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Nutritional Evaluation of Full-Fat Soyabean Boiled for Three Time Periods

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ABSTRAK

Nilai nutrien kacang soya penuh-lemak yang direbus bagi tempoh masa tiga kali dikaji dalam ujian yang seimbang terhadap tikus dan percubaan memberi makan bersama khinzir penyapih. Nilai peratus protein yang belum dimasak ialah 42.43, 42.7, 43.0 dan 43.4 bagi kacang soya mentah yang masing-masing direbus 30,60 dan 90 minit. Estrak eter disusun daripada 13.2% untuk contoh mentah kepada 19.0% bagi contoh-contoh yang direbus 90 minit fon. Terdapat sedikit kenaikan dalam kandungan asid amoni dengan penambahan masa memproses sementara pembalikan merupakan kes bagi elemen-elemen mineral dan faktor-faktor antinutrien. Indeks kualiti protein menunjukkan bahawa pengambilan makanan tidak dipengaruhi oleh rebusan. Kadar keefisienan protein (PER) dan nilai penahanan protein bersih (NPR) menurun dengan penambahan masa merebus. Tambahan berat dan pemakanan khinzir bertambah baik (P< 0.05) bersama masa merebus, manakala tidak mempunyai kesan yang signifikan terhadap pengambilan makanan.

ABSTRACT

The nutritional value of full-fat soyabean (FFSB) boiled for three time periods (30, 60, 90 min) was studied in a balanced experiment on rats and a feeding trial with weaner pigs. The crude protein percentage values were 42.34, 42.7, 43.0 and 43.4 for raw, 30, 60 and 90 min boiled soyabean respectively. Ether extract ranged from 12.3% for the raw sample to 19.0% for samples boiled for 90 min. There were slight increases in the amino acid content with increase in processing time while the reverse was the case for the mineral elements and the antinutritional factors. Protein quality indices showed that feed intake was not influenc by boiling. The protein efficiency ratio (PER) and net protein retention (NPR) values decreased with increasing boiling time. Weight gain and feed/gain of pigs were improved (P< 0.05) with boiling time, while boiling had no significant effect on feed intake. Increasing boiling time tends to improve the nutritive value of FFSB slightly.

INTRODUCTION

The use of full-fat soyabean (FFSB) for animal feeding has increased, particularly in Nigeria, because the high oil and protein content make it useful for inclusion in diets of high energy and high nutrient concentration. Use of the raw bean is limited due to the presence of heat-labile antinutritional factors, the most important of which are trypsin inhibitors, which seriously impair protein digestibility (Balloun 1980).

Because of this increasing use of soyabean and other legumes for animal nutrition, different technologies have been introduced for feedstuff processing. Depending on the technology use, the aims of processing are to inactivate the negatively acting substances by heat and mechanical treatment to destroy the plant cell structure. The latter should guarantee

*Present Address: Department of Animal Production & Health University of Agriculture, Abeokuta, Nigeria increasing nutrient availability for the animals.

Boiling of soyabean is the most commonly used farm-adaptable processing method in Nigeria (Awosanmi 1988). The optimum duration of boiling is an outstanding question. The American Soyabean Association recommends a minimum boiling time of 30 min (Monari 1988). In this study, three durations for boiling FFSB were investigated to determine their effects on the quality and utilization of the bean.

MATERIALS AND METHODS

Processing of Full-fat Soyabean

Raw soyabean was obtained from Pfizer Livestock Feeds Limited, Lagos, Nigeria. Raw soyabean packed in jute bags was lowered into a half-drum of boiling water and allowed to boil for 30, 60, and 90 min respectively. Timing of the boiling commenced when the water reached 100°C after introducing the bags. The boiled seeds were drained of water and sundried to less than 10% moisture level before being ground and stored. Portions were withdrawn for analysis and animal feeding experiments.

Analytical Procedure

The proximate and mineral composition of the processed samples were determined according to the Official Methods of AOAC (1990). Amino acid analysis was carried out using column chromatography. The phytin and phytic phosphorus content of the samples were determined according to the method outlined by Young and Greaves (1940). Urease activity was determined according to the procedure described by McNaughton *et al.* (1981) while trypsin inhibitor activity (TIA) was obtained through the procedure outlined by AOCS (1985).

Biological Evaluation

Twenty-four male albino rats of the Wistar strain, weighing 52-55 g and appropriately 21 days old, were obtained from the Faculty of Veterinary Medicine, University of Ibadan rat colony. They were divided into 6 groups of 4 rats each on the basis of initial weight. The rats were individually housed in perforated perspex cages with facilities for separate faecal and urinary collection.

The composition of the basal diet is shown in Table 1. The soyabean samples to be evaluated were added at excess of maize starch to give 10% crude protein on a dry matter basis. Nutritional casein diet was used as the reference standard. One group of 4 rats was given the N-free basal diet, and the remaining five groups were randomly allocated to the test and standard diets.

Rats were offered water and food *adlibitum* for 14 days. The rats were weighed weekly, faecal and urinary collections were made daily for the last 7 days of the experiment. The urine from each cage

TABLE 1
Composition of the basal diet for rats

Ingredients	%
Corn starch	64.95
Glucose	5.00
Sucrose	10.00
Non-nutritive cellulose	5.00
Vegetable oil	10.00
Premix*	2.00
Oyster shell	1.00
Bone meal	2.00
Salt (NaCl)	0.25

*Supplied per kg of diet: 500,000 IU vitamin A; 100,000 IU vitamin D3; 800 mg vitamin E; 400 mg vitamin K; 1200 mg vitamin B2; 1000 mg vitamin B3; 4 mg vitamin B2; 3000 mg niacin; 4000 mg vitamin C; 11,200mg choline; 24000 mg manganese; 800 mg iron, 16,000 mg copper; 18,000 mg zinc; 500 mg iodine; 48 mg selenium; antioxidant (BHT) was collected in small urine cups containing 3 cm^3 of 1.0M sulphuric acid as preservative. Each day's collection was stored in screw-capped bottles at -4°C. Faecal samples were collected daily, bulked for each rat, weighed, dried and stored. Duplicate samples of urine, faeces and diets were taken for nitrogen determination. From the data on nitrogen intake and excretion, and the weight gain, protein efficiency ratio (PER) and net protein retention (NPR) were calculated according to the procedure outlined by National Academy of Sciences/National Research Council (NAS/NRC) (1963) and Bender and Doell (1957) respectively, while biological value (BV) and net protein utilization (NPU) were calculated according to the procedure of Phillips *et al.* (1981). The true (nitrogen) N-digestibility was estimated according to the procedure of Dryer (1963).

Feeding Trial with Pigs

Four diets were formulated to contain raw, 30, 60, and 90 min boiled FFSB (Table 2). The diets were iso-nitrogenous and caloric, containing 20% crude protein and 3085 kcal ME/kg. A total 36 Large White × Landrace pigs weaned at 28 days, weighing initially 5.70 ± 0.09 kg, were assigned to four treatments of nine pigs each. Each treatment was replicated thrice with three pigs per replicate. Each replicate was housed in a concrete-floored pen. Feed and water were supplied *ad libitum*. The trial lasted for nine weeks.

Statistical Analysis

Data were subjected to analysis of variance, followed by the Duncan multiple range test (Steel and Torrie 1980) at 5% probability level to evaluate the difference among treatment means.

RESULTS AND DISCUSSION

Tables 3 and 4 show the proximate and mineral composition respectively of the test ingredients, while the amino acid composition is shown in Table 5. Processing has no significant effect ($P > 0.05$) on the proximate composition. The crude protein value

TABLE 2
Composition of diets for pigs

	FFSB			
	(Raw)	(30 min)	(60 min)	(90 min)
Maize	53.50	53.50	53.50	53.50
Maize offal	10.00	10.00	10.00	10.00
Fish meal	5.00	5.00	5.00	5.00
Full-fat soyabean	29.00	29.00	29.00	29.00
Bone meal	1.25	1.25	1.25	1.25
Oyster shell	0.75	0.75	0.75	0.75
Premix*	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Determined (Dry matter basis)				
Crude protein (%)	21.2	21.5	21.3	20.3
Crude fibre (%)	3.8	3.9	5.3	5.9
Ether extract (%)	3.1	2.1	3.5	2.3

*Supplied per kg diet: vitamin A, 10,000 IU; vitamin D_3; 2000 IU; vitamin E, 5 IU; vitamin K, 2.24 IU; vitamin B_{12} 0.01 mg; riboflavin, 5.5 mg; pantothenic acid, 10 mg; nicotinic acid, 25 mg; choline, 35 mg; folic acid, 4 mg; manganese, 56 mg; iodine, 1 mg; iron, 20 mg; copper, 10 mg; zinc, 50 mg; cobalt, 1.25 mg

TABLE 3
Proximate composition of the test ingredients (%)

		FFSB		
	(Raw)	(30 min)	(60 min)	(90 min)
Dry matter	91.4	91.29	91.79	91.51
Crude protein	42.2	42.7	43.0	43.4
Crude fibre	5.88	6.65	6.48	6.75
Ether extract	12.3	18.6	18.5	19.0
Ash	5.14	4.54	4.54	4.48
Nitrogen-free extract	34.28	27.51	27.48	26.37

TABLE 4
Mineral composition of the test ingredients (%)

		FFSB		
	(Raw)	(30 min)	(60 min)	(90 min)
Calcium (Ca)	0.731^{a}	0.670^{a}	0.591^{b}	0.502^{b}
Phosphorus (P)	0.102^{a}	0.099^{a}	0.086^{b}	0.095^{ab}
Sodium (Na)	3.247^{a}	2.946^{a}b	2.667^{b}	1.765^{c}
Potassium (K)	1.380^{a}	1.100^{b}	1.048b^{c}	0.950^{c}
Magnesium (Mg)	0.082^{a}	0.075^{a}b	0.061^{b}c	0.059^{c}
Iron (Fe)	0.043^{a}	0.038^{a}b	0.033^{b}	0.025^{c}
Copper (Cu)	0.0016^{b}	0.0019^{a}	0.0020^{a}	0.0020^{a}
Zinc (Zn)	0.008^{a}	0.0010^{b}	0.0010^{b}	0.0010^{b}
Manganese (Mg)	0.0057^{a}	0.0056^{a}	0.0057^{a}	0.0058^{a}

a, b, c Means with different superscript in horizontal rows are significantly different ($P < 0.05$)

is higher than values reported by Institut National de la Recherche Agronomique (INRA) (1984) but close to the value reported by Oyenuga (1968) for soyabean grown in Nigeria. The residual oil value fell within the range reported by Balloun (1980) and Tewe (1984). The ash and fibre content agrees with the values reported by Balloun (1980) and Tewe (1984).

Soyabean has been reported to be deficient in the sulphur amino acid - methionine and cystine (Balloun 1980). However, Patrick and Schaibe (1980) reported that the deficiency was due to unavailability rather than to absence. This may be a reason for the increased level of methionine with processing of the sample (Table 5). Generally, the mineral elements of the soyabean decreased ($P > 0.05$) with processing. This may be expected since most of the minerals are volatile; hence they are lost in water and through vaporization during processing. The longer the product stays in water during processing, the greater may be the loss. The antinutritional factors in the FFSB (Table 6) decreased with increased boiling time. This is the accordance with the findings of McNaughton *et al.* (1981). None of the soybean products is over-processed, but all were properly processed (except raw soybean).

Table 7 contains a summary of the biological evaluation of protein quality. Although the animals were offered isonitrogenous diets, their protein intake dif-

TABLE 5
Amino acid composition of the test ingredients (%) of dry matter

	Arginine	Histidine	Lysine	Phenylalanine	Tyrosine	Leusine	Isoleusine	Methnionine	Valine	Cystine	Alanine	Glycine	Glutamic acid	Serine	Threonine	Aspartic acid
FFSS (Raw)	2.77	1.07	2.35	1.80	1.38	2.85	1.78	0.50	1.82	0.54	1.58	1.79	7.08	1.71	1.44	3.76
FFSB (30 min)	2.88	1.52	2.64	2.49	1.69	3.55	2.20	0.61	2.03	0.60	1.97	1.96	8.8	3.32	1.79	5.36
FFSB (60 min)	2.90	1.57	2.74	2.54	1.68	3.65	2.23	0.63	2.06	0.60	1.99	1.99	8.86	2.38	1.81	5.50
FFSB (90 min)	2.89	1.60	2.80	2.57	1.71	3.64	2.22	0.63	2.05	0.60	2.02	2.02	9.14	2.44	1.83	5.52

TABLE 6
Antinutritional factors of FFSB samples

	FFSB				
	(Raw)	(30 min)	(60 min)	(90 min)	S.E. ±
Trypsin inhibitor activity (mg/g)	8.51[a]	4.43[b]	3.20[c]	2.85[d]	0.18
Urease activity (pH)	0.25[a]	0.16[b]	0.11[c]	0.08[d]	0.05
Dye-binding capacity (Cresol red absorbed) (mg/g)	2.63[b]	4.18[a]	4.22[a]	4.32[a]	0.03
Phytin (%)	0.95[a]	0.60[b]	0.56[bc]	0.50[c]	0.20
Phytin-phosphorus (% total phosphorus)	45.13[a]	28.5[b]	26.6[bc]	23.75[c]	0.42
Phytin-phosphorus (%)	0.29[a]	0.18[b]	0.17[b]	0.15[b]	0.3

a, b, c, d Means with different superscript in horizontal rows are significantly different ($P < 0.05$)
S.E. = Standard error

TABLE 7
Biological evaluation of protein quality using rats

	FFSB				
	(Raw)	(30 min)	(60 min)	(90 min)	S.E. ±
Average initial weight (g)	55.89	55.69	55.67	56.33	0.33
Average final weight (g)	59.98	63.37	64.55	65.13	1.32
Feed intake (g)	40.12[b]	42.38[b]	48.38[a]	41.99[b]	0.49
Crude protein of diet (%)	9.89	10.09	9.99	10.14	0.02
Protein intake (%)	3.97[b]	4.01[b]	4.66[a]	4.18[b]	0.07
Weight gained (%)	5.12[c]	7.68[b]	8.88[a]	8.80[a]	0.47
Protein efficiency ratio (PER)	0.53[b]	1.95[a]	2.01[a]	2.08[a]	0.20
Net protein retention (NPR)	2.08[a]	2.17[a]	2.04[a]	1.25[b]	0.03
Biological value (BV)	41.0[a]	60.76[b]	63.97[b]	64.66[b]	0.06
True nitrogen digestibility (TND)	44.33[b]	57.59[a]	55.16[a]	55.57[a]	1.78
Net protein utilization (NPU)	30.68	35.27	35.78	36.49	0.17

a, b, c Means with different superscript in horizontal rows are significantly different ($P < 0.05$)
SEM = Standard error of mean

TABLE 8
Performance of pigs fed boiled full-fat soyabean

	FFSB				
	(Raw)	(30 min)	(60 min)	(90 min)	S.E. ±
Initial weight (kg/pig)	5.6[a]	5.6[a]	5.8[a]	5.8[a]	0.09
Final weight (kg/pig)	18.00[b]	21.66[a]	22.10[a]	23.12[a]	0.66
Feed intake (gm/day)	620[a]	625[a]	635[a]	620[a]	0.22
Weight gain (gm/day)	196.8[b]	255[a]	265[a]	275[a]	0.64
Feed/gain	3.15[a]	2.45[b]	2.40[b]	2.25[b]	1.17

a, b, c Means with different superscript in horizontal rows are significantly different ($P < 0.05$)
SEM = Standard error of mean

fered, with rats on the 60-min processed FFSB consuming the highest protein ($P < 0.05$). Weight gain reflected the same trend as protein intake. Net protein retention was higher ($P < 0.05$) in the 90-min processed sample than in the others. Biological value, true nitrogen digestibility and net protein utilization increased ($P < 0.05$) with boiling time.

Variation in performance observed with rats fed with FFSB is in agreement with the observations of Bamgbose (1988) and Awosanmi (1988) for poultry that the nutritive value of a protein supplement can be improved by processing (heat treatment) due to increased availability and digestibility of intrinsic nutrients.

Results of the utilization by weaner pigs of the differently processed FFSB (Table 8) show that average daily feed intake was not significantly influenced by processing time of FFSB. This is in accordance with the findings of Awosanmi (1988) and Bamgbose (1988) for poultry that processing of soyabean may not affect the feed intake. Haywood *et al.* (1953) reported that the failure of raw soybean meal and low temperature oilseed meals to promote good growth was not due to a lack of feed intake but due to differences in the nutritional value of their protein as a result of the methionine deficiency. Feed to gain ratio improved ($P < 0.05$) in rats and pigs with processing time of FFSB. This agrees with the findings of Veltmann *et al.* (1987) for chicks.

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