

Chemical and Nutritional Evaluation of Extruded Complementary Foods from Blends of Fonio (*Digitaria Exilis* Stapf) and Cowpea (*Vigna Unguiculata* L. Walp) Flours

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Abstract— Complementary foods were formulated from fonio and cowpea, indigenous cereal and legume grains respectively. Both fonio and cowpea grains were prepared into flours. Blends of 50:50, 60:40 and 70:30 (w/w) fonio and cowpea flours respectively were prepared. The blends were conditioned to 22% moisture content (dry basis) by adding calculated distilled water and 5% vegetable oil was thoroughly mixed with each blend. The blends were separately extruded using a single screw extruder at 140 °C barrel temperature. The raw samples and extrudates were evaluated for proximate composition including crude protein, crude fibre, ash, fat, moisture using standard AOAC methods and trypsin inhibition activity using a recognized method. Nutritional quality of the extrudates was determined using rat feeding method. The animals were fed compounded experimental and control diets for 28 days. They were sacrificed after the experiment and their internal organs were removed and weighed. The results observed in this study revealed that blends of fonio and cowpea flours produced good complementary foods in terms of proximate composition especially protein content which increased with increase amount of cowpea in the blends. Protein content of formulated foods were 16.5- 20.3% compared to 7.91% value for fonio alone. Trypsin inhibition activities were drastically reduced in the extrudates by 81-82% compared to the raw blends used to prepare them. Protein quality evaluation revealed that the extrudates compared favourably with casein diet at 10% iso-nitrogenous protein level in all attributed studied. The extrudates had high protein quality and can support the growth of infants in developing countries.

Index Terms— Fonio, Cowpea, Extrusion cooking, Protein quality

I. INTRODUCTION

The attention of nutritionists and food scientists has focused on the problem of providing nutritious, low cost protein supplement to the diet of young children in developing countries including Nigeria. Ideally, the ingredients for low cost complementary foods must be derived from dietary staples available and affordable in the region of interest [1]. Complementary foods in most developing countries are mainly from cereal with animal protein being used as supplements. As a result of the high cost of animal protein, attempts were shifted to look into alternative sources of proteins, especially from plant sources [2]. According to Osundahunsi and Aworh [3] considerable efforts to improve the health and nutritional status of growing children have focused on the production of nutritious, low cost complementary foods from combinations of cereals and

legumes. Cereals are generally low in protein and are limited in some essential amino acids such as lysine and tryptophan, while legumes represent a major source of nutrients including valuable but incompletely balance protein [4]. Supplementation of cereals with locally available legumes that are high in protein and essential amino acids such as lysine is often practiced. Fonio (*Digitaria exilis* stapf.), an underutilized cereal, has the potential of providing enough food for the increasing population of people in West Africa and in the continent [5]. Fonio contains about 7% crude protein that is high in leucine (9.8%), methionine (5.6%) and valine (5.8%) [6]. Among legumes, cowpea (*Vigna unguiculata*) is predominantly grown and consumed in Nigeria. It is observed that cowpea is economically and nutritionally important legume as major source of proteins in developing countries. In addition to amino acid profile and digestibility, the nutritional quality of cowpea and other legumes is compromised by the presence of anti-nutritional factors, mostly trypsin inhibitor [7]. The nutritive value of a formulated food depends upon the processing methods, presence or absence of antinutritional factors and possible interactions among food components. There is little information on the use of fonio and cowpea for production of complementary foods despite the fact that cowpea and fonio are produced in large quantities in Nigeria, and are major sources of protein and carbohydrate respectively. The objective of this study is to produce high energy-protein low cost complementary food from blend of fonio and cowpea using extrusion cooking technology, and to evaluate nutritional quality of such foods using rat feeding method.

II. MATERIALS AND METHODS

Procurement of Materials: Cowpea (IT90K-277-2) was obtained from the farm store of IITA Ibadan, while cream coloured fonio was obtained from Jos central market in Jos Nigeria. A refined vegetable oil was obtained from Bodija market in Ibadan. A Insta Pro 600 Jr single screw extruder with 10.01 cm barrel bore diameter, 12.5 cm screw length, 9.01 screw diameter and 8.27 cm die opening at the farm house of IITA Ibadan was used in this study.

Preparation of Samples: Fonio and cowpea flours were prepared as shown in Figures 1 and 2 respectively. Blends of fonio and cowpea flours in ratios 50:50, 60:40 and 70:30 (w/w) were prepared respectively. Five kilogram each blend was conditioned into 22% moisture content and 5% vegetable oil was thoroughly mixed with the blend and allowed to equilibrate for 8 h. The blends were separately extruded at 140 °C barrel temperature. The extruder was stabilized for each run with 8 kg whole soybean. At steady state operation in each run, samples were collected in open pans, the

Manuscript received May 9, 2001.

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extrudates were allowed to cool then sealed in low density polyethylene bags and stored in a freezer (-10 °C) for subsequent analyses. Samples for analysis were milled into powders.

Chemical Analysis of Samples

Proximate composition of fonio, cowpea, the blends and extrudates was determined according to AOAC official methods [8] for crude protein, crude fibre, ash, fat, moisture. Carbohydrate was determined by difference. Trypsin inhibition activity (TIA) of the samples was determined according to the method of Kakade *et al.* [9].

Nutritional Evaluation of Samples

Twenty four weanling albino rats weighing between 40 and 60 g were randomly distributed into four groups each of six rats. They were placed in metabolic cages and fed a stabilizing diet containing 4% casein. After 5 days they were reweighed and regrouped for control and experimental diets. A basal diet comprised fermented corn flour (647.5 g); glucose (50 g); sucrose (150 g); non-nutritive cellulose (microgranular cellulose) (50 g), vegetable oil (100 g); minerals and vitamins premix (20 g); oyster shell (10 g); bone meal (20 g) and sodium chloride (2.5 g) was prepared according to Fanimo [10]. Experimental and control diets were prepared by incorporating the extrudates and casein (for control) into the basal diet to achieve an isonitrogenous diet at 10% protein level. The rats were housed in individual metabolic cages. Weighed diets and water were given ad libitum for 28 days and unconsumed diets were collected and weighed daily. The animals were weighed daily, while their faeces and urine were collected and pooled for each group. The faeces and urine were analysed for crude protein using AOAC [8] method. At the end of the test period, the animals were sacrificed with chloroform, the liver, pancreas, kidney and spleen were quickly excised and weighed. The food efficiency ratio (FER), protein efficiency ratio (PER), the net protein retention ratio (NPR) and protein retention efficiency (PRE) were calculated according to the procedures of Osundahunsi and Aworh [3].

Statistical Analysis

Data obtained were subjected to analysis of variance and the means were separated using Duncan's multiple comparison procedures.

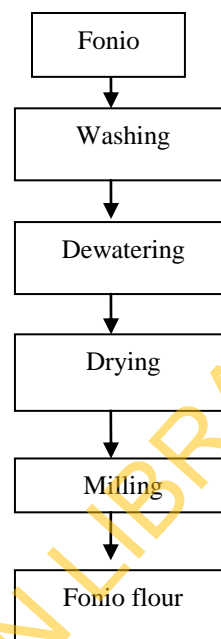


Figure 1: Preparation of Fonio Flour

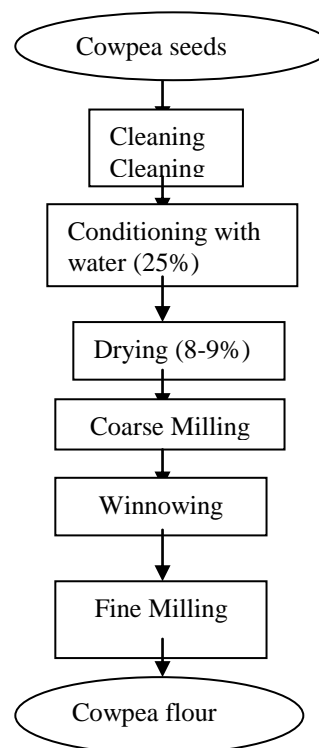


Figure 2: Preparation of cowpea flour

III. RESULTS AND DISCUSSION

Chemical and antinutritional components

The chemical compositions of foods are necessary for life as they act as sources of nutrition to both humans and animals or structural components of large molecules with specific functions as stated in recommended daily allowance. Foods uses of proteins cannot be overemphasized. The results of chemical composition analysis of the raw materials, the blends and extrudates obtained from fonio and cowpea powders are presented in Table 1. The values obtained were similar and within the ranges earlier reported for fonio (McWatters *et al.*, 2003; Jideani and Akingbala, 1993) and for cowpea (Bressani, 1985; McWatters *et al.*, 2003). The protein content of fonio (7.91%) was very low compared to that of cowpea (26.1%) and blends (16.0-19.4%), indicating that consumption of fonio alone cannot produce the needed level of protein required for complementary foods (FAO/WHO/UNU, 1985). The major differences in the two materials used were in protein and trypsin inhibition activity with cowpea having more than those of fonio. Addition of cowpea raised the protein and fonio contents but reduced the carbohydrate content of the blends. The fat content of the raw samples was very low ranging from 1.12 to 1.71%. Iwe (2000) and Iwe and Ngoddy, (1998) reported increases in protein, fat, ash and trypsin inhibitor components of potato-soybean mixtures compared to that of potato alone, which was similar to what was observed in this study. Crude protein values of the extrudates ranged from 16.5 to 20.3% showing adequacy of the formulations to meet the protein requirement of complementary foods (FAO/WHO/UNU, 1985). Protein contents of the feed mixtures were significantly ($p < 0.05$) affected by extrusion cooking and there were significant ($p < 0.05$) differences among the extrudates. Trypsin inhibition activity (TIA) of the feed mixtures was significantly ($p < 0.05$) reduced by the extrusion cooking. The findings in this study were consistent with the findings of Iwe (1998), who reported decrease in value for TIA of extruded sweet potato-soybean mixtures. Fu *et al* (1996) also confirmed that extrusion process destroyed the antinutritional factors of cowpea and inactivated lipo-oxygenase enzymes responsible for the beany flavour development thus overcome the drawbacks to cowpea utilization in foods. Fat content for the extrudates ranged from 6.88 to 7.32%, showing practical significance of addition of vegetable oil to the fonio-cowpea mixture. Ash content of the extrudates was high and varied from 3.52 to 3.90%, indicating that the extrudates were likely good sources of mineral elements. The results also revealed that the extrudates are high in crude fibre ranging from 0.05 to 0.81%. Crude fibre is very important in adding bulkiness to the food and for prevention of some diseases of the colon.

Nutritional components and weight of organs of animal fed the extrudates

Results of biological evaluation of protein quality of extruded blend of fonio and cowpea and control diet are presented in Table 2. The values observed for protein qualities for the extrudates were 0.25-0.33, 2.05-2.50, 2.33-2.77 and 37.5-44.6 for FER, PER, NPR and PRE respectively. There were

significant differences ($p < 0.05$) among the protein quality attributes of experimental diets of extruded blends of acha and cowpea flours compared to casein control diet. Diet containing extrudate of 50:50 acha and cowpea was scored next to the control diet in all attributes of protein qualities. Increase in amount of cowpea substitution led to increase in protein qualities as observed in this study. The complementary foods compared favourably with the casein diet. Similar results were observed for maize-based complementary foods enriched with cowpea and soya bean tempe [3]. Data on weights of organs of animal fed with different diets are also presented in Table 2. There were significant ($p < 0.05$) differences among weights of kidney, spleen, liver and pancreas for casein and complementary diets. Weights of internal organs of animals fed the experimental diets of extruded blends of acha and cowpea flours were significantly lowered ($p < 0.05$) compared to the animals fed casein control diet. The experimental diets compared favourably with casein diet in weights of all internal organs of the animal used in this study. The results obtained in this study were consistent with that of Osundahunsi and Aworh [3]. Extruded foods based on peanut, maize and soybean were reported to have better nutritional quality compared to similar convectional product as indicated by excellent rat growth response [19]. The PER values reported were 2.3-2.5, which were similar to the results observed in this study.

IV. CONCLUSION

The preliminary investigation into the possible use of combinations of fonio and cowpea flours for preparation of complementary food using extrusion cooking technology has revealed the possibility with good complementation of fonio and cowpea in terms of proximate chemical composition and protein quality.

ACKNOWLEDGMENTS

The authors wish to express our appreciation to Dr. JA Ayo of Federal Polytechnic, Bauchi for his assistance in sourcing fonio for this work

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Proximate Composition and Antinutritional Factor of Raw Fonio, Cowpea and Extruded Fonio and Cowpea Blends

Blend Cowpea	Fonio:	Moisture Content %	Crude Protein %	Crude Fibre %	Ash %	Ether Extract %	Carbohydrate %	Trypsin Inhibition activity mg
Raw:								
0:100		11.0±0.2 _e	26.1±0.3 _a	1.62±0.04 _a	3.14±0.05 _e	1.71±0.10 _d	67.5±0.3 _h	13.0±0.1 _a
100:0		12.4±0.2 _{bc}	7.91±0.11 _g	0.42±0.02 _f	2.72±0.03 _f	1.22±0.03 _e	87.7±0.1 _a	2.70±0.2 _e
50:50		11.5±0.6 _{de}	19.4±0.3 _c	0.52±0.03 _d	3.40±0.04 _d	1.21±0.03 _e	75.5±0.3 _d	8.95±0.09 _b
60:40		11.8±0.3 _{cd}	18.3±0.3 _d	0.48±0.03 _{de}	3.13±0.06 _e	1.20±0.02 _e	76.9±0.3 _c	8.10±0.04 _e
70:30		12.3±0.3 _{bc}	16.0±0.2 _f	0.45±0.02 _{ef}	3.15±0.05 _e	1.12±0.03 _e	79.2±0.2 _b	6.70±0.10 _d
Extruded:								
50:50		13.7±0.3 _a	20.3±0.5 _b	0.64±0.03 _c	3.90±0.02 _a	7.05±0.05 _b	68.1±0.5 _g	1.64±0.03 _f
60:40		12.8±0.3 _b	18.9±0.1 _c	0.81±0.01 _b	3.66±0.04 _b	6.88±0.02 _c	70.5±0.1 _f	1.56±0.05 _f
70:30		10.3±0.3 _f	16.5±0.3 _e	0.50±0.02 _{de}	3.52±0.03 _c	7.32±0.24 _a	72.1±0.1 _e	1.22±0.13 _g
Means		12.0±1.0	17.9±4.9	0.68±0.38	3.32±0.36	3.36±2.76	74.7±6.4	5.48±4.16

Means with the same subscripts along the column are not significantly different ($p < 0.05$)

Table 2: Nutritional Values of Experimental Diet compared with Control Diets and Weight Gain of the Organs

Sample	FER	PER	NPR	PRE	Liver (g)	Kidney (g)	Spleen (g)	Pancreas (g)
70:30	0.25 _c	2.16 _b	2.33 _c	37.5 _d	4.69 _d	0.64 _c	0.55 _a	0.58 _c
60:40	0.33 _a	2.05 _c	2.38 _{bc}	40.0 _c	4.87 _c	0.70 _b	0.43 _c	0.62 _b
50:50	0.28 _{bc}	2.13 _b	2.40 _b	40.8 _b	4.91 _b	0.70 _b	0.49 _b	0.64 _b
Basal Diet	0.08 _d	0.77 _d	0.00 _d	0.00 _e	3.29 _e	0.41 _d	0.19 _d	0.26 _d
Casein Diet	0.32 _{ab}	2.50 _a	2.77 _a	44.6 _a	5.19 _a	0.82 _a	0.45 _{bc}	0.73 _a

Means with the same subscripts along the column are not significantly different ($p > 0.05$)