EFFECT OF PERIOD OF BOILING FULL-FAT SOYABEANS ON ITS AMINO ACID PROFILE AND ON PERFORMANCE OF PIGS

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ABSTRACT

Amino acid analysis and 2 growth studies were carried out to determine the effect of period of boiling of full-fat soyabeans on their nutritive value for weanling and growing pigs. Soyabeans were boiled in water for 15, 20, 25 or 30 minutes in Experiment 1 and 25, 30, 35 or 40 minutes in Experiment 2. Forty cross-bred (Large White x Hampshire) pigs were used in each of the Experiments. Period of boiling had no effect on amino acid analysis of full-fat soyabeans. Weanling pigs had the best growth performance when soyabeans were boiled for 30 minutes and this was not significantly different ($P>0.05$) from the soyabean meal control diet. Period of boiling of full-fat soyabeans did not significantly ($P>0.05$) affect the performance of the heavier pigs, although improvement was observed up to 30 minutes of boiling.

Keywords: Pigs, soyabeans, amino acid, growth,

INTRODUCTION

Soyabean meal had been recognized and widely used as a source of high quality protein for non-ruminant animals. In Nigeria, where soyabean oil extraction mills are few, soyabean meal is in short supply and very expensive. Full-fat soyabeans therefore offers an attractive alternative. The advantages of full-fat soyabeans over soyabean meal are the high energy content of the beans which allows for higher energy diets to be formulated (Offiong, 1984), and the possibility of the

beans being incorporated in a simplified on-farm mixing programme without the extra expenses of oil extraction (Simovic *et al.*, 1972). Waldroup (1982) reported that the use of full-fat soyabeans in poultry diets was economically feasible.

The presence of antinutritional factors in raw soyabeans has limited their use in non-ruminant animals. Ologhobo (1980) classified the major antinutritional factors in soyabeans as trypsin inhibitors, haemagglutinins and goitrogenic factors. Since the discovery of the beneficial effects of heat treatment on the nutritional value of raw soyabeans, the challenge had been to determine the appropriate level of heat treatment for optimum utilization. A precise control of the heating process is presumed to be critical to the preparation of soyabeans for maximum nutritional value. Several heat treatment methods have been reported (Marty and Chavez, 1993) but facilities for many of them are rare in Nigeria. This study was designed to evaluate the effect of cooking time of full-fat soyabeans on their amino acid profile and growth performance of pigs.

MATERIALS AND METHODS

The soyabeans used in this study were procured at a local market. The soyabean meal was obtained from Taraku Mills Limited, a soyabean processing company in Benue State.

Raw soyabeans were cleaned and poured into a drum of boiling water. The beans were allowed to cook for the indicated time periods

TABLE 1: COMPOSITION OF DIETS FED TO WEANLING PIGS IN EXPERIMENT 1

	(% DM basis)				
Diet	1	2	3	4	5
Boiling time (minutes)	SBM ¹	15	20	25	30
Ingredient: g/kg					
Maize	565.2	502.00	502.00	502.00	502.00
Soyabean meal	308.8	-	-	-	-
Soyabeans	-	372.50	372.50	372.50	372.50
Maize offal	100.00	100.00	100.00	100.00	100.00
Limestone	5.00	4.50	4.50	4.50	4.50
Bone meal	15.00	15.00	15.00	15.00	15.00
Salt	4.00	4.00	4.00	4.00	4.00
Premix V/Tm. ²	2.00	2.00	2.00	2.00	2.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated nutrient composition (g per kg)					
Crude protein	200.00	200.00	200.00	200.00	200.00
Energy (ME, MJ kg ⁻¹)	14.86	15.71	15.71	15.71	15.71
Calcium	8.10	8.00	8.00	8.00	8.00
Phosphorus	6.00	5.80	5.80	5.80	5.80

¹SBM = Soyabean meal control diet

²The commercial premix (Roche VM-502) contributed the following per kg of the premix: Vit. A, 12,000IU.; Vit. E, 3.61IU.; Vit.K, 1.8mg; Vit B₂, 3.6mg; Nicotinate, 1.8gm.; Calcium-D-pantothenate, 9.6mg.; Biotin, 3.6mg.; Vit. B₁₂, 0.012mg.; Choline chloride, 120mg.; Chlortetracycline, 48mg.; Mn, 24mg.; Iron, 48mg.; Zn, 96mg.; Iodine, 1.8mg.; Cobalt, 0.48mg.

and the cooked beans spread out thinly on a concrete floor with occasional turning and allowed to dry before being ground in a hammer mill.

Amino acid analysis was carried out in triplicate, using Technicon – TSM sequential multisample amino acid analyzer on previously defatted and hydrolysed samples of soyabean meal and boiled soyabeans.

Experiment 1

Forty cross-bred (Large White x Hampshire) pigs with an average initial live weight of 12.82kg were used to evaluate the effect of cooking time on growth performance. Prior to the trial, the pigs were fed a common diet. They were weighed at the beginning of the experiment and allotted to the treatments in a randomized design with eight animals per treatment. The experimental diets contained full-fat soyabeans boiled for 15, 20, or 30

minutes (Table 1), while the soyabean meal diet served as the control. All the diets were formulated to be iso-nitrogenous. The pigs were individually fed and watered *ad libitum* in solid floor pens equipped with concrete feeders and waterers. Refused feeds were weighed every morning to determine feed intake by difference. Average daily feed intake, average daily gain (ADG), feed gain ratio and protein efficiency ratio (PER) were calculated. The experiment lasted for 42 days.

Experiment 2

Forty pigs, averaging 30.70kg were used to test the effect of cooking soyabeans for 25, 30, 35 or 40 minutes on their nutritive value. The composition of the diets is presented in Table 2. The experimental design and methodology were as described for Experiment 1. The experiment lasted for 35 days. The soyabean meal diet served as the control.

TABLE 2: COMPOSITION OF DIETS FED TO GROWING PIGS IN EXPERIMENT 2

Treatments	1	2	3	4	5
Duration of boiling (Minutes)	SBM ¹ Control	25	30	35	40
Maize	627.00	586.50	586.50	586.50	586.50
Soyabean meal	197.00	-	-	-	-
Soyabeans	-	237.50	237.50	237.50	237.50
Maize offal	152.00	152.00	152.00	152.00	152.00
Limestone	3.00	3.00	3.00	3.00	3.00
Bonemeal	15.00	15.00	15.00	15.00	15.00
Salt	4.00	4.00	4.00	4.00	4.00
Premix V/Tm ²	2.00	2.00	2.00	2.00	2.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated nutrient composition (g per kg)					
Crude protein	160.00	160.00	160.00	160.00	160.00
Energy (ME, MJ kg ⁻¹)	14.85	15.39	15.39	15.39	15.39
Calcium	6.60	6.50	6.50	6.50	6.50
Phosphorus	5.40	5.30	5.30	5.30	5.30

¹SBM = Soyabean meal diet

²The commercial premix (Roche Vm 502) contributed the following per kg of the product. Vit. A, 12,000 I.U.; Vit. D₃, 12,000 I.U.; Vit. E, 3.6 I.U.; Vit. K, 1.8 mg; Vit. B₂, 3.6 mg; Nicotinate, 18 mg; Calcium-D-pantothenate, 2.6 mg; Biotin, 3.6 mg; Vit. B₁₂, 0.01 mg; Choline chloride, 120 mg; Chlortetracycline, 4.8 mg; Mn, 24 mg; Iron, 48 mg; Cu, 60 mg; Iodine, 1.8 mg; Cobalt, 0.48 mg. MJ = Megajoule.

Statistical Analysis

Analysis of variance was applied (Snedecor and Cochran, 1980) to the data and significance determined by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Amino Acid Profile

The amino acid profiles of soyabean meal, raw and boiled soyabeans are presented in Table 3. Both soyabean meal and soyabeans (raw or cooked) were fairly rich sources of essential amino acids particularly lysine. The high lysine content of soyabean protein makes it a useful supplement for cereal grains which are generally low in this amino acid (Mostafa *et al.*, 1987 and Omar, 1989). The analysis

however shows that the sulphur amino acids methionine and cystine are low in both soyabean meal and full-fat soyabean samples. This agrees with Ortheofer (1978), Offiong (1984) and Weingartner (1987). Comparing soyabean meal and full-fat soyabeans, the meal contained higher levels of most amino acids than full-fat soyabeans. This is expected, since commercial soyabean meal is prepared by first extracting most of the oil, with the resultant concentration of other nutrients including the amino acids. Duration of boiling had no effect on amino acid composition as indicated by the lack of difference between raw soyabeans and those boiled for different durations. Also no definite trend was observed as duration of boiling increased from 15 to 30 minutes.

TABLE 3: AMINO ACID PROFILE OF SOYBEAN MEAL, RAW AND BOILED SOYBEANS

Treatment	(PERCENT DM)						SEM
	1	2	3	4	5	6	
Duration of boiling (min)	SBM ¹	0	15	20	25	30	
Amino acids							
Isoleucine	1.91	1.76	1.72	1.69	1.73	1.78	0.02
Leucine	3.23	2.77	2.52	2.47	2.54	2.64	0.05
Lysine	3.27	2.76	2.66	2.78	2.68	2.59	0.04
Methionine	0.55	0.45	0.46	0.43	0.51	0.46	0.01
Cystine	0.65	0.49	0.50	0.48	0.61	0.54	0.02
Phenylalanine	2.59	1.56	1.53	1.47	1.55	1.63	0.03
Tyrosine	1.50	1.10	1.18	1.05	1.15	1.22	0.03
Threonine	1.67	1.54	1.47	1.52	1.51	1.54	0.01
Tryptophan	0.70	0.49	0.77	0.51	0.51	0.54	0.05
Valine	2.11	1.35	1.37	1.38	1.38	1.37	0.01
Arginine	3.06	2.63	2.60	2.63	2.63	2.65	0.01
Histidine	1.37	1.02	1.00	1.02	1.01	1.01	0.01
Alanine	2.06	1.62	1.63	1.59	1.49	1.64	0.03
Aspartic acid	5.08	3.40	3.41	3.70	4.03	3.72	0.12
Glutamic acid	8.42	7.25	6.73	6.90	6.90	7.04	0.09
Glycine	1.94	1.55	1.53	1.51	1.54	1.57	0.01
Proline	2.49	1.86	1.78	1.88	1.71	1.45	0.08
Serine	2.45	1.98	1.79	1.95	2.00	2.02	0.04

¹SBM = Soyabean meal²Essential amino acids for pigs.**Experiment 1**

The results of the growth studies and protein utilization by weanling pigs is summarized in Table 4. The pigs fed diet 1 (control) had significantly ($P<0.05$) higher total and average daily weight gains than those on treatments 2, 3 and 4 (full-fat soyabean diets). The performances of animals on treatment 5, were generally similar to those on the soyabean meal control diets. Feed intake of animals on treatments 5 in which soyabeans were boiled for 30 minutes was similar to the soyabean meal control group ($P>0.05$). Pigs on the control diet however consumed significantly ($P<0.05$) more feed than those on treatment 2, 3 and 4, in which soyabeans were boiled for 15, 20 and 25 minutes respectively. Feed: gain ratio did not differ between treatment groups. However, the control animals required slightly less feed per unit gain and had higher protein

efficiency ratio than those on the full-fat soyabean diets except treatment 5. No mortality was recorded.

The significant ($P<0.05$) increase in growth performance when soyabeans were boiled for 30 minutes indicates the beneficial effect of that level of heat treatment in improving the nutritional value of soyabean protein. The fact that soyabean protease inhibitors and other toxic factors are heat labile (Liener and Kakade, 1980), suggests that boiling was responsible for their destruction and the enhancement of the nutritional value of the soyabeans. Soyabean protease inhibitors have been associated with pancreatic hypertrophy with consequent endogenous loss of essential amino acids (Booth *et al.*, 1960).

SOYABEANS PROCESSING AND NUTRITIVE VALUES FOR PIGS

TABLE 4: THE GROWTH PERFORMANCE OF WEANLING PIGS AS INFLUENCED BY BOILING TIME OF SOYABEANS

Treatments	1	2	3	4	5	SEM ¹
Cooking time, (minutes)	SBM ²	15	20	25	30	
Performance criteria						
Initial weight, (kg)	12.90	12.84	12.61	12.61	12.95	0.54
Final weight, (kg)	31.95	25.84	26.26	26.39	26.19	2.89
Total weight gain, (kg)	19.12 ^a	13.00 ^b	13.33 ^b	13.58 ^b	15.75 ^{ab}	1.41
Av. daily weight gain, (kg)	0.46 ^a	0.31 ^b	0.32 ^b	0.38 ^{ab}	0.37 ^{ab}	0.04
Av. daily feed intake, (kg)	0.99 ^a	0.77 ^b	0.78 ^b	0.80 ^b	0.89 ^{ab}	0.04
Feed: gain ratio	2.20	2.55	2.43	2.49	2.39	0.32
Protein efficiency ratio (PER)	2.45 ^a	1.92 ^b	2.01 ^b	2.04 ^b	2.13 ^{ab}	0.22

¹SEM = Standard error of means

²SBM = Soybean meal served as control

*Means in the same row with different superscripts differ significantly (P<0.05)

PER = $\frac{\text{Weight gain (g)}}{\text{Protein intake (g)}}$

The conservation of these essential amino acids would ensure that the amino acids go into the synthesis of body tissues rather than being wasted in the synthesis of excess pancreatic enzymes (Rackis *et al.*, 1986). It has been reported (Van der Poel *et al.*, 1990) that the chemical nature of soyabean protein is such that in the raw state, its molecules are globular in nature, being completely folded and not susceptible to proteinases until their internal structure has been disrupted by heat. Jorgensen *et al.* (1984) reported that the availability of amino acids in soyabeans becomes enhanced when heated and that methionine was released earlier from heated soyabean meal than from raw soyabeans during the process of digestion.

In a 42-day experiment with starter pigs, Zimmerman *et al.* (1970) observed that rate of gain was more rapid in pigs fed soyabean meal control diets than those fed infra-red roasted full-fat soyabean diets. In this study, the pigs on the soyabean meal control diet gave superior performance to the other treatments except treatment 5 in which soyabeans were boiled for 30 minutes. The generally lower feed intake of animals on the full-fat soyabean diets was due to the higher fat content and therefore higher caloric density of those diets

compared to the control. It has been suggested that pigs eat to satisfy their energy requirements. The lower feed to gain ratio and protein efficiency ratio obtained for pigs on the full-fat soyabean diets up to 25 minutes of boiling showed that longer period of boiling was required to effectively inactivate the anti-nutritional factors for inclusion in weanling pig diets. A major advantage of the use of full-fat soyabeans in pig rations in developing countries is the reduction in the quantity of maize required in the full-fat soyabean diets relative to the soyabean meal diet, thereby reducing the competition between humans and animals for maize.

Experiment 2

The results of Experiment 2 is presented in Table 5. No significant (P>0.05) differences were observed in the performance of the growing pigs across the treatments.

The lack of significant difference in performance between treatments is an indication that for growing pigs of the weight used in the trial, boiling soyabeans at 100°C for as short a time as 25 minutes was adequate. Jimenez *et al.* (1963) showed that while weanling pigs were limited in the use of protein from raw or partially processed

TABLE 5: THE PERFORMANCE OF GROWING PIGS FED BOILED FULL-FAT SOYABEANS FOR DIFFERENT PERIODS.

Treatments	1	2	3	4	5	SEM ¹
Boiling time, (min.)	SBM ²	15	20	25	40	
Performance (criteria)						
Initial weight, (kg)	30.70	30.65	30.79	30.75	30.70	1.55
Final weight, (kg)	48.90	49.20	50.74	50.00	48.55	4.11
Av. daily weight gain, (kg)	0.52	0.53	0.57	0.55	0.51	0.00
Av. daily feed intake, (kg)	1.46	1.49	1.52	1.44	1.40	0.00
Feed/gain	2.82	2.83	2.71	2.64	2.74	0.02
Protein efficiency ratio (PER)	2.28	2.21	2.31	2.36	2.27	0.12

¹SEM = Standard error of means²SBM = Soyabean meal diet (control)Differences between means were not significant ($P>0.05$)

soyabeans, mature pigs were able to utilize even raw soyabeans without affecting performance significantly. It was observed in the present study that performance tended to decline though insignificantly when pigs were fed full-fat soyabeans diets for which boiling time exceeded 30 minutes. This probably resulted from overboiling which would suggest that 30 minutes boiling time was optimum and would be in agreement with the results of Experiment 1. Van der Poel *et al.*, (1990) reported that overheating of soyabeans in terms of excessive temperature and/or exposure time to heat may depress digestibility of amino acids, particularly lysine. Early reports on the nutritional value of boiled soyabeans for swine indicated that cooked soyabeans were an excellent source of protein for pigs. Jimenez *et al.*, (1963) reported that rate of gain and feed: gain ratio of pigs fed corn-heated soyabean diets were essentially equal to corn-soyabean meal diets for growing swine.

In conclusion, the results support the view that heat treatment is essential in improving the nutritional quality of soyabeans. Thirty minutes cooking time for soyabeans is adequate for inclusion in rations for weanling and growing pigs. The use of full-fat soyabeans boiled for 30 minutes in young pig diets would have the advantages of on-farm

application and of serving as both protein and energy source.

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SOYABEANS PROCESSING AND NUTRITIVE VALUES FOR PIGS

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