Evaluation of extruded snacks from blends of acha (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours

Abiodun Adekunle Olapade*, Ogugua Charles Aworh

(*Department of Food Technology, Faculty of Technology University of Ibadan, Ibadan Nigeria*)

Abstract: The production of acha and cowpea are the complementary food and are produced in large quantities in Nigeria, which are the major sources of protein and carbohydrate respectively. The study was proposed on developed high protein-energy complementary foods from the blends of cowpea and acha using extrusion cooking. Cultivars of cowpea (IT90K-277-2) and acha (cream colour) were selected and milled into flours. Using the response surface methodology, the blends of acha and cowpea flours at 70:30 and 60:40 respectively were extruded using a single screw extruder at barrel temperature of 120-160℃ and feed moisture content of 18-25% (d.b). The proximate composition and trypsin inhibition activity of the extrudates and blends were determined, while compressive forces were determined using testometric analysis. The protein content increased from 7.98% for acha flour to 16.03% and 18.73% for blends containing 30.0% and 40.0% cowpea respectively. Trypsin inhibition activity of the blends decreased by 76.0% to 92.1% as a result of the increasing extrusion temperature and feed moisture content. Compression forces at the peak, break and yield of extrudates' ranged from 148.3 to 886.4 N, 140.2 to 882.5 N and 96.3 to 226.4 N respectively. Extrusion cooking parameters (barrel temperature, feed moisture content and feed composition) significantly affected the quality of the cowpea-acha blends.

Keywords: acha, cowpea, extrusion cooking, complementary food, chemical properties

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1 Introduction

Cowpea and acha are good sources of protein and carbohydrate respectively that can easily be processed into flours and blended to produce food of high protein quality with high nutritional value. Besides being a good source of B-vitamins, cowpea contains substantial quantities of lysine (Okaka and Potter, 1979) and when blended with acha it produced blends with complementary amino-acid profiles and improved the nutritional quality (Fu *et al*., 1996; Mensa-Wilmot *et al*., 2003; McWatters *et al*., 2004). Cowpea and acha utilization in food preparation is often limited because of drudgery and time waste associated with their preparations. Cowpea also contains some anti-nutritive substances and non-digestible oligosaccharides. These substances can be removed by appropriate processing methods to improve the nutritive value and organoleptic acceptance of such foods (McWatters et al., 2004). One of such processing methods is extrusion cooking (McWatters et al., 2004).

Extrusion cooking is a very versatile, high temperature processing method widely used in food processing industry because of its high throughput and high efficiency. Extrusion cooking technology uniquely combines mechanical shear, high pressure and inter-particulate frictional heat to transform raw materials into cooked products in a very short time. Extrusion cooking was reported to destroy the anti-nutritional factors of cowpea and inactivate lipoxygenase enzymes responsible for beany flavour development, thus overcoming the drawback to cowpea utilization in food preparation (Fu et al., 1996). Development of food

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* **Corresponding author's: Abiodun Adekunle Olapade,** Email: aaolapade@yahoo.com.

products through value added processes will help introduce and establish new domestic markets and open international market opportunities for the farmers. The objective of this work was to develop nutritious complementary foods from the blends of cowpea and acha using extrusion cooking technique.

2 Materials and methods

2.1 Materials

Cowpea variety (IT90K-277-2) was obtained from IITA Ibadan while cream coloured acha variety was obtained from Jos Central Market, Jos Nigeria. Refined vegetable oil was obtained from Bodija market, Ibadan.

2.2 Preparation of cowpea and acha flours

The cowpea was dehulled as described in Figure 1. The beans were briefly soaked in water for about 5 min at the room temperature (28℃) to loosen the seed coats. The wetted seeds containing approximately 22% to 25% moisture after draining the excess water, were spread in thin layer on wire mesh and dried in a forced-air oven at 60℃ for 4 h. The pretreated seeds were coarsely milled using a plate mill (Apex, Germany) to detach the seed coat. The loosed seed coats were then separated from the cotyledons using a locally fabricated aspirator (FIIRO, Nigeria). The dehulled cowpea was milled into powder using a laboratory hammer mill to pass through a 0.8 mm screen. Acha flour was prepared according to the procedure in Figure 2. Cream coloured acha was washed with tap water to separate stone and sand, then it was dried in the cabinet drier at 50℃ for 6 h. The

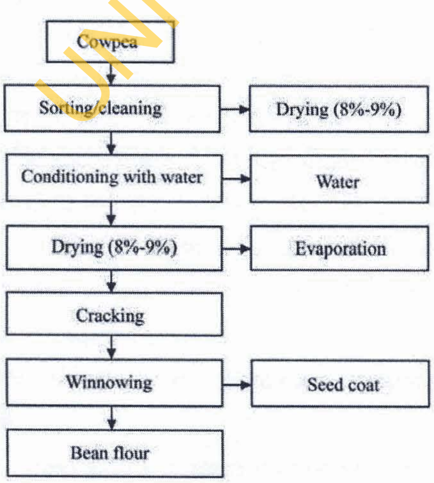

Figure 1 Preparation of bean flour

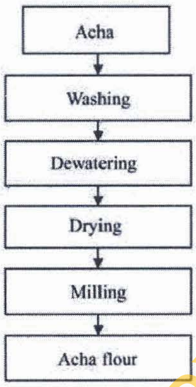

Figure 2 Preparation of acha flour

resultant dried acha was milled into powder using the milling plate. The flours were separately packaged in moisture proof polyethylene bags, sealed and stored under refrigeration for further use.

2.3 Particle size distribution analysis

Determination of particle size distribution in acha and cowpea flours was carried out using sieve analysis technique with seven sieves of various sizes. One hundred grams sample was weighed into the top sieve and mechanically shaken for 30 min. Sample part retained on each sieve was weighed, recorded and expressed as percentage of the original sample weight.

2.4 Formulation of complementary food from acha and cowpea blends

In accordance with the requirements of FAO/WHO/UNU (1985) for weaning foods to attain minimum levels of protein (16.7%), fat (6%) and energy 375 kCal/(100 g), two blends of cowpea flour and acha flour were prepared with the ratio 30:70 and 60:40 respectively. Five kilograms of each of the blends were conditioned to moisture content of 18% - 25% (permitted moisture range for the extruder utilized). 5% vegetable oil was thoroughly mixed with each blend and the blends were allowed to equilibrate for 12 h before being extruded.

2.5 Chemical analysis of the flours

The proximate chemical composition of acha and cowpea flours and their blends were determined (AOAC, 2000). The mineral content of the samples was also determined according to AOAC (2005) methods. Phosphorus was determined using Vanadomolybdate method (Tahir and Sumati, 2009). Gross energy was estimated using Atwater's factors.

2.6 Experimental design of extrusion variables

A response surface factorial design was used to evaluate the effects of process variables on extrudates' quality attributes (Design Expert 8.04). The process variables are nominal extrusion temperatures of 120, 140 and 160℃ and feed moisture content of 18%, 22% and 25% (d.b) as well as feed composition of 60:40 and 70:30 acha and cowpea, respectively. Table 1 shows the response surface factorial of the experiment design

Table 1 Custom Response Surface Factorial Experimental Design

Experiment No.	Coded			Actual		
	X_1	X_2	X_3	X_1/℃	X_2/%	X_3/%
1	1	1	C2	160	25	60/40
2	-1	-1	C2	120	18	60/40
3	1	1	C1	160	25	70/30
4	-1	1	C1	120	25	70/30
5	-1	-1	C1	120	18	70/30
6	-1	1	C2	120	25	60/40
7	1	-1	C1	160	18	70/30
8	-1	1	C2	120	25	60/40
9	0	1	C1	140	25	70/30
10	0	0	C1	140	22	70/30
11	-1	0	C2	120	22	60/40
12	-1	-1	C1	120	18	70/30
13	1	-1	C1	160	18	70/30
14	1	0	C2	160	22	60/40
15	1	1	C1	160	25	70/30
16	0	-1	C2	140	18	60/40

2.7 Extrusion cooking of blends

The blends of acha and cowpea flours were extruded on a single-screw extruder (Insta Pro 600Jr, U.S.A.) with 10.01 cm barrel bore diameter; 12.5 cm screw length, 9.01 screw diameter and 8.27 cm die opening. The extrusion was carried out at set (nominal) barrel temperatures of 120, 140 and 160℃. The extruder was stabilized for each run with 8 kg whole soybean. At steady operation in each case samples were collected in open pans. The extrudate was allowed to cool, then sealed in polyethylene bags and stored in the freezer (-10℃) for subsequent analysis.

2.8 Determination of chemical composition of extrudates

One hundred grams of each sample were milled into powder using a laboratory hammer-mill to pass through a 2.0 mm mesh sieve. Samples were packaged and heat sealed in high density polyethylene and stored under refrigeration (4℃) for further analysis. The proximate composition of the flours and extruded samples was determined (AOAC, 2000). Mineral elements were also determined according to AOAC (2000) methods. Phosphorus was determined using Vanadomolybdate method (Tahir and Sumati, 2009). Trypsin inhibitor activity (TIA) was determined according to a modified method of Kakade et al. (1974).

2.9 Evaluation of structural change in extrudates

The expansion at the die was determined by measuring the diameter and the length of the extrudate using Digital Venier caliper (Multitoyo, Japan). The transverse expansion is defined as the ratio of the diameter of the extrudate to the diameter of the die (Chang and El-Dash, 2003). The longitudinal expansion was expressed as length per unit dry weight of the extrudate. The extrudates were tested in an Instron Universal Testing machine (Testometric AX, England). The samples were placed between the jaws. The sample, 4 cm in length, was compressed at a deformation rate of 25 mm/min until failure or three levels of a preset deformation for recording the force relaxation curves. Ultimate strength (failure) results are based on five successful replicates.

3 Results

3.1 Particle size distribution of the flours

The particle size distributions of materials used are presented in Table 2. Acha flour used in this study was predominantly 300-500 µm in size while cowpea flour was predominantly 400-750 µm.

Table 2 Particle size distributions in acha and cowpea flours used for extrusion cooking

Particle size/µm	Acha flour/%	Cowpea flour/%
> 750	6.8	2.3
500-750	5.5	54.5
400-500	25.8	21
300-400	60.4	13
250-300	-	4.5
150-250	-	1
50-150	-	1.2
Recovery	98.5	98

3.2 Chemical composition of the flours and the blends

The results of the chemical composition analysis of the raw materials and the blends obtained from acha and cowpea powders are presented in Table 3. The major differences in the two materials used were the protein and trypsin inhibition activity, as the amount of cowpea is more than that of acha. The addition of cowpea raised the protein and ash contents but reduced the carbohydrate content of the blends. The fat content of the samples was very low ranging from 1.12% to 1.74% while energy values ranged from 389.62 to 393.68 kCal/(100 g). Mineral components of the blends were similar.

Table 3 Chemical composition of cowpea, acha and the blends

Components	Cowpea flour	Acha flour	Acha/Cowpea 70:30	Acha/Cowpea 60:40
Moisture content/%	11.00±0.20	12.57±0.15	12.53±0.31	11.88±0.75
Crude Protein/%	26.0±0.20	7.98±0.15	16.03±0.15	18.73±0.32
Ether extract/%	1.74±0.10	1.24±0.05	1.12±0.03	1.20±0.02
Ash/%	3.15±0.05	2.73±0.06	3.14±0.06	3.15±0.05
Crude fiber/%	1.62±0.08	0.40±0.05	0.45±0.06	0.48±0.08
Carbohydrate*/%	67.49±1.45	87.65±2.01	79.29±2.45	76.52±1.90
Energy/ Kcal · (100 g)$^{-1}$**	389.6±15.1	393.7±21.4	391.2±21.1	391.6±16.3
TIA/ mg · g^{-1}	13.1±1.6	2.70±.89	6.70±1.03	8.10±1.11
Fe/%	0.36±0.02	0.17±0.02	0.21±0.04	0.21±0.02
Ca/%	0.09±0.02	0.04±0.02	0.04±0.05	0.04±0.03
P/%	0.23±0.01	0.14±0.01	0.13±0.02	0.15±0.02

Note: ** Estimated using Atwater's factors;
* Determined by difference.

3.3 Chemical composition of the extrudates

The proximate compositions of extrudates from acha and cowpea mixtures are shown in Table 4. The moisture content of extrudates was considerably affected by the extrusion cooking. The moisture content of extrudates as emerged from the extruder was proportional to the moisture content of the blends. Crude protein values of the extrudates ranged from 16.0% to 18.9% showing that the adequacy of the formulations meets the protein requirement of complementary foods. The protein content of the feed mixtures was not significantly (p>0.05) affected by the extrusion conditions but there were significant differences (p<0.05) among the extrudates' samples. Trypsin inhibition activity (TIA) of the feed mixtures was significantly (p<0.05) affected by the extrusion parameters. The increase in the extrusion temperature led to the reduction in the TIA, while the increase in feed moisture content was observed to lead to a lower efficiency of the reduction. Energy values of the extrudates ranged from 410 to 421 kCal/(100 g). Ether extract values for the extrudates ranged from 6.09% to 7.66%, showing the practical significance of the addition of vegetable oil to the acha/cowpea mixtures. Ash content of the extrudates was high and varied from 2.91% to 3.79%, indicating that the extrudates were likely good sources of mineral elements. The results also revealed that the extrudates are high in crude fiber ranging from 1.21% to 2.13%.

3.4 Structural properties of the extrudates

The structural properties of the extrudates are shown in Table 5. The extrusion of the blends of acha and cowpea produced the expanded extrudates at all extrusion conditions. Both radial and longitudinal expansion ratios (p<0.05) were significantly affected by the extrusion temperature, feed moisture and blend ratio. The radial expansion ratio increased with the increase in temperature of the extrusion and feed moisture but decreased with the increase in the amount of cowpea in the blends. The radial expansion ratio measured for all the extruded products ranged from 1.88 to 4.04. The results revealed that high amount of cowpea in the blends led to the decrease in radial expansion ratio. The longitudinal expansion showed opposite trend to the radial expansion.

3.5 Compressive forces of the extrudates

The effects of extrusion conditions on the hardness of the extrudates are presented in Table 5. The force required to break the individual extrudate in this study exhibited the same patterns. This reflected a consistency and homogeneity in the produce. Tensile forces were the highest for the dense extrudates (i.e higher value of longitudinal expansion). The feed moisture, extrusion temperature and feed composition were found to have significant effects on extrudates hardness (p<0.05). An increase in the extrusion temperature caused a decrease in the peak force of the extrudates. Also, an increase in the feed moisture content resulted in a decrease in peak force, break force and yield force of the extrudates. The extrudate hardness was significantly (p<0.05) affected by the level of substitution of cowpea in the feed blend. The increase in the amount of cowpea caused the increase in the hardness of the extrudate as shown by the tensile forces.

Table 4 Proximate composition, energy and trypsin inhibition activity of extrudates from acha and cowpea mixtures

Sample	Moisture /%	Crude protein /%	Ether extract /%	Ash content /%	Crude fiber /%	Carbo-hydrate /%	Energy /Kcal · (100 g)$^{-1}$	TIA /mg · g^{-1}
A:120:18	12.4_{g}	16.2_{ef}	7.10_{b}	3.79_{a}	1.47_{e}	71.44	414.5	0.81_{h}
A:140:18	10.4_{ij}	16.5_{de}	7.20_{b}	3.11_{cd}	1.51_{e}	71.68	417.5	0.51_{j}
A:160:18	8.2_{l}	16.6_{de}	7.22_{b}	3.11_{cd}	1.21_{f}	71.86	418.8	0.23_{l}
A:120:22	14.2_{de}	16.0_{f}	7.45_{a}	3.08_{cde}	2.11_{ab}	71.36	416.5	1.80_{b}
A:140:22	10.3_{ij}	16.0_{f}	7.57_{a}	3.15_{c}	2.10_{ab}	71.18	416.9	1.20_{f}
A:160:22	8.9_{k}	16.5_{de}	7.66_{a}	3.10_{cde}	2.12_{ab}	70.62	417.4	0.80_{h}
A:120:25	17.7_{b}	16.6_{de}	6.87_{cd}	3.10_{cde}	1.45_{e}	71.98	416.1	1.93_{a}
A:140:25	13.9_{e}	16.6_{de}	7.03_{bc}	2.92_{g}	1.12_{g}	72.13	419	1.37_{e}
A:160:25	10.8_{hi}	16.9_{d}	7.10_{b}	2.97_{fg}	1.05_{g}	72.01	419.2	0.62_{i}
C:120:18	13.0_{f}	18.0_{c}	6.87_{cd}	3.40_{b}	2.13_{a}	69.6	412.2	1.52_{d}
C:140:18	12.5_{g}	18.8_{ab}	6.77_{de}	3.04_{def}	2.02_{b}	69.37	413.3	0.92_{g}
C:160:18	10.1_{j}	18.5_{ab}	6.57_{ef}	2.91_{g}	2.04_{ab}	69.98	413.1	0.33_{k}
C:120:22	15.8_{c}	18.3_{bc}	6.09_{g}	3.02_{ef}	2.03_{ab}	70.56	410.3	1.58_{cd}
C:140:22	13.1_{f}	18.9_{a}	6.09_{g}	3.07_{cde}	1.81_{d}	70.13	410.9	1.63_{c}
C:160:22	10.4_{ij}	18.9_{a}	6.08_{g}	3.09_{cde}	1.80_{d}	70.13	410.8	0.74_{h}
C:120:25	18.8_{a}	18.1_{ab}	6.73_{de}	3.37_{b}	2.03_{b}	69.77	421.1	1.70_{b}
C:140:25	14.7_{d}	18.7_{ab}	6.39_{f}	3.09_{cde}	2.04_{ab}	69.78	411.4	1.39_{e}
C:160:25	11.1_{h}	18.3_{bc}	6.83_{cd}	3.10_{cde}	1.91	69.86	414.1	0.56_{i}
p-value	0	0	0	0	0			0

Note: Means with the same subscripts along the column are not significantly (p>0.05) different from one another;

Sample code = feed composition: extrusion temperature: feed moisture;

A= 70: 30 Acha and cowpea respectively;

C= 60:40 Acha and cowpea respectively.

Table 5 Compressive forces of extrudates from acha and cowpea mixtures

Sample	Radial expansion	Longitudinal expansion /g · cm^{-1}	Peak force /N	Break force /N	Yield force /N	Energy to yield /N.m	Young modulus /N · mm^{-2}
A12018	2.25_{g}	1.54_{b}	756.1_{c}	751.9_{bc}	224.6_{b}	0.24_{e}	7808_{d}
A14018	2.47_{f}	1.33_{defg}	722.9_{cd}	723.0_{cd}	209.9_{bcd}	0.32_{d}	5832_{e}
A16018	2.60_{f}	1.27_{defgh}	630.1_{f}	628.7_{f}	183.4_{e}	0.44_{b}	8082_{c}
A12022	3.12_{c}	1.21_{efghi}	655.8_{ef}	654.2_{ef}	191.0_{de}	0.10_{f}	8086_{c}
A14022	3.85_{b}	1.19_{hi}	411.1_{h}	361.4_{j}	212.9_{bc}	0.08_{fg}	1153_{a}
A16022	4.12_{a}	1.10_{i}	451.7_{h}	425.8_{i}	134.6_{f}	0.40_{bc}	3535_{j}
A12025	3.04_{c}	1.27_{efgh}	289.5_{i}	288.1_{k}	107.7_{gh}	0.08_{fg}	3415_{j}
A14025	3.80_{b}	1.20_{fghi}	148.5_{i}	140.9_{l}	117.0_{fg}	0.07_{fgh}	4143_{i}
A16025	3.91_{b}	1.15_{hi}	293.2_{i}	290.7_{k}	94.0_{h}	0.05_{gh}	3391_{j}
C12018	1.94_{i}	1.84_{a}	886.6_{a}	882.5_{a}	226.7_{b}	0.52_{a}	5173_{g}
C14018	2.09_{ghi}	1.33_{defg}	811.9_{b}	802.6_{b}	209.3_{bcd}	0.49_{a}	5633_{f}
C16018	2.71_{de}	1.33_{defg}	730.9_{cd}	727.1_{cd}	202.3_{cde}	0.49_{a}	5917_{e}
C12022	2.07_{ghi}	1.35_{de}	609.6_{fg}	608.5_{fg}	198.2_{cde}	0.43_{b}	8005_{c}
C14022	2.86_{d}	1.20_{fghi}	691.1_{de}	696.4_{de}	188.3_{e}	0.39_{c}	8086_{c}
C16022	2.65_{ef}	1.20_{ghi}	563.7_{g}	551.5_{h}	332.0_{a}	0.52_{a}	10489_{b}
C12025	2.03_{hi}	1.49_{bc}	567.9_{g}	558.1_{gh}	331.2_{a}	0.49_{a}	10432_{b}
C14025	2.05_{hi}	1.38_{cd}	338.9_{g}	334.7_{jk}	96.0_{h}	0.05_{gh}	4718_{h}
C16025	2.22_{gh}	1.32_{def}	326.9_{i}	323.2_{jk}	91.5_{h}	0.03_{h}	5591_{f}
P-value.	0	0	0	0	0	0	0

Note: Means with the same subscripts along the column are not significantly (p>0.05) different from one another;

Sample code = feed composition: extrusion temperature: feed moisture;

A= 70: 30 Acha and cowpea respectively;

C= 60:40 Acha and cowpea respectively.

4 Discussion

The chemical composition of foods is necessary for life as it acts as the reference of nutrition to both humans and animals or to the structural components of large molecules with specific functions as stated in recommended daily allowance. Food uses of proteins cannot be overemphasized. The results of the chemical composition analysis of the raw materials and the blends obtained from acha and cowpea powders are presented in Table 3. The values obtained were similar and within the ranges reported earlier for acha (McWatters et al., 2004; Jideani and Akingbala, 1993; Irving and Jideani, 1997) and for cowpea (McWatters et al., 2004; Bressani, 1985). The protein content of acha (7.98%±0.15%) was very low compared with that of cowpea (26.0%±0.20%) and the blends (16%-19%), indicating that the consumption of acha alone cannot produce the required level of protein, which is necessary for complementary foods (FAO/WHO/UNU, 1985). Iwe (2000), and Iwe and Ngoddy (1998) reported the increases in the protein, fat, ash and trypsin inhibitor components of potato-soybean mixtures compared with that of potato alone. The increase in the protein content was reported for fufu enriched with soybean and maize product enriched with soybean tagged "soy-ogi" (Akinrele and Edwards, 1970). Ashaye et al. (2000) also reported the increase in the protein content of ogi supplemented with cowpea. Mineral components of the blends were similar. Similar observation was made when both raw cowpea and extruded cowpea were incorporated in wheat flour for bread making (McWatters et al., 2004). The energy values ranged from 389 to 392 kCal/(100 g). Ologhobo and Fetuga (1988) reported energy values of three improved cowpea varieties grown in Nigeria to the range between 327 and 469 kCal/(100 g). The results obtained in this study were within the reported range.

The proximate compositions of the extrudates from acha and cowpea mixtures are shown in Table 4. The moisture content of the extrudates was considerably affected by the extrusion cooking. The moisture content of the extrudates as emerged from the extruder was proportional to the moisture content of the blends used in preparing them. Similar observations were made for some extruded products (Phillips et al., 1984; Maurice and Stanley, 1978; Lorenz et al., 1974). Phillips et al. (1984) reported that the initial moisture of the feed was the major factor influencing final product moisture, with the extrusion temperature playing a minor role. Maurice and Stanley (1978) also reported that the initial moisture of the feed materials accounted for 69.8% of the variability in the final product moisture while temperature accounted for 19.4%. However, it was observed that the increase in the extrusion temperature at constant feed moisture content reduced the extrudates' moisture content. Crude protein values of the extrudates ranged from 16.0% to 18.9% showing the adequacy of the formulations to meet the protein requirement of complementary foods. The protein content of the feed mixtures was not significantly affected by the extrusion conditions but there were significant differences among the extrudates' samples (p<0.05).

Trypsin inhibition activity (TIA) of the feed mixtures was significantly affected by the extrusion parameters. The increase in the extrusion temperature led to the reduction in the TIA, while the increase in the feed moisture content was observed to lead to a lower efficiency of the reduction. Apata and Ologhobo (1997) reported a complete destruction of Trypsin inhibitor and haemagglutinnins in some tropical legumes by cooking. Iwe (1998) reported the decreases in values for TIA of the extruded sweet potato and soybean mixtures. The TIA values for the sweet potato and soybean mixtures were significantly affected by the screw speed and feed composition (Iwe, 2000). Fu et al. (1996) confirmed that the extrusion process destroys the anti nutritional factors of cowpea and inactivates lipoxygenase enzymes responsible for the beany flavour development. Thus, it overcame the drawbacks to cowpea utilization in food. Energy values of the extrudates ranged from 410 to 421 kCal/(100 g). Ether extract values for the extrudates ranged from 6.09% to 7.66%, showing the practical significance of the addition of vegetable oil to the acha/cowpea mixtures. Ash content of the extrudates was high and varied from 2.91% to 3.79%, indicating that the extrudates were likely good sources of mineral elements. The results also revealed that the extrudates are high in crude fiber ranging from 1.21% to 2.13%. Crude fiber is very important in adding bulkiness to the food and for the prevention of some diseases of the colon. There were strong correlations between feed composition and crude protein in the extrudate, as well as Trypsin inhibition activity and crude protein of the extrudates.

The structural properties include the expansion characteristics of the extruded products, which have important roles in determining the quality and acceptability of the final products (Yagci and Gogus, 2008). The expansion characteristics of the extrudates seek to describe the degree of puffing undergone by the materials as they exit the extruder through the die. The stored energy released in the expansion process caused the increase in the radial expansion ratio (Thymi et al., 2005). The feed moisture content had significant effect on both radial expansion ratio and longitudinal expansion ratio (p<0.05). Increasing the feed moisture content from 18% to 25% caused an increase in the radial expansion ratio and a decrease in the longitudinal expansion ratio. Similar trends were observed by earlier workers (Philips and Falcone, 1988; Yagci and Gogus, 2008). The feed composition, is the amount of cowpea in the blend, had significant effect (p<0.05) and negative correlation with the radial expansion ratio but positively correlated with the longitudinal expansion ratio. Yogci and Gogus (2008) reported a similar observation for the radial expansion ratio when different combinations of ingredient were used in feed blends. Increasing the amount of cowpea in the blend caused a decrease in the radial expansion ratio but an increase in the longitudinal expansion ratio of the extrudates. The decrease in the radial expansion ratio has been attributed to the dilution effect of protein on starch gelatinization with the increased firmness of plasticized extrudates (Yogci and Gogus, 2008).

5 Conclusions

The investigation so far revealed that the blending of acha and cowpea has the potential of producing enriched complementary food for teeming undernourished children of developing countries especially Nigeria. Also the study revealed that extrusion cooking parameters used in this study significantly affected the extrudate parameters (p<0.05).

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