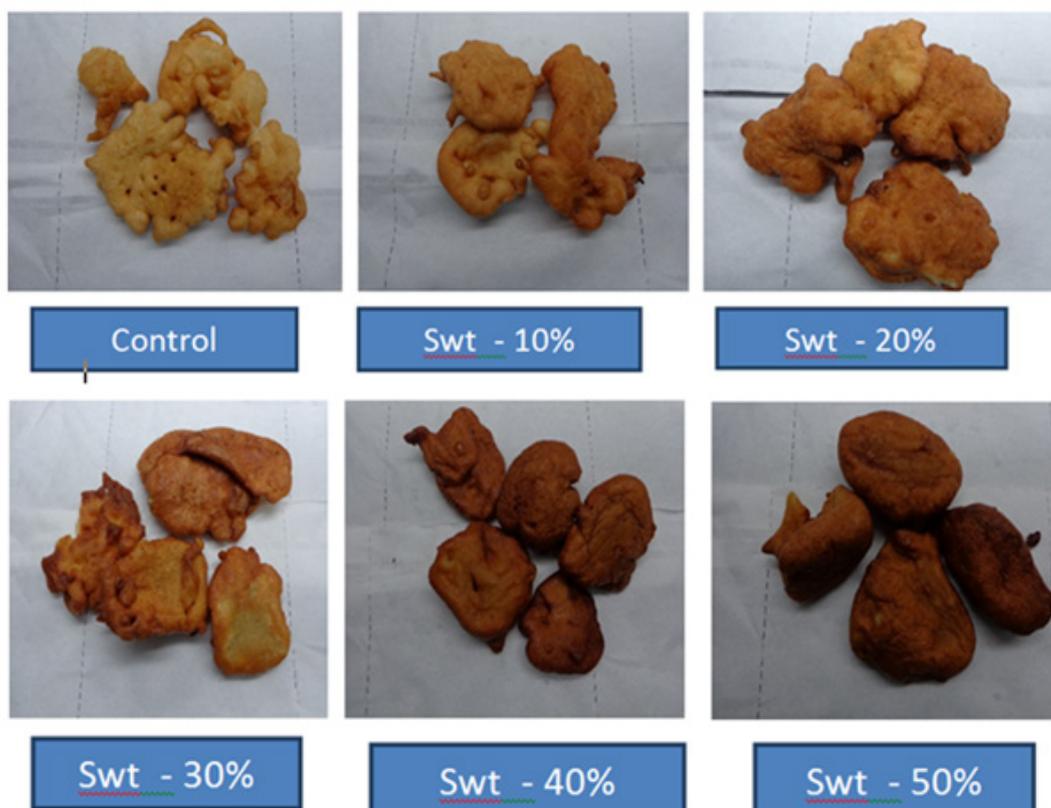


Figure 1 Akara made from different cowpea-sweet potato composite.

Swelling power

The swelling power variation with the percentage of sweet potato flour in the composite flours is shown in Figure 2. Significant ($P < 0.05$) differences were observed between cowpea flour and composite cowpea-sweet potato flours. Increased sweet potato percentage in the blends resulted in increasing the swelling power of the composite flours. It can be concluded that sweet potato's starch swell than cowpea's during gelatinization. In fact, it was reported by Agnes & Correia et al.,^{3,21} that swelling index is a parameter that

indicates the swelling of starch granules during gelatinization, as well as water retention due to protein gelation. The lowest swelling power was recorded for cowpea flour while the highest one was observed for the composite cowpea-sweet potato (50-50%) flour. However, the swelling (2.47; 2.10) powers reported by Oladele & Aina²² for tigernut flours were higher than those obtained in this study. In addition, relative high swelling powers values (2.65 to 2.68) were reported by Appiah et al.,³ for some cowpea flours grown in Ghana. This may be attributed to the varietal differences.

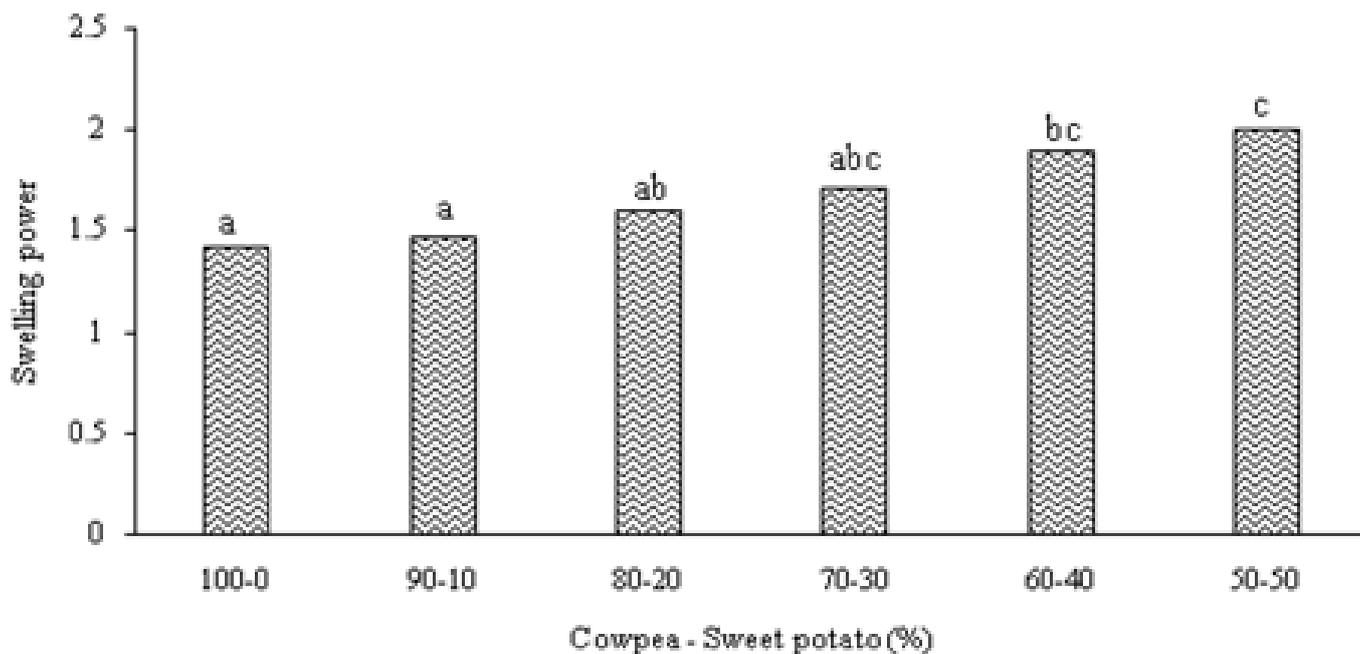


Figure 2 Swelling power of different cowpea-sweet potato composite.

Wettability

The wettability variation as a function of sweet potato's percentage in cowpea flour is shown in Figure 3. Significant ($P < 0.05$) differences were observed between cowpea flour and composite cowpea-sweet potato flours. Cowpea (100-0%) flour had poor wettability compared to the composite flours (Figure 3), however, Okezie & Bello¹⁷ had reported less wettability level for winged bean flour compared to cowpea flour. The time required to achieve complete wetness decreased with the increasing of sweet potato percentage in the composite cowpea-sweet potato flours. In fact, the composite cowpea-sweet potato (50-50%) flour needed almost the half time (3.9min) of the time (6.85min) necessary to completely wet the cowpea flour (100-0%). From these results, it can be concluded that sweet potato's flour had improved the water absorption and retention. Therefore, the composite cowpea-sweet potato flours will be more suitable than cowpea flour for cowpea past preparation during *akara* processing.

Sensory evaluation

Sensory evaluation scores are presented in Table 3. All quality parameters considered were significantly affected by the ratio of sweet potato mixed with cowpea. The score of *akara* appearance had increased significantly ($P < 0.05$) from 7.10 to 7.53 for cowpea

flour (100-0%) and the composite cowpea-sweet potato (90-10%) respectively. This result suggests that the adding of sweet potato flour in this ratio to cowpea flour improve the appearance of the resulted *akara* thus made it more attractive. However, it can be pointed out that the score of *akara* appearance had significantly declined from 6.50 to 2.59 while the sweet potato's ratio in the blend is more than or equal to 20%. This finding implies that if the ratio of sweet potato flour is more 20%, the resulted *akara*'s appearance is not accepted by consumers. The texture of *akara* was enhanced significantly ($P < 0.05$) by the incorporation of sweet potato at a ratio of 90 to 10% (Table 3). As for the flavor the addition 10% sweet potato had significant ($P < 0.05$) improve in the taste of *akara* whereas, the above 40% addition scored far below the 100% cowpea *akara*. The overall acceptability of the *akara* sensory properties was lay on the composite cowpea-sweet potato (90-10%) with significant difference when compare to other ratio. This work corroborate with the findings of Huse et al.,²³ in their studies the consumer acceptance indicated that, compared with two-stage fried/100% cowpea *akara*, the two-stage fried/6% soy formulation had similar hedonic ratings for flavor, texture, oiliness and overall acceptance. However, no significant differences were found between the *akara* (fried cowpea paste) and moinmoin (steamed cowpea paste) prepared from five varieties of cowpea flour.²⁴

Table 3 Sensory evaluation scores of akara

Parameters	Cowpea-sweet potato (%)					
	100-0	90-10	80-20	70-30	60-40	50-50
Appearance	7.10±0.04 ^f	7.54±0.06 ^e	6.50±0.04 ^d	4.51±0.05 ^c	2.41±0.13 ^a	2.59±0.05 ^b
Texture	6.29±0.06 ^b	7.31±0.04 ^c	6.11±0.03 ^b	6.37±0.06 ^b	5.19±0.25 ^a	5.11±0.04 ^a
Flavor	5.29±0.06 ^b	7.18±0.22 ^d	6.45±0.05 ^{cd}	6.42±0.04 ^c	3.94±0.09 ^a	3.40±0.57 ^a
Overall Acceptability	6.68±0.10 ^c	8.10±0.09 ^d	6.63±0.05 ^c	5.37±0.54 ^b	4.38±0.35 ^a	3.47±0.40 ^a

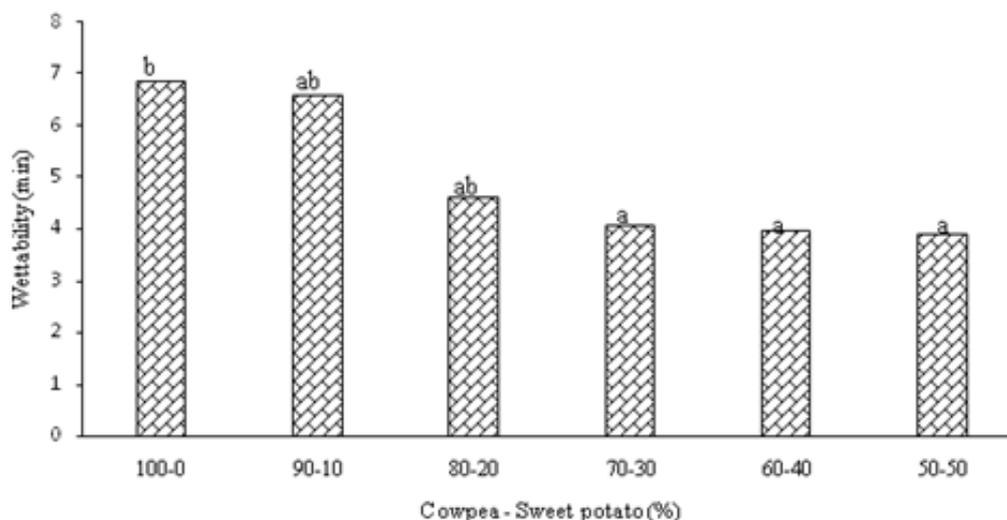


Figure 3 Wettability of different cowpea-sweet potato composite.

Conclusion

In conclusion the incorporation of sweet potato in cowpea flour for making akara as a functional ingredient had significant effect on the physico-functional and sensory properties of the product. The results of the study revealed that sweet potato flour has a great potential to be used in improving the quality of akara. Apart from, the diverse influences of different ratio on the functionality of blended flour; the highest overall acceptability of the recipe sensory evaluation was the composite cowpea-sweet potato (90-10%).

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Conflict of interest

The author declares no conflict of interest.

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