Compositional, Physical, and Sensory Characteristics of *Akara* Processed from Cowpea Paste and Nigerian Cowpea Flour

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Cereal Chem. 60(5):333-336

ABSTRACT

Akara, deep-fat fried balls prepared from cowpea (*Vigna unguiculata*) paste is widely consumed in West Africa. Quality characteristics of *akara* processed from a commercial Nigerian cowpea flour and from soaked but not dehulled cream peas (Dixiecream cultivar) were compared to traditionally prepared *akara* as a reference. The flour's poor water absorption properties resulted in paste consistency that was too fluid to dispense properly for frying and in *akara* balls that were misshapen. Particle size analysis showed that the flour was considerably finer than traditional paste, with the greatest concentration (68%) of flour particles occurring in the 200–400-mesh range, compared to 64% in the 50–100-mesh range for traditional paste. Uncooked Dixiecream paste was darker (L = 74.8) and greener ($a = -6.3$) than reference paste (L = 77.7, $a = -3.7$) and produced *akara* that browned more during frying (L = 61.7) than reference or flour-based *akara* (L = 67.2 and 67.4, respectively). Reference and Dixiecream *akara* were higher in moisture (45.3 and 48.5%, respectively) and crude fat (31.8 and 30.3%, respectively) than flour-based *akara* (40.8% moisture, 20.8% crude fat). Flour-based *akara*, which contained whole egg, was higher in protein content (19.3%) than reference (16.1%) or Dixiecream *akara* (17.3%). Significantly greater force (27.7623 N/g) was required to shear flour-based *akara* than reference or Dixiecream *akara* (16.9713 and 17.0694 N/g, respectively). Sensory attributes of *akara* from all treatments were highly acceptable except for the dry, tough texture and beany flavor noted in flour-based *akara*. Cowpea meal or flour may require a particle size distribution closely resembling that of traditional paste if it is to function successfully in the preparation of *akara*.

Cowpea (*Vigna unguiculata*) is a primary food legume in West Africa, with more than 90% of the world crop being produced in that region of the world. Consumed locally rather than exported, cowpeas are used in Africa much as in the United States, as a fresh vegetable and reconstituted dry bean. In addition, a varied and sophisticated African cuisine exists that is based on the use of cowpea paste (Dovlo et al 1976). The paste forms the basis of several popular food items such as *moin moin* and *akara*, which are prepared by steaming or deep-fat frying, respectively. *Akara* has been described as the most common cowpea-based food product in Africa (Reber et al 1983), which makes its contribution to the diet particularly significant.

Although cowpeas are favored and readily consumed in West Africa, a major constraint to their wider use is the labor-intensive and time-consuming task of preparing them for consumption. In paste processing, dry peas are soaked in water to loosen the seed coat, decorticated by either manual rubbing or stirring the wetted peas in a mortar and floating off the seed coats in water, and grinding to paste either on a stone, in a mortar, or in an electric blender (Dovlo et al 1976). Consumers prefer dehulled peas, particularly those with dark seed coats or black eyes, for use in paste preparation because these ensure a light-colored paste and attractive end products. Dehulling may not be necessary, however, if cowpea cultivars with white seed coat and little pigmentation in the hilum region (eye) can be used. Preliminary studies with this type of cultivar (eg, Dixiecream) indicate that paste with acceptable processing performance and sensory quality can be prepared from nondehulled peas (McWatters and Brantley 1982, McWatters and Flora 1980).

Efforts to devise mechanical means for dehulling (Oomah et al 1981, Reichert and Youngs 1976, Reichert et al 1979) and milling (Anonymous 1976, Eastman 1980) cereal grains and grain legumes on a village scale have been successful, and flourlike products processed from these sources are available in some local markets. Consumer acceptance of these products will depend largely on their successful performance in preparation of traditional foods. Although cowpea flour simplifies food preparation for the consumer by eliminating the need for dehulling and grinding, problems with its use have emerged. Major complaints noted in the use of commercial cowpea flour by Nigerian housewives were poor water absorption of the flour and production of *akara* balls that were heavy, lacked crispness and lacked the cowpea flavor normally associated with *akara* made from fresh paste (Dovlo et al 1976). The purpose of this study was to compare quality characteristics of *akara* processed from a commercial Nigerian cowpea flour with traditionally prepared *akara* made from soaked, dehulled blackeye peas as a reference; *akara* made from soaked but not dehulled cream peas was also included for comparison.

MATERIALS AND METHODS

Cowpea Sources

California blackeye peas were obtained from a local wholesale food supplier. Dixiecream peas were grown by the Department of Horticulture at Experiment, GA; they were dried in the field before harvest, shelled, and graded. Dry peas were held at 1°C when not in use. The Nigerian cowpea flour was a commercial product (Lisabi Mills, Ltd., Lagos, Nigeria) obtained during a visit to Nigeria in 1981. The flour was held at −18°C when not in use.

Akara Preparation

Dry peas (200 g) were soaked in 400 ml of tap water; the blackeye peas were manually dehulled during a 30-min soak period, whereas the Dixiecream peas were soaked for the same length of time but not dehulled. Soaked, drained peas (220 g) were blended with 158 ml of water in an Oster blender (no. 965-04F) at speed 3 for 5 min to a smooth paste consistency. Appropriate proportions of peas and water were determined by Dovlo et al (1976) and confirmed in additional trials (McWatters and Brantley 1982, McWatters and Flora 1980). Ingredients for *akara* prepared from each treatment are shown in Table I. The paste was transferred to a Hobart (N-50) mixer and whipped at speed 3 for 1.5 min. Whipping incorporates air into the batter and produces a desirably light, spongy texture in the cooked product. Seasonings of salt and finely chopped green pepper and onion were stirred into the whipped batter which was then dropped in portions of about 12 g into peanut oil at 193°C and fried in a Wells automatic fryer (no. F-48) until brown. Frying time for paste made from California blackeye and Dixiecream peas was 4 and 3 min, respectively. The fried products were drained on absorbent paper.

Attempts were made to prepare *akara* from Nigerian cowpea flour according to the manufacturer's instructions, which appeared on the package label. However, pastes made with the recommended proportions of flour and water were too liquid to dispense and fry properly. Adjusted levels of flour and water, which performed more satisfactorily than levels recommended by the manufacturer, are shown in Table I. The flour was hydrated by stirring in warm water. Whipping and frying conditions for the flour-based samples were the same as those described above for pastes; frying time was 4 min. Cooked samples from each treatment were held at −18° C for sensory evaluations that were conducted the following day.

Sensory Evaluation

Akara samples for sensory evaluation were reheated from the frozen state for 5 min in a conventional oven at 205° C. Coded samples consisting of a whole *akara* ball from each treatment were arranged in random order on white plates and served warm to the sensory panelists, who evaluated them under incandescent lighting in individual booths. Appearance, color, aroma, texture, and flavor were rated on a hedonic scale of 9 to 1 (9 = excellent, 5 = borderline, 1 = very poor) by a volunteer panel consisting of seven men, one of whom was Nigerian, and three women. All participants had served on previous *akara* panels, and thus were very familiar with the traditional product; panelists were trained in the use of sensory evaluation procedures.

Objective Measurements

The proximate composition of *akara* samples from each treatment and the cowpea sources used to prepare them was determined. For analytical purposes, *akara* samples were cut into small pieces in a Hobart cutter (model 84142), and whole peas were ground in a Morehouse stone mill. Moisture content was determined by vacuum drying 5-g samples for 24 hr at 70° C. Crude fat content was determined on moisture-free samples extracted for 24 hr with Skelly F in a Goldfisch apparatus. Nitrogen content was determined by Kjeldahl procedure (method Ab 4-50, AOCS 1970) using 2-g samples of milled peas and 3-g samples of *akara*. A factor of 6.25 was used to convert nitrogen content to protein values. Ash content was determined on 2-g samples (method Ba 5-49, AOCS 1970). Analyses for proximate composition were determined in quadruplicate.

Color, including visual lightness (L), redness to greenness (*a*), and yellowness to blueness (*b*), of uncooked paste and fried products was measured in duplicate with a Gardner color difference meter (model C-4 [L]) using an orifice size of 5 cm and an ivory standard. Reference values for the standard were: L = 76.6, *a* = −1.1, and *b* = 24.2. Fried products were cut into small pieces in a Hobart cutter before color analysis. Optical glass cups were completely filled for reading.

The texture (force required to shear) of eight individual *akara* balls from each treatment was determined with a Food Technology Corp. shear press (model TP-1). Shear-press operating conditions included a standard shear-compression cell, 136-kg transducer ring, downstroke speed of 17.8 cm/min, and recorder range setting of 50. Peak heights were measured and reported as Newtons per gram.

Statistical Analysis

Sensory quality scores ($n = 10$) and shear values ($n = 8$) were analyzed by standard procedures of analysis of variance and multiple range testing of the significance of mean differences ($P \leq 0.05$) (Snedecor and Cochran 1967) using the computer statistical analysis system of Barr et al (1976).

TABLE I
Ingredients for *Akara*

Treatment	Peas or Flour (g)	Water (ml)	Whole Egg (g)	Green Pepper (g)	Onion (g)	Salt (g)
Reference (California blackeye peas, soaked, dehulled)	220	158	···	36	36	8.0
Dixiecream peas, soaked but not dehulled	220	158	···	36	36	8.0
Nigerian cowpea flour	200	170	25	35	35	7.8

TABLE II
Proximate Composition of Cowpea Sources Used for *Akara* Preparation

Source	Moisture (%)	Crude Fat[a] (%)	Protein[a] (%)	Ash[a] (%)	Carbohydrate[a,b] (%)
California blackeye peas	11.5	1.0	25.1	4.3	69.6
Dixiecream peas	13.1	1.2	26.9	3.8	68.1
Nigerian cowpea flour	8.9	1.5	24.5	3.3	70.7

[a] Dry weight basis.
[b] Carbohydrate content determined by difference.

RESULTS AND DISCUSSION

The proximate composition of the various cowpea sources used for *akara* preparation is shown in Table II. The Nigerian cowpea flour was considerably lower in moisture content than either of the other cowpea sources. All were low in crude fat content and contained similar amounts of total protein and carbohydrate.

The cowpea sources and *akara* prepared from them are shown in Fig. 1. The California blackeye sample represents *akara* made in the traditional manner. Dixiecream peas (nondehulled) produced *akara* balls that were similar in size and shape to the traditional product, although they tended to be slightly browner, even with 1 min less frying time, and were less smooth in appearance. Gardner color values of uncooked paste from nondehulled Dixiecream peas were: L = 74.8, *a* = −6.3, and *b* = 18.5. For paste from dehulled blackeye peas, these values were: L = 77.7, *a* = −3.7, and *b* = 17.8. The darker color (lower L value) and greater degree of greenness (larger *a* value) of Dixiecream paste may have accounted for its tendency to brown more during frying than blackeye paste. Preparation was simplified considerably by the use of cream peas since the manual dehulling step was eliminated; the presence of the seed coat produced no problems in the processing of *akara*. Cultivars with white seed coats and little pigmentation in the hilum are available in West Africa (Dovlo et al 1976), but the socioeconomic and sociocultural aspects of using this type of cultivar in preference to the blackeye should be explored. The Nigerian cowpea flour produced *akara* balls that were rounder and smoother than the traditional product and had similar browning characteristics. The hydrated paste made from the flour was almost

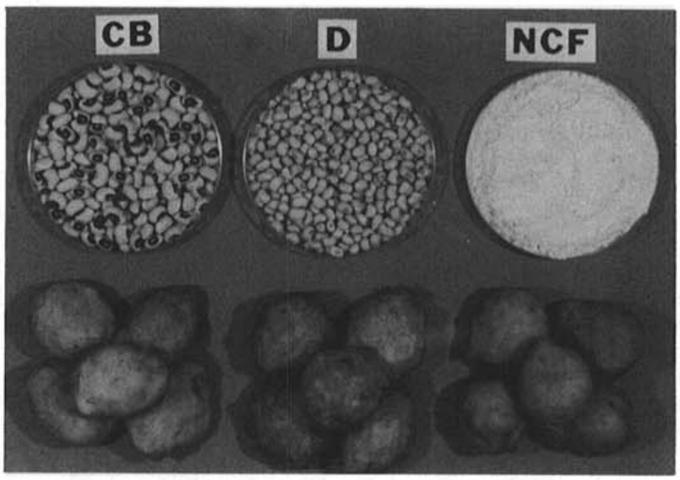

Fig. 1. *Akara* prepared from California blackeye peas (CB), Dixiecream peas (D), and Nigerian cowpea flour (NCF).

too fluid, even after substantially reducing the amount of water that had been recommended. This made the batter difficult to dispense into the fryer and produced *akara* balls that were more misshapen than those produced by the traditional process.

The poor water absorption of the flour may have been due to its physical form and structure. Sefa-Dedeh and Stanley (1979) investigated the relationship of microstructure of cowpeas to water absorption and dehulling properties and demonstrated that intact seeds, although nonhomogeneous in nature, had a highly organized cellular structure. Water uptake of whole seeds was a complex process in which several anatomical and compositional factors—seed coat structure and thickness, seed size, hilum size, and protein content and properties—became sequentially important. Although starch, pectic substances, and other macromolecules contribute to water absorption, the chief water-imbibing component of seeds is protein (Mayer and Poljakoff-Mayber 1975). Structural and compositional components of cowpeas likely undergo considerable alteration in the process of dehulling and milling seeds into flour, thus altering the physical and compositional factors necessary for the sequential uptake of water.

Analysis of the particle size distribution of traditionally processed paste and Nigerian flour indicate that differences in the cowpea products were considerable (Table III). The flour was notably finer than traditional paste with 47% of the flour particles riding a 400-mesh screen compared to 16% at the 400-mesh size for the paste. The greatest concentration of flour particles was in the 200- to 400-mesh sizes (68%), whereas 64% of the paste particles was concentrated in the 50- to 100-mesh sizes. Williams (1980) concluded that cowpea middlings, an intermediate particle size between flour and grits, were more suitable for *akara* preparation than cowpea flour.

Physical characteristics of *akara* prepared from the various cowpea sources are shown in Table IV. The California blackeye peas and the Nigerian cowpea flour produced *akara* with similar lightness (L) values. As noted in Fig. 1, *akara* from Dixiecream peas was slightly darker than *akara* from the other treatments, which is indicated by its lower L value. Degrees of greenness, negative *a* values, and yellowness, positive *b* values, were similar for all treatments. The cooked batch weight, or yield, of *akara* from each treatment was similar, as was the average weight of individual *akara* balls. In West Africa, *akara* is prepared in the home and by street vendors for sale in the marketplace. It is eaten as both a breakfast food and snack food, and an average adult serving is 100 g. Therefore, eight or nine of the balls produced from these cowpea sources would constitute a typical West African adult serving.

Compositional characteristics of *akara* prepared from each treatment are also shown in Table IV. *Akara* made from California blackeye peas and Dixiecream peas was higher in moisture and fat content and slightly lower in protein content than *akara* made from Nigerian cowpea flour. The addition of egg to the flour-based formula, as recommended by the manufacturer, accounted for the higher level of protein of *akara* produced by this treatment. Ash content of *akara* was similar for all treatments. Carbohydrate content of *akara* from California blackeyes and Dixiecream peas was similar and lower than that of *akara* made from Nigerian cowpea flour.

Shear values for *akara* prepared from cowpea pastes and flour are shown in Table V. These values were similar for *akara* made from California blackeye and Dixiecream peas. Significantly greater force was required to shear *akara* made from the Nigerian cowpea flour than *akara* from the other treatments.

Sensory scores of *akara* prepared from the various cowpea sources are also shown in Table V. *Akara* made from California blackeye and Dixiecream peas was highly acceptable in all sensory attributes, receiving ratings of good or very good. *Akara* from Nigerian cowpea flour scored favorably in appearance, color, and aroma, but received significantly lower scores for texture and flavor than *akara* from the other treatments. Panelists described the texture of *akara* made from the flour as "dry," "dense," and "having a tough outer surface." The flavor of the flour-based sample was described as "beany" and "more cooked on the outside than inside."

We observed that crust formation occurred at the surface of *akara* made from the hydrated flour; this produced an undesirably tough, dry texture and may have prevented the transfer of a sufficient amount of heat to completely cook the interior. Crust formation may have been due to the small particle size of the flour, the presence of egg in the flour-based formula, insufficient hydration time, or to the combined effects of these factors.

In order to provide more definitive information regarding the influence of particle size on handling and frying characteristics of hydrated cowpea meal/flour, cowpea products varying in particle size distribution were prepared. Blackeye peas were decorticated mechanically in a batch-type rollover dehuller developed by the Prairie Regional Laboratory, Saskatoon, and equipped with seven carborundum disks. Dehulled peas were passed through an Almaco air-blast seed cleaner to separate seed coats and fines; any peas that still retained the black eye following dehulling were removed manually. Decorticated peas were milled in a Microjet 10 ultracentrifugal mill operated at 10,000 rpm and equipped with 2.0-, 1.0-, or 0.5-mm screens.

Meal/flour from each screen size was wetted by stirring in a constant level of water (60% added to 11%-moisture meal/flour); stirring time of 2 min was sufficient to completely wet the dry particles. The flour-water mixture was covered tightly and allowed to hydrate for 30 min, a typical time period for soaking whole peas in water to facilitate manual dehulling. It was necessary to blend

TABLE III
Particle Size Distribution of Traditionally Processed Cowpea Paste and Mechanically Milled Cowpea Flour

Tyler Screen Size (mesh)	Percent Retained on Screen	
	Traditional Paste[a]	Nigerian Flour[b]
8	0	0.04
14	0	0.57
30	0.72	1.59
50	21.50	16.26
100	42.10	13.20
200	16.50	20.34
400	16.30	47.53
Collecting pan	2.80	0.47

[a] Alcohol-washed several times, air-dried overnight, then sieved.
[b] Commercial product, milling conditions unknown.

TABLE IV
Physical and Compositional Characteristics of *Akara* Prepared from Cowpea Pastes and Nigerian Cowpea Flour

Treatment	Gardner Color Values			Cooked Batch Wt (g)	Average Ball Wt (g)	Moisture (%)	Crude Fat[a] (%)	Protein[a] (%)	Ash[a] (%)	Carbohydrate[a,b] (%)
	L	*a*	*b*							
Reference (soaked, dehulled California blackeye peas)	67.2	−1.3	18.0	401.2	11.8	45.3	31.8	16.1	5.5	46.6
Soaked but not dehulled Dixiecream peas	61.7	−1.7	18.2	398.0	12.1	48.5	30.3	17.3	5.2	47.2
Nigerian cowpea flour	67.4	−1.5	17.9	400.0	11.1	40.8	20.8	19.3	5.2	54.7

[a] Dry weight basis.
[b] Carbohydrate content determined by difference.

TABLE V
Shear Values and Sensory Scores of *Akara* Prepared from Cowpea Pastes and Nigerian Cowpea Flour[a]

Treatment	Shear (N/g)	Sensory Scores				
		Appearance	Color	Aroma	Texture	Flavor
Reference (soaked, dehulled California blackeye peas)	16.9713 a	8.3	8.3	8.2	7.5 a	8.0 a
Soaked but not dehulled Dixiecream peas	17.0694 a	7.5	7.6	8.0	7.7 a	7.8 a
Nigerian cowpea flour	27.7623 b	7.7	7.8	7.2	5.9 b	5.8 b

[a] Values within a column having no letter in common are significantly different at $P \leqslant 0.05$.

TABLE VI
Effect of Mill Screen Size on Particle Size Distribution of Cowpea Meal/Flour and Characteristics of Resulting Paste[a] and *Akara*

Tyler Screen Size (mesh)	Percent Material Retained on		
	2.0-mm Screen	1.0-mm Screen	0.5-mm Screen
8	0.11	0.04	0.14
14	4.58	0.28	0.35
30	34.02	2.02	0.25
50	27.96	24.29	3.18
100	14.12	20.62	14.72
200	9.60	37.24	40.83
400	9.37	15.27	38.96
Collecting pan	0.25	0.23	1.58
Paste viscosity, cP	89,500	13,250	9,500
Paste handling characteristics	Good foam formation, easy to dispense	Slightly too liquid to dispense properly	Very fluid, extremely difficult to dispense
Akara ball shape	Uniform	Slightly distorted	Extremely distorted

[a] For paste preparation, all mesh size particles were recombined after sizing.

hydrated mixtures from the 2.0-mm and 1.0-mm screen sizes to obtain smooth paste consistencies; blending was accomplished in an Oster blender at speed 3 for 5 min. The 0.5-mm flour was sufficiently fine to produce a smooth paste consistency without blending. Apparent viscosity of paste from each screen size was measured at 23°C with a Brookfield Viscometer (model RVT) and Helipath Stand (model C) equipped with a T-C spindle turning at 5 rpm. Cowpea paste from each mill screen size was used to prepare *akara* by the procedure described.

The particle size distribution of cowpea meal-flour from each of the mill screen sizes and characteristics of resulting paste and *akara* are shown in Table VI. The greatest concentration of particles was in the 30–100 mesh range (76%) with the 2.0-mm screen, 50–200 mesh range (82%) with the 1.0-mm screen, and 100–400-mesh range (95%) with the 0.5-mm screen. Paste viscosity and ease of handling decreased with decreasing mill screen size. The more fluid the paste became, the more difficult it was to dispense for frying and the more distorted the shape of the resulting *akara* balls. Cowpea meal-flour may require a particle size distribution closely resembling that of traditional paste (Table III) if it is to function successfully in preparation of *akara*.

Results of this study have shown that the use of a commercial Nigerian cowpea flour simplified preparation of paste for *akara* production by elimination of the soaking, dehulling, and grinding operations; however, the particle size of the flour was too small to function in the same manner as traditionally-processed paste. The use of cream peas having little pigmentation in the hilum simplified cowpea paste processing by elimination of the dehulling step and resulted in *akara* that was as acceptable as traditional *akara*. Processes and products that simplify the use of cowpeas by consumers have the potential for increasing cowpea consumption worldwide.

ACKNOWLEDGMENTS

The technical assistance of Margree Ector and photography by Richard Stinchcomb are gratefully acknowledged.

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[Received August 9, 1982. Accepted March 25, 1983]