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The Effect of Feeding Sodium Sesquicarbonate Treated Soyabean on the Energy Utilization and Performance of Broiler Chickens

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ABSTRAK

Pelbagai jenis benih kacang soya tempatan (Glycine max) *yang direndam dalam empat pekatan 'sodium sesquicarbonate' (0.0, 0.1, 0.5, dan 1.0%) selama 24 jam, dibuang airnya dan dikering udara telah digunakan dalam merumuskan diet isokalorik dan isonitrogenous untuk ayam daging. Semua diet menyokong pembesaran ayam daging. Tiada perbezaan signifikan (P>0.05) diperhatikan pada purata pengambilan makanan, berat badan dan pertambahan berat badan kumpulan ayam daging yang berlainan walaupun persamaan dalam pengambilan tenaga. Kecekapan tenaga secara signifikannya (P<0.05) sangat tidak memuaskan dalam memberi makan ayam daging dengan diet yang dikawal berbanding kacang soya yang dirawat dengan 1.0% 'sodium sesquicarbonate'. Penilaian Carcass menunjukkan bahawa bahagian kepala, paha dan lemak pada perut secara signifikannya (P<0.05) turut meningkat sama seperti pekatan 'sodium sesquicarbonate'. Pemprosesan kacang soya dengan 'sodium sesquicarbonate' mengurangkan kandungan protein kasar (CP) dan fiber kasar (CF) biji benih ion-ion Na^+, Ca^{2+} dan Mg^{2+} biji benih yang dirawat meningkat manakala ion-ion K^+ menurun.*

ABSTRACT

A local variety of soyabean (Glycine max) *seeds which were soaked in four different concentrations of sodium sesquicarbonate (0.0, 0.1, 0.5, and 1.0%) for 24 h, drained and air dried were used in formulating isocaloric and isonitrogenous diets for broilers. All the diets supported the growth of the broilers. No significant differences (P>0.05) were observed in the average feed intake, body weight and body weight gains of the different groups of broilers in spite of the similarities in energy intake. Energy efficiency was significantly (P<0.05) poorer in broilers fed the control diet than in 1.0% sodium sesquicarbonate treated soyabean. Carcass evaluation showed that the proportions of the head, drumsticks and abdominal fat significantly (P<0.05) increased as the concentration of sodium sesquicarbonate increased. Processing of soyabean with sodium sesquicarbonate reduced the crude protein (CP) and crude fibre (CF) contents of the seeds, Na^+, Ca^{2+} and Mg^{2+} ions of the treated seeds increased as K^+ ions decreased.*

INTRODUCTION

The potential value of soyabean as a relatively cheap source of protein in animal diet is on the increase. However, raw soyabean needs to be processed to remove the anti-nutrients including polyphenols and trypsin inhibitors. The common methods of processing, that is, soaking and boiling have their limitations. Soaking under tropical climates can lead to deterioration. Boiling uses fuel or firewood which are scarce and expensive (Omueti *et al.* 1992). Heat treatment of soyabean may not be of any advantage since when heat processing is applied below or above a required level, protein availability and solubility are adversely affected (Sadiku and Jauncy 1977).

Singh *et al.* (1988) had demonstrated that the addition of alkaline salts such as sodium bicarbonate has been shown to be effective in reducing soaking and cooking time for many legumes. However, processing of soyabean with a strong alkali like phosphate resulted in decreased protein quality, loss of amino acids and reduction in lysine availability (Friedman *et al.* 1984). The use of mildly alkaline salts had been demonstrated to improve the nutritive value of products (Bourne *et al.* 1976). Sodium sesquicarbonate, a cheap alkaline salt is commonly used as a flavouring agent and as a tenderiser in cooking legumes and vegetables (Raeburn and Jones 1934; Buchanan and Pugh 1969). The enhancement of nutritional and organoleptic properties of cowpeas was demonstrated by Uzogara *et al.* (1988, 1991). It is however, feared that alkaline processing of soyabean can have undesirable nutritional and toxicological consequences (Friedman *et al.* 1984). This work was therefore carried out to investigate the effect of feeding soyabean treated with sodium sesquicarbonate on energy utilization and performance of broiler chickens.

MATERIALS AND METHODS

Preparation of Sodium Sesquicarbonate Solutions

Aqueous solutions of sodium sesquicarbonate ($Na_2CO_3NaHCO_3.2H_2O$) were prepared by adding 0.0 g, 1.0 g, 5.0 g and 10.0 g of powdered sodium sesquicarbonate to 1,000 millilitres of water at room temperature. The water was properly stirred with the powdered samples of sodium sesquicarbonate to obtain 0.0. 0.1, 0.5 and 1.0% solutions respectively. Raw local variety of soyabean seeds were then divided into four parts. Each part was then soaked in each of the prepared solutions for a period of 24 h after which the soyabean seeds were brought out of the solutions, drained and air-dried. Soaking was done in such a way that about 10.0 cm of the solution was above the soyabean levels in the containers. The soyabean, when properly dried was ground and used in preparing four isocaloric and isonitrogenous diets fed to the broiler chickens. The composition of the diets is shown in Table 1.

Feeding Trial

A total of one hundred and twenty Avian broiler chickens were randomly allocated to the four diets at thirty birds per diet in three replicates. Starter diets were fed for 35 days while finisher diets were fed from 36 to 63 days. Feed and water were supplied *ad-libitum.* All the birds were raised from day-old on a deep litter system. The litter materials were wood shavings. Open-sided poultry houses for birds raised under tropical climates as described by Oluyemi and Roberts (1979) were used for raising the birds. The broiler chickens used were of mixed sexes with equal numbers of male to female that is ratio 1:1. Data were collected weekly on average growth rate, feed consumption and body weight gain.

Carcass Evaluation

At the end of the feeding trial two birds (one male and one female) were randomly selected per replicate and fasted for twelve hours (overnight) to allow the gut to be cleared of feeds. The birds were weighed at 0600 h in the morning. The feathers were removed after scalding. A cut was made in the abdominal

TABLE 1
Composition of experimental diets(%)

	Starter diets				Finisher diets			
Ingredients	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Maize	43.25	43.25	43.25	43.25	44.25	44.25	44.25	44.25
Soyabean	15.00	15.00	15.00	15.00	11.00	11.00	11.00	11.00
Maize Offal	10.00	10.00	10.00	10.00	16.50	16.50	16.50	16.50
Groundnut Cake	19.00	19.00	19.00	19.00	16.00	16.00	16.00	16.00
Fish Meal	3.50	3.50	3.50	3.50	3.00	3.00	3.00	3.00
Palm Oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone Meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Oyster Shell	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
*Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

* supplied per kg diet: Vitamin A 10,000 *Im;* vitamin D_3, 2000 *Im;* vitamin E, 5 *Im;* vitamin K, 2.24 *Im;* vitamin B 12, 0.01 mg; riboflavin, 5.5 mg; pantothemic acid, 10 mg; nicotimic 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.

region of each bird with a sharp knife. Each of the livers, kidneys, lungs, hearts and gizzards were removed, weighed and labelled. The different parts of the body (head, neck, thighs, drumsticks, shanks, backs and breasts) were manually cut and expressed as the percentage of the live weight.

Experimental Design and Statistical Analysis

The experimental design for the feeding trial was Randomized Complete Block (RCB) Design. The statistical analysis was done according to the methods of Gomez and Gomez (1984); Steel and Torrie (1981) and mean separation was by Duncan Multiple range test (Duncan 1955).

Analytical Procedure

The air-dried soyabean was milled and protein determination was carried out by the Kjeldahl method. Proximate analysis involving determination of ether extract, crude fibre, ash and dry matter contents were done according to procedures by A.O.A.C (1990).

Energy Efficiency Determination

Energy efficiency was calculated as:

$$\text{Energy efficiency} = \frac{\text{Energy intake}}{\text{Weight gain}}$$

where energy intake is

Feed intake (dry matter basis) x metabolisable energy of diets.

RESULTS AND DISCUSSION

The composition of the soyabean seed processed with different concentrations of sodium sesquicarbonate is shown in Table 2.

The chemical composition of the soyabean seeds processed with the different concentrations of the sodium sesquicarbonate is shown in Table 2. There was a significant difference in the crude protein content of the soyabean seeds treated with 1% Na sesquicarbonate compared to the ones soaked in 0.1, 0.5 concentrations and water.

The crude protein content of the seeds tends to decrease as the concentration of sodium sesquicarbonate increased. A similar decrease in protein content as the alkaline pH increased had been attributed to increased solubility of soyabean' proteins and enhanced hydration causing increased permeability of the seed coat leading to more efficient leaching of the proteins into the water (Ku *et al.* 1976).

The fat content of the soyabean increased while the crude fibre (CF) decreased as the concentrations of the alkaline solutions increased. This is attributed to the combined effects of losses of protein and carbohydrates as observed by Omueti *et al.* (1992). Since the fat content of the soyabean increased with the increasing concentrations of Na sesquicarbonate, it means that there would be a corresponding increase in energy supply to birds by the diets. The reduction observed in the CF level indicates that more fibre had been digested and used as energy.

The mineral composition of the processed soyabean is presented in Table 3. The highest value of ash content was found in soyabean with the greatest concentrations of sodium sesquicarbonate (Table 2). The implication is that the uptake of the minerals from solutions increased as the concentrations of the sodium sesquicarbonate increased. The effects were particularly noticeable on Na^{+}, Ca^{2+} and Mg^{2+}.

TABLE 2

Composition of soyabean seeds processed with different concentrations of sodium sesquicarbonate

Parameters (%)	Sodium sesquicarbonate concentrations(%)				
	0.0	0.1	0.5	1.0	SEM^{C}
Crude protein	48.20^{a}	48.10^{a}	48.00^{a}	46.20^{b}	0.31
Ether extract	22.30	22.50	22.60	22.60	0.49
Crude fibre	2.47	2.45	2.40	2.39	2.00
Total ash	3.50	3.40	3.60	3.90	2.15
Gross energy(kcal/g)	3.55	3.69	5.80	6.00	0.08

a, b. means with different superscripts within the same row are significantly different (P<0.05).

C SEM is the standard error of the mean.

TABLE 3
Mineral composition of soyabean seeds processed with different concentrations of sodium sesquicarbonate

Minerals(%)	Concentrations (%)			
	0.0	0.1	0.5	1.0
Ca	0.30	0.31	0.33	0.32
Mg	0.20	0.20	0.19	0.16
Na	0.06	0.09	0.15	0.24
K	0.90	0.78	0.80	0.90
P	0.60	0.39	0.40	0.45

There was increased sodium content as potassium decreased and this could be attributed to leaching. Incidentally, Na^+, Ca^{2+} and Mg^{2+} are involved in the process of energy metabolism in chickens (Kleiber *et al.* 1941; Lloyd *et al.* 1978; Church and Pond 1982).

Figs. 1, 2 and *3* illustrate the pattern of growth, feed intake and weight gain of the birds respectively. Feed intake, body weight and weight gain increased with age. The different concentrations of sodium sesquicarbonate did not affect the pattern of growth, feed intake and weight gain as body weight increased progressively with age. This is also true of the pattern of feed consumption shown in *Fig. 2.* This indicates that the energy consumption will obviously follow this trend. The figures indicate that maximum body weight, feed consumption and weight gain were reached at the ninth week.

The chemical composition of the diets compounded from the sodium sesquicarbonate treated soyabean is shown in Table 4. The data show that the diets are isocaloric for either the starter diets or the finisher diets.

Table 5 shows the energy efficiency of the diets based on sodium sesquicarbonate processed soyabean. The energy efficiency of the diets improved as the concentration of the sodium sesquicarbonate increased. The deficiency of Na^+ ions in the control diet is a contributing factor to the poor utilization of energy of the diet. Additional limitation on the utilization of energy in the control diet is placed by the marginal deficiency of Ca^{2+} ions and Mg^{2+} ions. Sodium functions as the extra-cellular components through an energy dependent sodium 'pump' and Na^+ ions promote glucose absorption against a concentration gradient which requires adenosine triphosphate (ATP). The Na^+ ion gradient is considered the primary driving force in the active transport of sugar through the intestinal wall. Deficiency of Na^+ ion aggravated

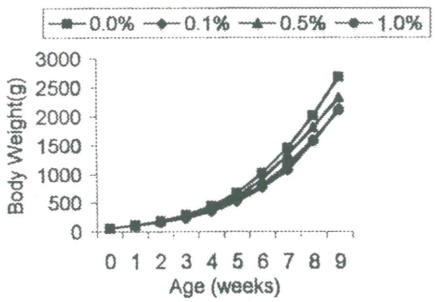

Fig. 1: Mean weekly body weight of broilers fed soyabean treated diets

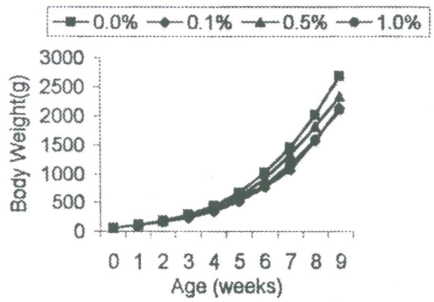

Fig. 2: Mean weekly body weight of broilers fed soyabean treated diets

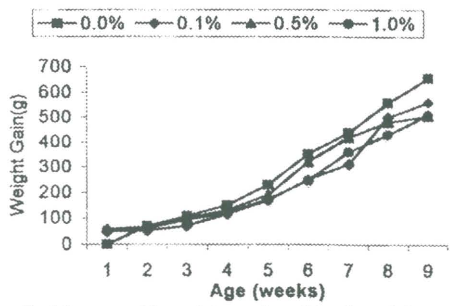

Fig. 3: Mean weekly weight gain of broilers fed soyabean treated diets

by marginal deficiency of Ca^{2+} and Mg^{2+} ions of the control diet could be the main factor for the poor energy efficiency of the diet. Kleiber *et al.* (1941) showed that Mg^{2+} deficiency decreased the efficiency of energy and protein utilization. Lloyd *et al.* (1978) stated that Mg^{2+} ions activate the enzymes (kinases, mutases and enolase) that are concerned with energy metabolism.

The data shown in Table 6 show that the broilers fed the control diet had the highest body weight (2.68 kg/bird) at 63 days of age. The control broilers also consumed higher feed along with 0.5% sodium sesquicarbonate treated soyabean. Similarly, feed to gain ratio tends to be better in the control birds than in any of the other groups. However, statistically, the values obtained were not significant (P>0.05). This agrees with the report in Table 5 that the deficiency of the Na^+ in the control is a major contributory factor to the poor utilization of the energy of the diets since the diet cannot produce a significant difference in the performance of the birds in spite of high feed intake.

TABLE 4
Proximate composition of sodium sesquicarbonate processed soyabean diets (%)

Parameters(%)	Starter diets				Finisher diets			
	0.0	0.1	0.5	1.0	0.0	0.1	0.5	1.0
Dry matter	88.50	88.05	88.09	88.00	87.92	87.01	87.00	86.99
Crude protein	22.50	22.02	22.01	22.00	20.35	20.33	20.04	20.00
Crude fibre	4.88	4.63	4.63	4.59	6.79	6.58	6.52	6.79
Ether extract	14.00	14.12	14.20	14.34	14.80	14.82	14.88	14.85
Ash content	23.00	23.01	23.80	24.86	20.08	20.25	20.50	20.98
Nitrogen free extract	35.02	35.47	34.56	34.01	38.00	37.81	37.59	37.14
Metabolisable energy(kcal/g)	2.99	2.99	2.99	2.99	2.80	2.80	2.80	2.80

TABLE 5
Energy efficiency of broilers fed sodium sesquicarbonate treated soyabean

Starter Phase	Concentrations (%)				
(0 – 35 days)	0.0	0.1	0.5	1.0	SEM
Feed intake day^{-1}(g)	56.50	56.00	55.90	55.68	0.22
ME intake (day^{-1}) (kcal/kg)	168.00	164.59	163.85	164.74	2.34
Weight gain (day^{-1}) (g)	19.84	20.10	20.42	21.94	1.44
Energy efficiency (36 - 63 days)	8.46[a]	8.19[ab]	8.02[ab]	7.74[b]	0.17
Feed intake day^{-1}(g)	111.32	103.53	104.03	104.61	2.15
ME intake (day^{-1}) (kcal/kg)	323.65	300.25	301.70	303.38	2.18
Body weight gain (day^{-1}) (g)	24.54	23.33	23.06	26.02	1.07
Energy efficiency	13.18[a]	13.02[ab]	12.93[ab]	11.63[b]	0.12

Values denoted by different letters in the same row are significantly different (P<0.05).
SEM is the standard error of mean.

TABLE 6
Performance of broilers fed sodium sesquicarbonate processed soyabean

	Dietary Treatments (%)					
	0.0	0.1	0.5	1.0	SEM	
Initial live weight (g/bird)	55.62	55.60	55.61	55.60	-	
Final live weight (kg/bird)	2.68	2.14	2.33	2.32	2.03	NS
Total feed intake (kg/bird)	5.60	5.47	5.60	5.50	1.26	NS
Live weight gain (kg/bird)	2.62	2.08	2.27	2.26	2.11	NS
Feed gain ratio	2.14	2.63	2.47	2.43	1.05	NS

NS is no significant difference (P>0.05).

TABLE 7
Carcass value of broilers fed sodium sesquicarbonate processed soyabean

Parameters (%)	Concentrations(%)				
	0.0	0.1	0.5	1.0	SEM
Live weight (%)	100.00	100.00	100.00	100.00	-
Head	2.32[a]	2.49[ab]	2.88[ab]	3.12[b]	0.21
Drumsticks	8.42[a]	9.32[ab]	9.67[ab]	11.52[b]	0.68
Liver	2.08	1.94	2.21	2.20	0.07
Gizzard	2.96	3.18	3.49	2.77	0.18
Heart	0.61	0.50	0.69	0.56	0.05
Abdominal fat	3.38[a]	2.18[b]	2.26[b]	2.28[b]	0.92

Values denoted by different letters in the same row are significantly different ($P<0.05$)

The values obtained on carcass evaluation (Table 7) show that the head, drumsticks and the abdominal fat proportions of birds fed the 1.0% sodium sesquicarbonate treated soyabean were significantly higher ($P<0.05$). The results on the carcass evaluation might be affected by the method of cutting which was manual. This could partly account for the differences observed in the values for the head, and the drumstick. However, Rand *et al.* (1957); Sonaiya (1985) reported works in which diets with more energy gave higher abdominal fat. This is in contrast with Hood and Thornton (1979) who found body composition of animals to be related to body weight, which is in agreement with the present work.

CONCLUSION

The soyabean seeds treated with different sodium sesquicarbonate concentrations supported broiler growth. The crude protein and Na^+ ions of the treated seeds decreased as the concentrations of the alkaline salt increased. Energy efficiency of the broilers fed soyabean treated with 1.00% sodium sesquicarbonate was better than those in control diets at starter and finisher phases. The results of the carcass evaluation was not consistent but there was a tendency of the composition of the broilers to increase with body weight as shown by the abdominal fat values.

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