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The Effect of Feeding Soyabeans Treated with Different Alkaline Salts on the Protein and Energy Utilisation by Starter Boilers

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ABSTRAK

Satu eksperimen telah dijalankan untuk menguji kesan efisyen susu kacang soya beralkali terhadap protein kepada ayam pedaging. Benih soya direndam selama 24 jam dalam sebatian akueus sodium klorida (3% kelikatan), trona dan alum, dikeringkan, dikisar dan digunakan bagi melakukan rawatan pokok, kacang soya yang dirawat dengan sodium klorida (T2), trona (T3) dan alum (T4), dengan kacang soya yang dibakar sebagai kawalan (T1). Keputusan menunjukkan kacang soya yang direndam dalam sebatian garam alkali telah mengurangkan sedikit DM, CF, NFE and GE manakala EE dan abu mencatatkan kadar lebih rendah dalam kacang soya yang dibakar. Nilai PER untuk T1 dan T4 adalah sama dan lebih tinggi, manakala efisyen tanaga bertambah dalam T3 dan T4. Pada peringkat akhir fasa pertama, berat badan dan penambahan berat ayam pedaging yang mana ia dirawat dengan NaCI adalah lebih lemah berbanding dengan kumpulan lain, ini diakibatkan oleh jumlah pemakanan yang rendah ($p<0.05$) dan efisien pemakanan lemah ($p<0.05$). Ayam pedaging diberi makan kacang soya yang dirawat oleh trona dan alum mempunyai kadar efisyen tenaga yang lebih tinggi berbanding yang diberi dengan rawatan NaCI dan kawalan diet. Ia boleh disimpulkan bahawa mana-mana dari tiga garam alkali tersebut boleh digunakan untuk proses kacang soya untuk pemakanan ayam pedaging tetapi untuk tenaga yang lebih baik dan efisyen protein, penggunaan alum dan trona adalah lebih elok.

ABSTRACT

An experiment was conducted to evaluate the effect of feeding alkaline treated soyabeans to broilers on protein and energy efficiency of the starter boilers. Soyabean seeds were soaked in aqueous solution (3% concentration) of sodium chloride, trona, and alum respectively for 24 hours, air-dried, ground and used in compounding the three treatments, sodium chloride treated soyabeans (T2), trona (T3), and alum (T4), with roasted soyabeans as the control (T1). The results indicated that soaking soyabeans in alkaline salt solution slightly reduced DM, CF, NFE and GE while EE and Ash were lower in the roasted soyabean seeds. The PER values for T1 and T4 were similar and higher values while energy efficiency was improved in T3 and T4. At the end of the starter phase, the body weights and body weight gains of the broiler on diets in which soyabeans were treated with NaCI were poorer even compared to the other groups, which was partly attributed to the lower feed intake ($p<0.05$) and poor feed efficiency ($p<0.05$) of the group. The broilers fed trona and alum treated soyabeans had better energy efficiency ratio than the ones fed the NaCI treated soyabean and the control diets. It was concluded that any of the three alkaline salts could be used to process soyabeans for broiler consumption but for better energy and protein efficiency the utilization of trona and alum were preferable.

INTRODUCTION

In countries like Nigeria, the use of raw or whole soyabeans as a source of plant protein in animal diets was on the increase. However, raw soyabeans need to be processed before their incorporation into the animal diets in order to remove anti-nutritional factors including polyphenols and typsin inhibitors. It is also desirable to reduce the high levels of oligosaccharides, notably raffinose and stahyose, which cause flatulence and abdominal discomfort in animals. Soaking in water and boiling are the methods commonly in use (Fanimo 1996). Excessive soaking under tropical conditions can lead to serious microbial deterioration while

boiling uses firewood or other fuel, which may be scarce and expensive. This creates the obvious need for seeking alternative methods of processing soyabeans.

The addition of alkaline salts such as sodium bicarbonate has been shown to reduce soaking and cooking time (Singh *et al.* 1988). Polyphenols were removed by soaking legumes in water and sodium bicarbonate, which makes the process efficient (Laurena *et al.* 1986). Omueti *et al.* (1992) reported that soaking and blanching of soyabeans is an effective way of inactivating trypsin inhibitors and removing a significant proportion of polyphenols and oligosaccharies. Nelson *et al.* (1976) stated that removal of trypsin inhibitor by blanching was made more effective by addition of sodium bicarbonate. Ayanwale (1999) also reported that sodium sesquicarbonate (trona) can be used without detrimental effect on broiler performance and carcass quality. Consequently, this work was designed to evaluate the effect of sodium chloride, trona and alum, which are equally cheap and readily available, on the protein and energy utilization, by starter broilers.

MATERIALS AND METHODS

Processing of the Soyabeans

The different alkaline salt solutions, sodium chloride (NaCl), sodium sesquicarbonate (trona) ($Na_2CO_4NaHCo_3.H_2O$) and alum ($A1_2$ (So_4) $.24H_2O$) were prepared by adding 30g of each alkaline salts to 1,000 milliliters of water at room temperature. The raw soyabean seeds were then soaked in the prepared 3% solutions of the salts for 24 hrs, drained, air-dried, ground and used in preparing the four isocaloric and isonitrogenous diets (Table 1). The crude protein level of the diets is 24.16% while energy level is 3.18kcal/g.

Soaking was done in such a way that the soyabeans were always completely covered with the alkaline solution. This was ensured by checking at regular intervals. Four broiler starter diets were formulated and designated T1, T2, T3, and T4, respectively. Diet T1 was the control, which contained roasted soyabeans while diets T2, T3, and T4 contained sodium chloride, trona and alum-processed soyabeans respectively. (Table 1) Roasting of the soyabeans was done by autoclaving at 100 C for 30 minutes as described by Ewing ('963) since Kratzer (1990) reported that heating at 130 C for 60 minutes destroyeds or renders unavailable several essential amino acids.

Analytical Procedure

The proximate composition of the processed samples as shown in Table 2 was determined according to the Official Methods (A.O.A.C.,

TABLE 1
Composition of the starter diets T_1-T_4

Ingredients	(%)
Maize	50.23
Rice Offal	5.00
Fish Meal	5.00
Palm Oil	2.50
Bone Meal	2.50
Salt	0.30
Lysine	0.20
Methionine	0.20
Premix	0.25
Soyabeans	33.82
Total	100.00
Chemical composition	
Energy Kcal/g %	3.18
Crude protein %	24.16
Crude fibre %	3.95
Ether Extract %	4.40

a: to provide the following per kg diet: vitamin A 1500iμ; vitamin D3, 1600iμ; riboflavin 9.0mg; biotin 0.25mg; pantothenic acid 1.10mg; vitamin K 3.0mg; vitamin B_2 2.5mg; vitamin B_6 0.3mg; vitamin B_{12} 8.0mg, nicotinic acid 8.0mg; Fe 5.0mg; zn 4.5mg; Mn 10.0mg; Co 0.02mg and Se 0.01mg.b: T1-Roasted soyabeans; T2-soyabeans soaked in NaCl; T3-soyabeans soaked in trona; T4-soyabeans soaked in trona.

1990) and gross energy by Gallen Kamp oxygen calorimeter (Miller and Payne 1959).

Biological Evaluation

One hundred and eighty day-old Sussex broiler chicks of equal male to female ratio (1:1) were used for this work. They were randomly allocated in the diets at forty-five birds per diet and replicated in three groups of fifteen birds each. All experimental birds were given feed and water *ad-libitum*. Records of average growth rate and feed consumption were taken over a 28-d period from which values for average live body weight, gain, feed to gain ratio, protein efficiency ratio (PER) was calculated as energy intake per unit body weight gain (Ayanwale and Ogunmodede 1999) The birds were raised on a deep litter system. Heat was provided with 60 watts bulb supplemented with charcoal pot for brooding.

Determination of Nitrogen Utilization

At 3 weeks, two birds from each replicate were randomly selected and transferred to metabolic cages. They were allowed 7 days adjustment period. Weighed quantities of feed were supplied and droppings collected over a 72-hr period using total collection method (Longe 1980). Faecal samples were dried at 80°C, weighed and ground prior to chemical analysis. The faecal samples were collected daily, bulked for each replicate, weighed, dried and stored. From the data on nitrogen intake and excretion, the proportion of nitrogen was calculated.

Statistical Analysis

The experimental design was randomized complete block (RCB) design using the Replicates as the blocks. The statistical analysis was done according to Gomez and Gomez (1984) and mean separation by Duncan multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

The proximate composition of the soyabean seeds processed by roasting and with sodium chloride, trona, and alum is shown in Table 2. The results indicated that processing of soyabeans by soaking in different alkaline solutions reduced the dry matter (DM), crude protein (CP) and crude fibre (CF) contents of the seeds. This is in agreement with the reports of Ku. *et al.* (1976) who attributed such reductions to the increased solubility of soyabean proteins at the alkaline pH of the salts resulting in increased leaching of the proteins into solution. However, the relatively lower ether extract content of the control (T1) could only be attributed to the higher temperature (100°C) at which the soyabean seeds were roasted compared to the soaked beans. Similarly, a decrease in fibre content due to (NaOH) alkali treatment of farm residue was ascribed almost entirely to a reduction in hemicellulose content of the residues (Moss *et al.* 1990). The nitrogen free extract (NFE) and gross energy (GE) were slightly higher in the roasted soyabeans than the treated ones due possibly to the solubility of parts of the nutrients in the alkaline salts. The lowest ash value was found in the control diet ($p<0.05$). This reflects the uptake of minerals from the solution. A similar observation on the uptake of inorganic minerals of cocoa pod husk resulting from alkali treatment (NaOH) was made by Sobamiwa and Longe (1994). Also the chelated minerals in the legume could be released into the solution leading to greater uptake as explained by Ayanwale (1999).

TABLE 2
Proximate composition of the soyabean seeds processed with different alkaline salts (%)

Parameters	T_1	T_2	T_3	T_4
Dry Matter	93.00	92.00	92.20	92.00
Crude Protein	43.82	43.7	43.45	43.65
Ether Extract	18.00	18.92	18.84	18.88
Crude Fibre	5.87	4.86	4.93	4.91
Ash	3.16	3.98	3.96	3.97
NFE	22.15	20.54	21.02	20.59
GE (Kcal/g)	6.00	5.68	5.80	5.69

NFE is Nitrogen Free Extract, GE is Gross Energy
T_1-Roasted soyabeans; T_2-soyabeans soaked in NaC1; T_3-soyabeans soaked in trona; T_4-soyabeans soked in alum.

Table 3 shows the performance characteristics of the broilers fed the alkali-treated soyabeans and the control soyabeans. The birds fed sodium chloride-treated soyabeans had significantly lower ($p>0.05$) body weight compared to the trona-fed diets. The weights of birds on the control diet were similar to the weights of those fed trona and alum diets. The weight gains of the broilers also followed the same pattern as the body weights. The observed reductions in the body weights and weight gains could be attributed to the reductions in the feed intake which is significantly lower ($p<0.05$) in the NaCl-treated soyabean-based diets. Although the feed consumption of NaCl-based diet and alum-based diets were similar, feed efficiency (feed/gain ratio) of the alum based diets were better. This was attributed to the differences in the composition of the two alkaline salts. Alum would have been more effective in the removal of the anti-nutritional factors of soyabeans than the sodium chloride since stronger alkaline salts are reported to be more effective in this aspect (Omueti *et al.* 1992).

The results presented in Table 4 show that nitrogen intake, nitrogen output and nitrogen retained in grams per day were not significantly ($p>0.05$) different for all the broiler groups. However, efficiency of protein utilization was better in trona and alum treated diets than in the control. This might be due to higher protein available to the broilers for utilization due to the destructive effects of the alkaline salts on the trypsin inhibitors of the soyabean seeds. The results of the in vitro trona treatment of soyabeans flour showed that trona destroyed the trypsin inhibitors present in raw soyabeans (Omueti *et al.* 1992).

The energy efficiency results shown in Table 5 indicate that the energy of the control diet (T1) was poorly utilized by the broilers as compared to those of the other diets. These observations could be due to the release of the inorganic mineral elements of the treated soyabeans. Some of the minerals when available serve as co-enzymes and co-factors of enzyme systems involved in both protein and energy metabolism (Lloyd *et al.* 1978; Church and Pond 1988) and their levels in the diets affect feed utilization. Although the formation of lysinoalanine has been reported for soyabeans soaked in aqueous NaOH (DeGroot and Slump 1969) the authors also remarked that feeding mildly treated soyabeans to broilers did not

TABLE 3
Performance characteristics of broilers fed alkali-treated soyabeans for 28 days

Parameters	T_1	T_2	T_3	T_4
Initial live weight (g/bird)	32.50	32.51	32.53	32.52
Final live weight (g/bird)	5400.00^{a}18.92	400.10^{a}23.90	484.53^{a}27.20	511.49^{a}29.92
Body weight gain (g/bird)	507.50^{a}4.11	367.59^{b}5.69	452.00^{b}3.57	478.97^{a}6.22
Feed intake (g/bird)	989.00^{a}3.60	921.66^{b}2.10	993.00^{a}2.40	952.97^{a}b2.40
Feed/gain ratio	1.95^{b}0.08	2.51^{a}0.26	2.20^{a}0.33	1.99^{a}0.07

Means denoted by the same letter in the same row are not significantly ($p>0.05$) different.
T1 is roasted soyabean diet; T2-NaCl treated soyabean diet; T3 trona treated soyabean diet; T4-alum-treated soyabean diet.

TABLE 4
Nitrogen utilization by broilers fed the experimental diets

Parameters	T_1	T_2	T_3	T_4	SEM
Nitrogen intake (g/bird/day)	3.41	3.36	3.39	3.40	0.06
Nitrogen output (g/bird/day)	1.15	1.12	1.13	1.14	0.20
Nitrogen retained (g/bird/day)	2.26	2.24	2.26	2.26	0.11
Nitrogen retention (%)	66.28	66.67	66.49	66.49	1.54
Protein Efficiency ratio	2.12a	1.83b	2.09ab	2.14a	0.12

T_1 is Roasted soyabean diet; T_2 NaCl-treated soyabean diet; T_3 trona treated soyabean diet; T_4 alum treated soyabean diet.

TABLE 5
Energy efficiency of broiler fed soyabeans treated with different alkaline salts

Parameters	T_1	T_2	T_3	T_4	SEM
Dry matter intake (g/day)	32.85	31.28	32.63	31.31	1.22
Energy intake (Kcal/day)	116.12	90.40	96.42	94.89	4.83
Live weight gain (g/bird	16.85	13.84	16.44	16.21	0.32
Energy efficiency	7.00a	6.46ab	5.86a	5.85b	0.17

Means detonated by the same letter in the same row are not significantly ($p>0.05$) different.
SEM is the standard error of mean
T1 is roasted soyabean diet; T2 is NaCl-treated soyabean diet; T3-trona-treated soyabean diet; T4-alum-treated soyabean diet.

produce any adverse effect in the birds, which is true of the diets used in this work. The results of the present work agree with the findings of Lauren *et al.* (1969) and Nelson *et al.* (1976) that soaking of legumes in alkaline salts removed polyphenols and destroyed trypsin inhibitors.

CONCLUSION

All the alkaline-treated soyabeans supported the growth of the broilers since all the birds were raised to the end of the starter phase. However, on the bases of body weight gain, feed consumption and PER similar optimal results were obtained in broiler fed roasted soyabeans and the ones fed alum-treated soyabeans more than those of the roasted ones. So, alum at 3% concentration could be recommended for treating soyabeans for starter broilers.

REFERENCES

Association Of Official Analytical Chemists (AOAC). 1990. *Official Methods of Analysis*, 15th edn. Washington D.C.

Ayanwale, B.A. 1999. Performance and carcass characteristics of broiler chickens fed sodium sesquicarbonate processed soyabean diets. *Tropical Journal of Animal Science* **2:** 85-89.

Ayanwale, B.A and B.K. Ogunmodede. 1999. Growth and energy efficiency of broilers fed different commercial premixes at two developmental stages. *Nigerian Journal of Animal Production* **26:** 43-47.

Church, D.C. and W.G. Pond. 1988. *Basic Animal Nutrition and Feeding.* 3rd edn. U.S.A: John Wiley and Sons.

Degroot, A.P. and P.I. Slump. 1969. Effects of severe alkali treatment of proteins on amino acid composition and nutritive value. *Journal of Nutrition* **98:** 45.

Duncan, D.B. 1955. Multiple range and multiple F-tests. *Biometrics* **11:** 1-42.

Ewing, W.R. 1963. *Poultry Nutrition.* 5th edition. p. 498-502. California: Ray Ewing Co. Div. Hoffman La Roche Inc.

Fanimo, A.O. 1996. Nutritional evaluation of full-fat soyabeans boiled for three time periods. *Pertanika Journal of Tropical Agricultural Science* **19:** 175-182.

Gomez, K.A. and A.A. Gomez. 1984. *Statistical Procedures for Agricultural Research.* 2nd edition. New York: John Wiley & Sons.

Kratzer, F.H., S.V.P. Bersh and R.E Ernst. 1990. Chemical and biological evaluation of soyabean flakes autoclaved at different temperatures for different durations. In *Proceedings of the Aquaculture Feed Processing and Nutrition Workshop*, ed. D.M. Akinyama and K.H. Ronnie (1991), p. 184-241. Thailand and Indonesia.

Ku, S.L.S. Weis, M.P. Steinberg, A.I. Nelson and T. Hymowitz. 1976. Extraction of oligosaccharides during cooking of whole soyabeans. *Journal of Food Science* **41:** 361-364.

Laurena, A.C.O., V.V. Gracia and E.M.T. Mendoza. 1969. Effect of soaking in aqueous, acid, and alkali solutions on removal of polyphenols and *in vitro* digestibility of cowpea. *Qual. Plant Foods and Human Nutrition* **36:** 107-118.

Longe, G.O. 1980. Effect of processing on the chemical composition and energy value of cassava. *Nutri. Rep.* **21:** 819-828.

LLOYD, L.E., M.C. DONALD and E.W. CRAMPTON. 1978. *Fundamentals of Nutrition.* 2nd edn. San Francisco: Freeman Coy.

MILLER, D.S. and P.R. PAYNE. 1959. A ballistic bomb calorimeter. *British Journal of Nutrition* **13:** 501-508.

NELSON, A.I., M.P. STEINBERG and L.S. WEI. 1976. Illinois process for preparation of soya milk. *Journal Food Science* **41:** 57-61.

MOSS, A.R., D.I. GIVENS and J.M. EVERYINGTOM. 1990. The effect of sodium hydroxide treatment on the chemical composition, digestibility and digestible energy content of wheat, barley and oat straws. *Animal Feed Science Technology* **29:** 73-87.

OMUETI, O.I.D. MORTON and P.W. EMERY. 1992. Nutrition characteristics of soyabean seed floor after processing with sodium bicarbonate or trona. *Journal Food Science and Technology* **43:** 121-180.

SINGH, K. B.W. BERSKINE, L.D. ROBERTSON, NAKKOUL and P.C. WILLIAMS. 1988. Influence of pre-treatment on cooking quality parameters of dry food legumes. *Journal of Feed and Agriculture* **44:** 135-142.

SOBMIWA, O. and O.G. LONGE. 1994. The nutritive value of alkali-treated cocoa husk meal in broiler chick diet. *Animal Feed Science Technology* **46:** 32-330.

STEEL, R.G.D. and J.H. TORRIE. 1981. *Principles and Procedures of Statistics-A Biometrical Approach.* 2nd edn. New York: McGraw-Hill.

DEGROOT, A.P. and P. SLUMP. 1969. Effects of severe alkali treatment of proteins on amino acid composition and nutritive value. *Journal of Nutrition* **98:** 45.

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