Nutritional and Sensory Evaluation of Akara Made from Blends of Cowpea and Hard-to-Cook Mottled Brown Dry Beans

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The effect of replacing cowpea with hard-to-cook beans on the nutritional and sensory properties of akara were evaluated. Cowpea (*Vigna unguiculata*), traditionally used for making akara, was substituted 0%, 25%, 50%, 75%, and 100% with hard-to-cook (HTC) mottled brown beans (*Phaseolus vulgaris*). Cowpea (CP) soaked for 60 min HTC beans soaked for 18 h were separately decorticated, ground to a paste, and mixed in the following CP:MBB ratios: 0:100, 25:75, 50:50, 75:25, and 100:0. The paste mixtures were each whipped and fried into akara. The samples were analyzed for bulk density, nutritional composition, carbohydrate and protein digestibility, α-amylase inhibitor and trypsin inhibitor activity, and sensory attributes. The bulk density of paste as well as of akara increased with the increasing content of HTC bean. Akara made from composite paste had a relatively better amino acid profile. Frying beyond 5 min destroyed the α-amylase inhibitors as well as the trypsin inhibitor activity. No significant difference was observed in the overall acceptability of akara made from cowpea substituted up to 50% with HTC beans. Hence, this approach permits the utilization of hard-to-cook beans.

Keywords: *Akara; cowpea; hard-to-cook beans; blends; nutritional quality; acceptability*

INTRODUCTION

Dry beans (*Phaseolus vulgaris*) are commonly grown in many African countries and constitute a very important source of dietary carbohydrates, proteins, and B vitamins. In most of these countries, beans are typically boiled alone or in combination with other foods and eaten as such. When stored for long periods of time under tropical conditions of high temperatures and humidity, beans develop the hard to cook (HTC) defect (Stanley and Aguilera, 1985; Hentges et al., 1991) which affects their palatability, cooking and eating quality, and nutritional value. Dry beans with this defect require extended cooking times to reach acceptable tenderness levels, which, in turn, leads to increased fuel use, minimum consumer acceptance, and economic losses.

In Cameroon the development of the HTC defect in beans has been reported to significantly reduce the preparation and consumption of beans (Mbofung et al., 1996). Postharvest storage under controlled conditions of temperature and humidity would have been the best way to resolve this problem, but this is not economically feasible at the local farmer level in the developing countries of the tropics. There is thus a need to look for alternative methods for processing dry beans into acceptable foods. One such food may be *akara.*

Akara has been described as the most common cowpea-based food product in Africa (Rebert et al., 1983). It is made from whipped cowpea paste flavored with spices like onions, peppers, and salt and dropped by tablespoon portions into hot oil and deep-fried (Dovlo et al., 1976; McWatters et al., 1983). As a very common breakfast and snack food, akara has been reported as making a significant contribution to the diet of the consumers, especially in the fast growing urban areas where small-scale processors are known to make brisk business selling akara (Reber et al., 1983; McWatters, 1983). An extensive review by Prinyawiwatkul et al. (1996) on cowpea flour as a potential ingredient in food products shows that much work has been carried out on the production of akara from cowpea. Further investigation of the literature shows that except for some work reported by Odouraine et al. (1989) and another by Prinyawiwatkul et al. (1994), no attempt has been made for producing akara from other legume sources or from a combination of dry beans with cowpea.

The purpose of this study is to investigate for the first time the effect of supplementing cowpea with HTC dry beans on the nutritional and sensory characteristics of akara. It is part of a wider group of studies funded by the European Economic Commission aimed at improving the cooking quality of hard-to-cook dry beans.

MATERIALS AND METHODS

Dry Bean and Cowpea Samples. Dry mottled brown beans (MBB) (*P. vulgaris*) and blackeye peas or cowpea (*Vigna unguiculata*) were purchased from a local farmer in Ngaoundere, Cameroon, and taken to the laboratory where they were picked clean of all debris and broken seeds. The MBB were of an old stock which had developed the HTC defect and had a CT_{50} (time required to cook 50% of beans) of 2 h, while the CP was of a new stock with a $CT_{50} = 20$ min. The cookability of beans and the cowpea was determined using the Mattson Bean Cooker (Mattson, 1942).

Processing of Akara. On the basis of several pretrials, akara was prepared from a mixture of cowpea and the dry bean pastes as shown in Figure 1. Essentially, the MBB were soaked in distilled water at 30 °C for 16−18 h to fully imbibe water before being decorticated. Soaking in warm water at 37 °C for 9 h was found to give the same results. The CP was soaked at

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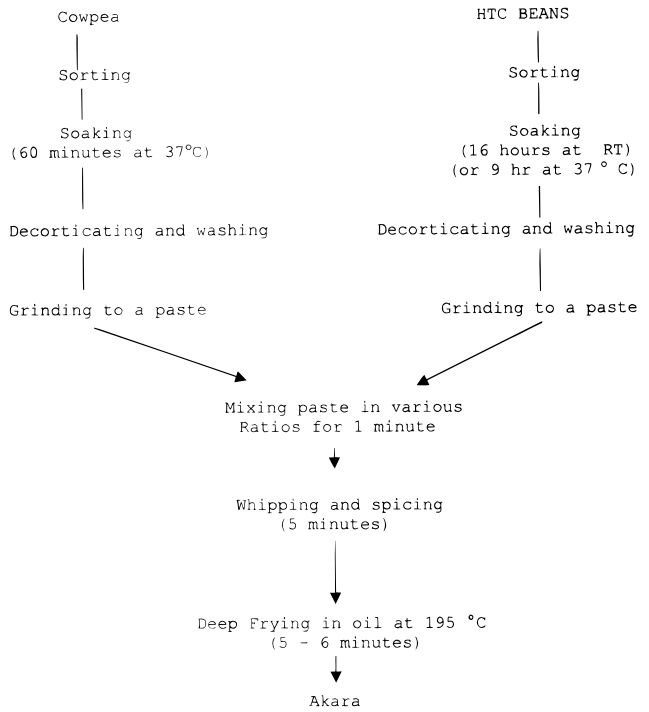

Figure 1. Flow chart for akara preparation.

37 °C for 60 min followed by decorticating. Decorticating in either case was carried out by a simple rubbing motion of the seeds between the palms followed by washing them in copious amounts of water to separate the testa and cotyledons. Each of the decorticated samples were washed and ground in a hand-operated abrasive machine (Moulinex brand, France) set to produce a near smooth paste. Following grinding, five paste mixtures each of a total weight of 200 g were made up (w/w) in the following MBB:CP ratios: 0:100, 25:75, 50:50, 75:25, 100:0.

Each combination was initially blended for 1 min using a fork followed by continuous and vigorous whipping for 4 min in a wooden mortar using a pestle. In the course of the fourth minute, 3 g of salt, one-half a cube of Maggie Cube (2 × 2 × 2 cm) Spice (Camad-Nestle, Douala), 4 mL of pepper sauce (20 g of powdered pepper dissolved in 100 mL of boiling water), and 10.5 g of thinly sliced onions were added. This was followed by the addition of 90 ± 5 mL of lukewarm water (37 °C) and further whipping for 1 min. (Preliminary frying trials had shown that the addition of water in excess of this amount to the MBB:CP paste mixture produced by the method described resulted in a batter with poor dispensing properties and akara of irregular shape.) Whipping at high speed for 3 min using an electric hand-held blender (Kenwood, U.K.) was also found to produce batter of a comparable good frying quality as that produced by the pestle and mortar method.

Whipping incorporates air into the paste, giving it a foamy feel, which is necessary for the spongy bread-like texture of akara. In the making of akara from cowpea, whipping is usually carried out for shorter periods, but in the present case, it was necessary to whip for much longer because of the HTC bean component of the blend. The batter was dispensed in desert spoonfuls into the frying pot containing cotton seed oil (Diamaor brand, Garoua, Cameroon), and frying was carried out at 195 °C for 5−6 min, making sure each akara ball was rolled over every minute to allow for uniform frying and browning. At the end of the frying period, akara was removed and placed in a basket to drain off excess oil. It was then kept warm in a heated oven (Gallenhamp, U.K.) in preparation for sensory evaluation, which was carried out no more than 30 min after the last batch of akara had been fried. The batter for sensory analysis generally took 30 to 10 min to fry. Samples for chemical analysis were stored frozen at −20 °C until required for analysis.

In order to determine the effect of frying time on the destruction of α-amylase inhibitor (AAI) and trypsin inhibitor activity (TIA) in the fried product, different frying batches were carried out and samples taken at 0, 30, 60, 120, 180, and 360 s of frying on each side. Samples were allowed to drain dry and weighed, defatted using hexane, and ground to a fine powder before being used for the different analysis.

Sensory Evaluation. Akara samples for sensory evaluation were served to a panel of 12 final year students in the Department of Food Science and Nutrition and who were regular eaters of cowpea-based akara. In addition to their knowledge of akara as regular consumers, the 12 panelists underwent four training sessions each lasting 30 min on how to carefully judge akara for such qualities as color, taste, flavor, texture, and overall acceptability using a hedonic scale of 9 to 1. On this scale, 9 = 'I like very much' and 1 = 'I dislike very much'. For each training session akara made from 100% CP was used as the standard.

All sensory analysis studies were carried out in a standard sensory testing laboratory with individual booths for the panelists and each supplied with free-flowing portable water, sinks, disposable cups, and napkins. At each sensory evaluation session, the panelist was served the coded samples of the different types of akara following a randomized block design in such a way that not more that two panelists at each time were served in the same order.

T-test as well as analysis of variance of different data were performed using SPSS software for Windows (SPSS, 1993). For the effect of frying time and HTC bean content on the enzyme inhibitors in akara, surface plots were carried out using the distance-weighted least-square smoothing procedure as contained in the *Statistica* Software for Windows (Statsoft, 1995).

Proximate Analyses. *Chemical* analyses were carried out in duplicate on the proximate composition of the samples according to AOAC (1990) methods. Protein content was determined by analyzing samples for their nitrogen content using the micro-Kjeldahl method and converting into protein using the factor of 6.25. Moisture was determined by weight differences of samples dried to constant weight in an air-drying oven at 80 °C. Crude fat content was determined by extracting the ground samples with hexane overnight in a soxhlet apparatus, while the ash content was determined by weight differences following combustion in a muffle furnace for 48 h at 550 °C.

Available Carbohydrate Content. The available carbohydrate content of the different samples was determined by carrying out acid hydrolysis of known weights of the samples and measuring the reducing sugar concentration of the hydrolysate using 3,5-dinitrosalicyclic acid as described by James (1967).

Bulk Density (BD). BD of fried akara was calculated as

$$(\mathrm{BD}) = \frac{\text{mass of akara}}{\text{volume of akara}}$$

where the volume of akara, V_a, was estimated by determining the amount of clean washed and dried fine sand of known mass, M_t, and density, d, displaced by a given mass of akara, M_a, contained in a glass container of known volume, V_T. The equation used in this case was given as

$$V_a = (V_T) - \frac{(M_t - M_a)}{d}$$

Amino Acid Analysis. The amino acid profile of representative samples of the different akara was carried out essentially by the reverse-phase HPLC method (Elkin and Wasyczuk, 1987). A Perkin Elmer HPLC system was used consisting of an LC200 series pump, a Rheodyne injection valve with a 20 μL loop, a Waters column in a column heater, an Applied Biosystems UV 22 Absorbance detector, and a 1022 data handling computer. HPLC-grade reagents were used, including acetonitrile, methanol, pyridine, and ethanol (Fisher Scientific). HPLC-grade water was supplied by a Milli-Q

purification system with 18 μm filter (Millipore) and supplied with in-house deionized water. Triethylamine (TEA), phenylisothiocyanate (PITC), and amino acid standards were obtained from Pierce. All other chemicals used were of reagent grade.

Defatted akara samples were ground and sieved to pass through a 40 mesh sieve, and the nitrogen content was determined by AOAC (1990) Kjeldahl method. Samples containing 40 mg of N were hydrolyzed in the presence of 6 M HCL at 110 °C for 23 h. Hydrolyzed samples were centrifuged, filtered, and derivatized using PITC before injection into the HPLC fitted with a Waters column (Silica analytical column reversed-phase Novapak C18) measuring 3.9 × 159 mm. The solvent system consisted of two solvents: A and B. Solvent A consisted of 0.14 M sodium acetate containing 0.7 mL/L TEA titrated with glacial acetic acid to pH 5.70, while solvent B was made up of acetonitrile and water in a ratio of 60:40 (w/v). The gradient settings optimized for full separation consisted of 0% rising to 10−30% in 10 min, 30−48% in 16 min and 48−100% in 6 min. Final results on amino acid content were expressed on the dry weight basis of the original whole akara.

Carbohydrate Digestibility. In vitro carbohydrate digestibility was carried out in duplicate as follows. Defatted and finely ground samples containing 50 mg of available carbohydrate were weighed into tubes each containing 6 mL of phosphate buffer (pH 6.9) containing 0.04% NaCl and incubated in a shaking water bath at 37 °C for 10 min. After this, 1 mL (10 mg/100 mL) of porcine pancreatic amylase (Sigma) was added and allowed to act for 30 min. Following this the tubes were removed and immersed into boiling water for 5 min to terminate the enzyme activity, cooled to room temperature, and centrifuged for 10 min at 10000*g*. Duplicate 1 mL samples of the supernatant were then withdrawn and mixed with 0.1 mL of dinitrosalicylic acid (DNS), mixed by vortexing, heated for 5 min in a boiling water bath, cooled, and diluted with 3 mL of distilled water before reading the absorbance at 540 nm. A standard maltose solution (2 mg/mL) was used for the calculation of the maltose released. Results obtained were calculated in terms of milligrams of maltose released per gram of sample subjected to the digestive enzyme action.

Protein Digestibility. *In vitro* protein digestibility of samples was carried out essentially by the multienzyme method as described by the AOAC (1990) with the following modifications. One gram of defatted and finely ground sample was allowed to soak in the buffer for 1 h before proceeding with the addition of the first group of enzymes. This was to allow the sample to adequately imbibe in the buffer solution and thus ensure a better substrate−enzyme contact at the initial point of the reaction. Preliminary trials had shown that a shorter contact time between dried flour samples and the buffer tended to influence the initial rate of enzyme action.

α-Amylase Inhibitor (AAI). *Changes in the AAI in the Cowpea.* HTC bean paste blend during frying was measured essentially by the method described by Piergiovannie (1992). One gram of each defatted sample was extracted in 25 mL of normal saline solution for 2 h at 4 ° C. Portions of the filtered extract were incubated with 50 μL of pancreatic porcine amylase (30 μL/mL in 0.05 mol/L Tris-HCl buffer pH 6.9 and containing 0.01 mol/L $CaCl_2$) for 20 min at 30 °C. Two milliliters of starch solution (10 mg/mL) and 2 mL of Tris buffer (pH 6.9 containing 0.01 mol/L $CaCl_2$) were added, and the total mixture was incubated for a further 40 min after which suitable quantities were withdrawn, discharged into 4 mL of iodine solution (50 mg of iodine and 500 mg of potassium iodide in 1 L of 0.05 mol/L HCl), and mixed, and the absorbance was read at 564 nm in a Perkin-Elmer spectrophotometer. By this method, the nonhydrolyzed starch that reacts with the iodine solution has been shown to be proportional to the recorded absorbance and to reflect the degree of activity of the α-amylase inhibitor. This procedure was carried out in duplicate for each of the samples collected serially during the course of akara frying.

Trypsin Inhibitor. Trypsin activity was determined in duplicate on duplicate samples at 37 °C using benzoyl-D,L-arginine-*p*-nitroanilide (BAPNA) and casein as the substrate following the procedure of Kakade et al. (1969).

Statistical Analysis. All results were analyzed statistically using the statistical package SPSS (1993). Graphic representation of results was made using the *Statistica* package for Windows (Statsoft, 1995).

RESULTS AND DISCUSSION

On the basis of the results of several preliminary trials, the method adopted for the production of akara from a mixture of Cowpea and HTC dry beans is as shown in Figure 1. Of special note in this process is the need to soak the dry beans at high temperatures for a long enough time to ensure full imbibition of water. Full imbibition of water improves protein solubility, which is an important and needed functional property for the production of a good batter for akara. Soaking also has an effect on the final texture of the akara. However, the development of the HTC defect in cowpea has been reported to lead to reduction in water uptake and the solubility of protein in cowpea leading to relatively poor quality akara (Hung et al., 1995). Soaking of the dry beans in water at 30 °C for 18 h was enough to ensure full imbibition. Use of high soaking temperatures have been known to increase the water uptake (Kon, 1979; Quast et al., 1977). In the present study, using a high soaking temperature of 37 °C was found to improve water uptake and reduce the soaking time to 9 h.

The total frying time to obtain cooked and well browned akara from cowpea has been reported to vary from 2 to 4 min (McWatters and Brantly, 1986). Results from preliminary frying trials during this study had shown that with a composite MBB:CP batter, frying for 4 min gave an acceptable light-brown color but did not fully cook in the interior. When extended to between 5 and 6 min full browning as well as cooking were attained. It is evident therefore that the use of MBB:CP composite paste for the production of akara requires a longer frying time than using whole CP.

The shape of cooked akara depends very much on the dispensing characteristics of its batter. As reported by McWatters and Brantly (1986), very fluid batter tends to disperse very poorly and thus give poorly shaped akara. We made the same observations in our preliminary trials. To obtain a good dispersing batter from the MBB:CP composite paste, an average ratio of 1 part of wet meal to about 0.5 parts of lukewarm water was necessary. Any ratio far below or above this level tended to give poorly shaped akara. The characteristics of cowpea batter for the processing of akara is related to its albumin content (Phillips et al., 1988). Recent studies by Hung et al. (1995) had also shown that whipped paste of 100% HTC cowpea had relatively poor batter dispensing properties.

Since the solubility of proteins in beans following the development of the HTC defect is known to change with the development of the HTC defect (Mbofung et al. 1996), this affects bean paste behavior during whipping. In the present study, the problem was resolved after several trials in which the amount of lukewarm water added to the composite paste was varied before whipping. Generally the amounts of water added increased slightly with an increase in the HTC bean content of the paste.

One characteristic of good akara is its light bread-like spongy texture usually brought about by the incorporation of air into the batter during the whipping

Table 1. Effect of Incorporation of HTC Beans into Cowpea Paste on Bulk Density of Akara

% cowpea in akara	bulk density		
	mean	SE[a]	% increase[b]
0	1.3666a	0.0473	16.9
25	1.297	0.0736	10.9
50	1.2683	0.0334	9.9
75	1.2413	0.0530	6.2
100	1.1691a	0.0342	0

[a] SE = standard error. [b] Increase over control value. Figures in a column with the same letter are significantly ($P < 0.01$) different from each other.

Table 2. Proximate Composition of Cowpea:HTC Bean Akara

	% HTC Beans in Akara				
	0	25	50	75	100
total protein (g kg^{-1} dry wt)	180.0	170.8	170.3	170.0	170.2
carbohydrate (g kg^{-1} dry wt)	470.3	460.1	460.3	480.0	480.1
oil (g kg^{-1} dry wt)	300.2	300.8	310	290.4	290
ash (g kg^{-1} dry wt)	40.5	50.3	50.4	50.6	50.7
moisture (g kg^{-1} wet wt)	340.4	350	370	360.9	360

stage of cowpea paste. This reduces the final bulk density of akara. In the present study, the progressive partial replacement of cowpea with HTC MBB was accompanied by a concomitant increase in bulk density. The temperature of water added to the paste at the whipping stage influenced the bulk density of akara. Batter obtained by whipping paste mixed with lukewarm water produced less bulky akara than that obtained from batter produced by mixing paste blends with cold water. Akara made from 100% HTC MBB was 16.9% bulkier than that made from cowpea paste (Table 1). In a relatively similar study in which cowpea paste was progressively replaced by peanut flour up to 50%, Prinyawiwatkul et al. (1994) had also observed an increase in the specific density of the paste, as well as a decrease in the whipped past volume with an increase in the level of peanut flour supplementation.

The proximate composition of akara prepared from the different MBB:CP mixtures is as shown in Table 2. Akara prepared from the different blends had relatively lower protein contents, ranging from 17.2% to 17.8% compared to 18.0% for 100% cowpea akara. The differences were, however, not significant. The oil content of akara increased slightly with the level of incorporation of HTC bean up to 50% HTC bean and thereafter decreased with a further increase in HTC content. This pattern of change in the oil content may partially be explained by the relative differences in the oil absorption capacity of the HTC bean and Cowpea as earlier observed by Tunkap et al. (1996). The amount and pattern of oil uptake may be associated with the variation in the swelling characteristics of the different cowpea and bean mixtures during whipping. According to Prinyawiwatkul et al. (1994), the spongy character of akara brought about by the incorporation of air during the whipping stage of batter may facilitate oil uptake during frying. A significant correlation was observed between oil uptake and bulk density of akara made from composite paste ($r = 0.85$; $P < 0.05$). The carbohydrate, ash, and moisture content of akara made from composite pastes increased with the HTC bean content of akara. The average weight of akara from the mixtures was higher than that from the control. The average calculated energy content was about 162 kJ (Table 3).

Table 3. Average Weight, Energy, and Trypsin Inhibitor Content of Akara

	% HTC beans in akara				
	0	25	50	75	100
av ball wt (g)	13.37	14.21	14.14	13.54	13.3
av energy/g (kJ)	167	157	158	162	164
trypsin inhibitor (g kg^{-1} dry wt)	2.4	2.7	2.8	3.2	3.6

Table 4. Amino Acid Content of Akara Made from HTC Beans:Cowpea Composite Pastes

amino acid (g kg^{-1} of sample)	% HTC beans in akara				
	0	25	50	75	100
cystine	3.69	3.53	3.36	3.80	3.91
isoleucine	10.17	8.97	7.77	6.57	8.97
leucine	13.86	12.60	11.97	11.03	12.92
lysine	11.97	9.93	7.88	7.55	7.18
methionine	2.11	2.14	1.98	1.82	2.14
phenylalanine	10.46	9.80	9.15	9.90	9.80
threonine	9.90	8.87	7.83	6.80	8.87
tyrosine	5.85	7.50	6.61	5.72	7.50
valine	10.93	11.35	10.28	9.00	10.07
alanine	8.06	7.07	6.07	5.08	7.07
arginine	14.09	12.65	10.46	9.46	12.65
aspartic acid	23.29	21.06	18.82	16.59	21.06
glutamic acid	24.70	25.73	26.75	30.87	30.25
glycine	8.06	7.60	7.13	6.67	7.60
histidine	4.54	3.68	4.64	4.91	4.59
proline	11.41	11.20	12.36	12.84	11.89
serine	11.16	10.35	11.57	10.75	11.36

Table 4 shows the amino acid content of akara prepared from the various cowpea:bean blends. In all cases, the sulfur amino acids were the limiting amino acids. However, for akara made from 100% HTC beans, the cystine and methionine levels were, respectively, 5.85% and 1.71% higher than that in 100% cowpea akara. With respect to the other amino acids, only the levels of glutamic acid, histidine, and proline increased with increasing levels of HTC beans in the akara. The essential amino acid content of akara made from 100% HTC mottled brown beans was on the whole relatively higher that that observed by Idouraine et al. (1989) for akara made from tepary beans, except in the case of lysine where observed levels were lower. In comparison with the FAO/WHO/UNU (1985) requirements, akara made from cowpea or from a mixture of cowpea and HTC beans was found to contain more essential amino acids (excluding tryptophan, which was not analyzed) than the standard pattern for adults as well as for children. Akara prepared from copwea:bean composite paste is thus equally as nutritive as 100% cowpea akara with respect to its protein content and quality.

The digestibility of raw bean proteins is generally very low, but cooking improves it. The degree of improvement depends on the process and cooking method. In the present study the degree of improvement in in vitro protein digestibility varied between 18% and 25% and with the bean content of akara (Figure 2). The variations were however not significant. In general, protein digestibility in akara decreased with an increase in HTC bean content. This was to be expected as earlier studies had shown that the development of the HTC defect reduces the digestibility of proteins in beans (Mbofung et al., 1996). Generally, protein digestibility ranged from 80.5% for 100% HTC bean akara to 83% for 100% cowpea akara. The level of protein digestibility (83%) in 100% cowpea-based akara was virtually identical to that (82.8%) reported by Phillips and Baker (1987). The effect of frying on protein digestibility is to be expected since heat treatment has been reported to improve the

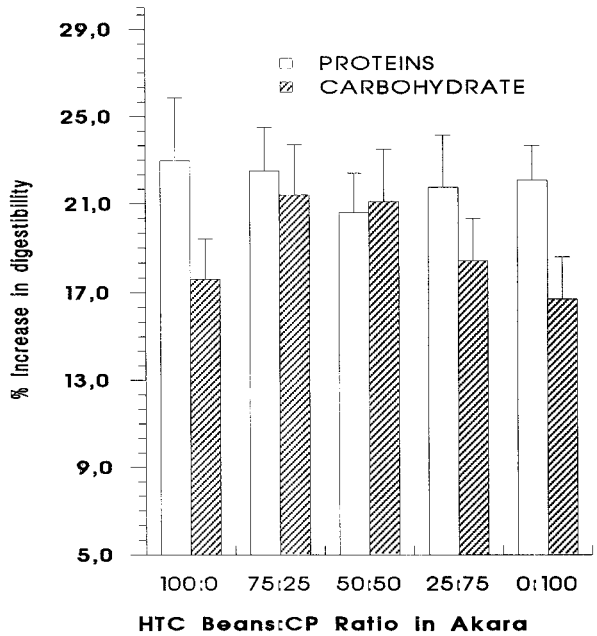

Figure 2. Percentage increase in protein and carbohydrate digestibility of akara after frying.

digestibility of legume proteins (Antunes et al., 1980; Sathe et al., 1982; Mansour and El-Adawy, 1994) through its effect on the destruction of antinutritional factors and on protein denaturation. On the whole, the relatively high level of digestibility emphasizes the fact that cowpea:HTC bean-base akara could be as nutritious as that traditionally made from cowpea.

In vitro carbohydrate digestibility was also observed to vary with the type of akara and ranged from 80.5% for 100% HTC bean-based akara to 91.0% for cowpea-based akara. On a relative basis, the improving effect of frying on the carbohydrate digestibility varied with the bean content of (Figure 2). The observed degree of digestibility of carbohydrate in akara is higher than those commonly reported for unprocessed beans or cowpea. This is to be expected because grinding, as a step in the processing of beans into akara, has been shown to enhance starch digestibility of cowpea (Tuan and Phillips, 1989). The relative increase in carbohydrate digestibility may also be associated with the decrease in α-amylase inhibitors following frying.

An increase in frying time was accompanied by a decrease in the antinutrient content. This is to be expected as the application of heat has been reported to cause a fall in the activity of α-amylase and trypsin inhibitors (Khalil and Mansour, 1995; Karanja et al., 1996). This was true for α-amylase inhibitor as well as for trypsin inhibitor activity (Figures 3 and 4). It is important to note, however, that the initial rate of fall in the activity of these inhibitors with an increase in frying time was not the same. The rate of α- amylase inhibitor destruction seemed to be faster than that of trypsin inhibitor. These differences in the pattern and rate of destruction may be related to the nature and concentration of the various inhibitors in the paste mixture besides other factors. In fact, the HTC bean content of akara seemed to be important in this case. There was an initial lag in the rate of destruction of AAI. The duration of this initial lag increased with an increase in HTC bean content of akara. However, irrespective of the latter factor, the lag phase was followed by an accelerated rate of destruction of AAI.

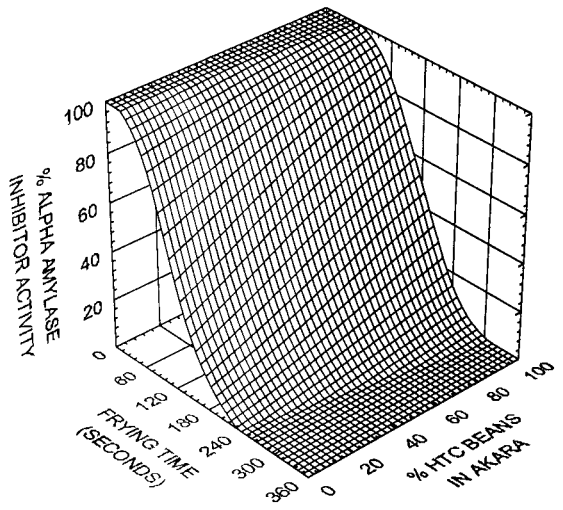

Figure 3. Response surface of α-amylase inhibitor activity as a function of frying time and HTC content of akara.

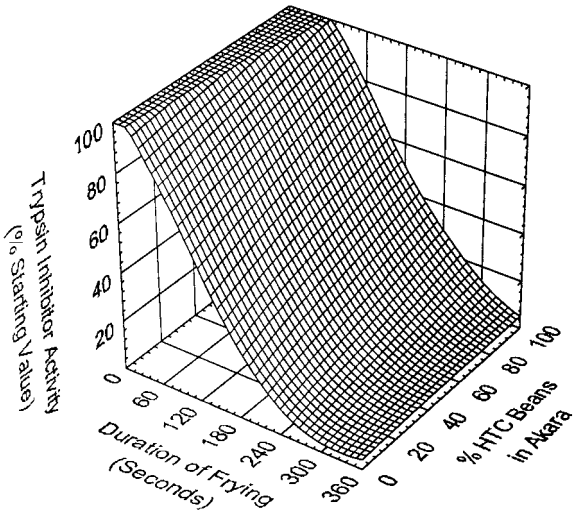

Figure 4. Response surface of trypsin inhibitor activity as a function of frying time and HTC content of akara.

In the case of TIA, the initial lag phase was about the same but the phase following was not as steep. The differences in the pattern of fall in the activity of these two antinutritional factors suggest that the two differ in their susceptibility to heat treatment. This observation needs to be investigated further. Differences in the bulk density of the different batter and by deduction, differences in the rate of heat penetration during the course of frying may also be contributing factors for the observed pattern of destruction of the antinutrients during frying. Generally, at the end of frying there was no detectable activity of α-amylase inhibitors. Furthermore, the levels of residual trypsin inhibitor activity observed in akara made from the different cowpea:HTC bean blends were far below those considered to be toxic and varied from 2.4 TIU/mg of sample of 100% cowpea akara to 3.9 TIU/mg of sample of 100% HTC bean akara. Compared to the raw pastes, these levels indicate an average decrease of well over 96% of inhibitors.

Sensory scores for the different akaras are as shown in Table 5. The taste, flavor, texture, and color of akara varied with the different type of akara. The differences were, however, not significant nor closely linked to the HTC content of the akaras. In any case, the scores for all attributes measured were systematically higher for 100% cowpea-based akara than for 100% HTC bean-

Table 5. Sensory and Acceptability Scores of Akara

	% HTC beans in akara				
attribute	0	25	50	75	100
color	6.4	6.8	5.8	6.3	6.5
taste	6.9	7.1	6.3	5.8	6.0
flavor	6.5	6.7	6.2	5.9	6.3
texture	7.1	6.6	6.0	5.8	6.3
acceptability	6.3a	7.0a	6.1	5.8ab	6.0

[a] Figures in a row bearing the same letter are significantly different ($P < 0.05$) from each other.

based akara. Significant differences were observed in the overall acceptability of akara made from the different composite pastes. Cowpea akara containing 25% HTC bean was rated higher than 100% cowpea akara. Using the Duncan multiple range test, a significant difference was observed between the acceptability of akara made from 100% cowpea and that made from composite paste containing 75% bean paste. Interestingly, akara made from 100% bean paste, though rated lower than that made from 100% cowpea paste, did not show any significant difference in acceptability. Using Spearman ranked correlation analysis it was observed that acceptability was influenced first by taste ($r = 0.69$) followed by texture (0.62), flavor (0.61), and lastly by color (0.41). In all cases the correlations were significant ($P < 0.05$).

The results of this study show that akara, a popular fried product usually made from cowpea, can also be made from a mixture of cowpea and HTC beans. The maximum acceptable level of incorporation of HTC beans attained was 50%. The akara produced from this mixture is of good nutritional value and has a better amino acid profile than that of whole cowpea akara. The use of composite CP:HTC bean paste for the production of akara represents a new possibility for increasing the consumption of HTC beans. Further studies are on the way to improve on the HTC component of the mixture as well as on the overall rating of the different attributes and acceptability of the akara.

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