

**Effects of diets containing alkali-treated Soybeans on performance traits, nutrient digestibility and cost benefits of broiler chickens**

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**Abstract**

*The effects of diets containing different alkali-treated soybeans on performance traits, nutrient digestibility and cost implication of broiler chickens was evaluated using 240 day-old Anak broiler chickens that were randomly divided into four (4) experimental groups of three replicates each. The soybeans were treated in alkali as follows: soaked in water as T1 (control), sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) as T2, Potassium carbonate ( $\text{K}_2\text{CO}_3$ ) as (T3) and sodium hydroxide ( $\text{NaOH}$ ) as T4. The alkali-treated soybeans were incorporated into the diets at both starter and finisher phases using a completely randomized design. There were significant ( $P < 0.05$ ) variations in performance parameters, nutrient retention and bio-economic implication indices measured. The use of potassium carbonate (1%  $\text{K}_2\text{CO}_3$ ) and sodium carbonate (1%  $\text{Na}_2\text{CO}_3$ ) in the processing of soybean recorded greater improvement in the performance traits, nutrient retention and economic returns. These factors accounted for the overall best performance recorded in 1%  $\text{K}_2\text{CO}_3$  - treated soybeans which was closely followed by 1%  $\text{Na}_2\text{CO}_3$  treated soybean base diets.*

**Keywords:** Alkaline treatment, Broilers, Economics, Nutrient retention, Performance traits,

**Introduction**

Alkali treatment of oilseeds and other feeds materials for nutritional improvement to support optimum utilization by poultry and other livestock has been reported (Ayanwale, 1999; Fayomi, 2004; Ari *et al.*, 2012). Soybean remains the most commonly used source of supplementary protein for poultry on accounts of its consistently high quality product (Britzman, 2006; Sarikhan *et al.*, 2010), this important feed ingredient is however limited in utilization by the feed industry due to the presence of anti-nutritional factors (ANFs).

Ayanwale (1999), Wanjekeche *et al.* (2003), Fayomi, (2004), Akande and Fabiyi (2010), Ocheme and Mikailu (2011), Oskoueisan *et al.* (2011) and Ari *et al.*

(2012) have variously reported the use of alkali in the removal of anti-nutritional factors and the nutritional improvement of feedstuff for poultry and livestock utilization. These alkalis include among others sodium sesquicarbonate (trona) (Ayanwale, 1999 and Ayanwale 2003), sodium hydroxide and sodium hypochloride (Cano-Asseleith *et al.*, 1989; Aregheore *et al.*, 2003). Similarly, Vidal-Valverde *et al.* (1997), Parsons *et al.* (1991) and Ocheme and Mikailu (2011) have also reported the use of sodium bicarbonate solution, distilled water and potassium hydroxide in the removal of trypsin inhibitor activity in oilseeds of which soybean is one.

Alkaline treatment of soybeans is dependent on the concentration levels of the alkaline used (Friedman and Master, 1984;

Ayanwale, 1999; and Oskoueisan *et al.*, 2011), as treatment of soybeans with strong alkaline resulted in decreased protein quality, loss of amino acids and the formation of amino acids lysine-alanine complex, which reduce lysine availability. The objectives of this experiment are to evaluate the effects of diets containing different alkali treated soybeans on performance traits, nutrient digestibility and cost benefit implication of broilers.

## **Materials and Methods**

### **Experimental site**

This study was conducted at the Livestock Complex of College of Agriculture, Doma Road, Lafia which is located between latitude 8° and 9° North and longitude 80° and 90° East. The minimum temperature is 21.9°C and maximum temperature of 37.6°C between January to June and the average annual rainfall is 823mm. The test ingredients were processed at both the Livestock Complex and the Nutrition Laboratory of the college while the final feed was compounded at the feed mill unit of the complex.

### **Soybean Collection, Processing and Diet Preparation:**

Soybeans seeds (*Glycine max*) were procured from a local market in Lafia metropolis of Nasarawa State, Nigeria. The collected seeds were cleaned by winnowing and hand picking of stones and debris. The raw soybeans were subjected to three alkali treatments viz: sodium carbonate (T2), potassium carbonate (T3) and sodium hydroxide (T4). Each of these alkaline solutions that served as experimental treatment group was compared with the control treatment ; soaking in water (T1). The different alkali treatments are described as thus:

### **Soaking in Water (H<sub>2</sub>O) - T1 (control)**

The cleaned raw soybeans were poured into a plastic container of cold water according to the methods reported by Ayanwale (1999) and adopted by Ari *et al.* (2012). The soybeans were allowed to soak by immersing the soybeans in water at room temperature for 24 hours, this represents 0% alkaline. The soaked grains were drained, and sun dried by spreading on jute bags. The sun dried samples were milled and bagged.

### **Soybeans Processed with Sodium Carbonate (Na<sub>2</sub>CO<sub>3</sub>) - T2**

The method reported by Ayanwale (1999) and adopted by Ari *et al.* (2012) was used. The cleaned sample grains were soaked in 1% solution of sodium carbonate

The soybeans sample was allowed to soak by immersing in the aqueous alkaline solution at room temperature for 24 h. The soaked grains were drained and sun dried by spreading on jute bags until stable weight was attained. The sun dried products were milled and bagged.

### **Soybeans Processed with Potassium Carbarnate (K<sub>2</sub>CO<sub>3</sub>) - T3**

The method reported by Ayanwale (1999) and adopted by Ari *et al.* (2012) for alkali treatment of soybeans was applied. The cleaned sample grains were soaked in 1% solution of potassium carbarnate (potash). The potash used was procured from local market in Lafia. The soybean samples were allowed to soak by immersing the soybeans in the aqueous solution at room temperature for 24 h. The soaked grains were drained and sun dried by spreading on jute bags until stable weight was attained. The sun dried samples were milled and bagged.

### **Soybeans Processing with Sodium Hydroxide (NaOH) - T4**

The cleaned samples grains were soaked in

1% solution of sodium hydroxide. The method reported by Ayanwale (1999) and adopted by Ari *et al.* (2012) for alkali treatment of soybeans was applied. The soybeans samples were soaked in the aqueous solution of NaOH at room temperature for 24 h. The soaked and wet grains were drained, and sun dried by spreading on jute bags until stable weight was attained. The sun dried samples were milled and bagged.

#### **Experimental treatment:**

A total of 240 day-old Anak broilers that were randomly divided into four (4) experimental groups of three replicate each. Dietary treatments were as follows: T1, T2, T3 and T4 which had: soybeans soaked in water, soybeans processed with sodium carbonate, soybeans processed with potash; and soybeans processed with sodium hydroxide at both starter and finisher phases using Completely randomized design having the test ingredients incorporation as the main source of variation. The starter diets were fed for five (5) weeks (1- 35 d) brooding phase and the finisher diets were fed for four (4) weeks (36- 63 d). The experimental feeds were formulated using a least cost feed formulation software *Feedwin*.

#### **Data Collection**

##### **Performance parameters**

The following parameters were measured from the data generated from daily and weekly recording in each of the feeding trials: feed intake, body weight, bodyweight gain, feed conversion ratio (feed:gain), mortality, survival percentages and performance index and the following formulas were used for performance parameters computation.

Feed conversion ratio (Feed:Gain) = Average feed intake per week (g)/ Average

weight gain per week (g)

Mortality (%) = total number of dead birds/total birds raised x 100

Survival percentage (%) = (100% - mortality percentage)

Performance index = Survival % x weight gain/bird/week (g) x 100 / FCR (Ari, 2006)

#### **Digestibility Trail:**

At 8 weeks, two birds were randomly selected from each replicate of the treatment groups and placed in metabolic cage for total faecal collection according to the methods described by Low (1990). The birds were allowed 5 d adjustment period and faecal collection was made daily for the last 7 d of the experiment. Each day's collection were bulked for each treatment group, weighed, dried and stored in screw capped bottles and taken for analysis.

#### **Cost/Benefit analysis**

The cost-benefit implication for each of the experimental diet, the total feed consumed per treatment, cost of feed per kg, protein and energy cost obtained from *feedwin* and the cost of feeding to the final weight were computed along with the cost per kg body weight gain while the cost / benefit was computed as the ratio of the total cost of production to the total income generated.

#### **Chemical Analysis:**

Chemical composition of each of the fermented soybeans samples, experimental diets and faecal collections were determined following standard methods (AOAC, 1995). Crude protein (N\*6.25) was determined by the Kjeldahl method after acid digestion (Gerhardt, Königswinter, Germany). Crude fat analysis without acid hydrolysis was determined by the ether-extraction method using a Soxtec System (Gerhardt, Königswinter, Germany). Moisture was determined by oven drying at 105 °C until a

constant weight was achieved. Ash content was estimated by incinerating the samples in a muffle furnace at 600 °C for 6 h. Total Carbohydrates (Nitrogen-free extract) was determined by difference and calculated thus: 100% - % (CP+ Ash + Crude Fat + Moisture).

**Statistics:**

Data collected were subjected to One-way Analysis of Variance (ANOVA), means were separated ( $P>0.05$ ) where there were significant differences using Duncan's Multiple Range Test (Duncan, 1955) using SPSS 16.0 (2004).

**Results and Discussion**

The compositions of the experimental diets are presented in Table 1. The experimental diets are within recommended range (NRC, 1994). The variations in the nutrient composition of the alkali-treated soybean based diets at both starter and finisher phases were also within recommended range for birds in the tropics as reported by Oluyemi and Roberts (2000).

The performance parameters of broilers fed alkali-treated soybean based diets are presented in Table 2. Effects of treatment did not differ significantly ( $P>0.05$ ) on in the starter and finisher phase while broilers fed Diets 3 and 2 had better body weight (1614.33 and 1529.33g) respectively when compared with Diets 1 and 4 whose values were 1366.67 and 11422.10g respectively. There were significant ( $P<0.05$ ) difference in feed intake at the starter and finisher phases. The highest feed intake value in the starter phase was 661.33 and 425.00g in Diets 2 and 4 respectively while the least feed intake was 371.00g for Diet 3. Similarly, diet 3 had the least feed intake (928.00g) when compared with diet 1 (1144.67g) and 1% potash (1140.67g) feed

intake values in the finisher phase.

The average body weight gain values were also significantly ( $P<0.05$ ) different in both the starter and finisher phases. Diets 1 and 4 had the lowest body weight gain (121.33 and 120.33.00g) when compared with 144.33 and 153.00g for diets 2 and 3 groups, respectively in the starter phase while the average body weight gain value for Diets 4 and 1 were also lowest in the finisher (249.67 and 285.00g) as compared with 329.67 and 303.33g for Diets 2 and 3 respectively. FCR was significantly ( $P<0.05$ ) different at both the starter and finisher phases with diet 3 having the best FCR values of 2.45 a at the starter phases while diet 3 gave the best value at the finisher phase. However, performance index was significantly ( $P<0.05$ ) different at both the starter and finisher phases. The performance index ranged from 31.03 to 61.59 in the starter phase and from 54.08 to 114.04 in the finisher phase.

The differences observed between the starter and finisher phases and treatment groups in the performance evaluation traits especially in feed intake, weight gain, FCR and performance index were as a result of anti-nutritional factor removal and type of alkaline salts used, as diet 1 which had the lowest levels of anti-nutritional factors removal from the test soybean and diet 4 recorded the poorest performances as reported by Ari *et al.* (2012).

The effect of alkaline treatment of soybeans on the nutrient digestibility in broilers is presented in Table 3. The dry matter values showed significant ( $P<0.05$ ) difference at the starter phase only while no significant ( $P>0.05$ ) difference was observed in the digestibility of other nutrients at both the starter and the finisher phases. The high digestibility recorded for nutrients

**Table 1** Composition and analysis of diets containing Alkali-treated Soybeans

Ingredients	Starter diets				Finisher diets			
	T1	T2	T3	T4	T1	T2	T3	T4
Maize	38.00	38.00	37.00	38.00	46.55	46.00	46.00	46.30
Maize Bran	10.25	10.00	10.25	10.50	8.00	8.00	9.30	8.00
Rice Bran	2.50	2.25	2.80	2.55	1.25	1.25	1.75	1.5
Soya 0% Alkaline	32.00	-	-	-	31.50	-	-	-
Soya 1% Na <sub>2</sub> CO <sub>3</sub>	-	33.25	-	-	-	32.55	-	-
Soya 1% K <sub>2</sub> CO <sub>3</sub>	-	-	33.00	-	-	-	31.00	-
Soya 1% NaOH	-	-	-	33.25	-	-	-	31.5
Blood Meal	3.50	3.50	3.25	3.25	3.00	3.00	3.00	3.00
Fish Meal	3.50	3.50	3.25	3.25	1.00	1.00	1.00	1.00
Bone Meal	3.50	3.50	3.50	3.50	3.00	3.00	3.00	3.00
Limestone	0.80	1.05	2.00	0.75	-	-	-	-
Palm Oil	3.00	2.00	2.00	2.00	2.75	2.25	2.00	2.75
L-Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt (NaCl)	2.50	0.25	2.50	2.50	2.50	2.50	2.50	2.50
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
Calculated analysis								
MEKcal/kg	3009.85	3007.13	3009.17	3003.74	3061.75	3088.23	3107.94	3108.37
CP%	24	24	24.14	24.11	21.99	21.92	22.07	21.97
Determined analysis								
Dry Matter (%)	92.10	92.10	91.30	92.42	91.81	92.12	92.73	91.99
Crude Protein (%)	21.14	21.86	23.36	23.36	20.44	23.63	20.56	20.62
Crude Fibre (%)	7.15	6.58	6.88	6.24	7.06	7.01	7.41	6.80
Ether extract (%)	11.75	9.52	10.32	8.86	12.45	11.16	13.52	11.93
Total Ash (%)	11.49	10.55	11.2	11.25	5.72	6.80	14.03	7.76
NFE (%)	37.57	43.59	39.49	42.71	46.14	43.52	37.21	44.88

\*Premix to provide the following per Kg of diet: Vitamin A, 9,000 IU; Vitamin D3, 2,000 IU; vitamin E, 18 IU; vitamin B1, 1.8 mg; vitamin B2, 6.6 mg; vitamin B3, 10 mg; vitamin B5, 30 mg; vitamin B6, 3.0 mg; vitamin B9, 1 mg; vitamin B12, 1.5 mg; vitamin K3, 2 mg; vitamin H2, 0.01 mg; folic acid, 0.21 g; nicotinic acid, 0.65 mg; biotin, 0.14 mg; Choline chloride, 500 mg; Fe, 50 mg; Mn, 100 mg; Cu, 10 mg; Zn, 85 mg; I, 1 mg; Se, 0.2 mg.

especially crude fibre in the entire alkali-treated soybean based diets can be linked to the possible reduction in the hemicellulose

contents of the treated soybean as reported (Moss *et al.* 1990 and Ayanwale, 1999) and the *in vitro* destruction of trypsin inhibitor

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**Table 2: Effect of diets containing Alkali-treated Soybeans on the Performance of Broiler chickens**

Processing Methods	Initial Body Weight	Average Final Body Weight	Feed Intake (g)	Average Body Weight gain (g)	FCR	Survival (%)	Performance Index
Starter Phase							
Control (T1)	42.67	423.13	373.00 <sup>b</sup>	121.33	3.06 <sup>ab</sup>	97.00	38.17 <sup>b</sup>
T2	40.33	429.20	661.33 <sup>a</sup>	144.33	4.63 <sup>c</sup>	97.67	31.03 <sup>b</sup>
T3	40.00	494.67	371.00 <sup>b</sup>	153.00	2.45 <sup>a</sup>	97.00	61.59 <sup>a</sup>
T4	39.00	501.33	425.00 <sup>b</sup>	120.33	3.55 <sup>b</sup>	98.00	33.55 <sup>b</sup>
SEM	0.85NS	16.92NS	38.50*	6.78NS	0.26*	0.23NS	4.50*
Finisher Phase							
Control (T1)	423.13	1366.67 <sup>b</sup>	984.33 <sup>ab</sup>	285.00 <sup>bc</sup>	3.46 <sup>a</sup>	97.67	81.63 <sup>b</sup>
T2	429.20	1529.33 <sup>ab</sup>	928.00 <sup>b</sup>	329.67 <sup>a</sup>	2.83 <sup>a</sup>	97.00	114.04 <sup>a</sup>
T3	494.67	1614.33 <sup>a</sup>	1140.67	303.33 <sup>ab</sup>	3.75 <sup>ab</sup>	98.67	80.00 <sup>b</sup>
T4	501.33	1422.10 <sup>ab</sup>	1144.67 <sup>a</sup>	249.67 <sup>c</sup>	4.62 <sup>b</sup>	98.33	54.08 <sup>b</sup>
SEM	16.92NS	46.64*	10.10*	40.69*	0.23*	0.29NS	7.18*

<sup>a,b,c</sup>: Means in the same column with the same superscript are not significantly ( $P>0.05$ ) different

SEM Standard Error of Means

\* Significant

NS Not Significant

activity TIA for all the treated soybeans (Omoeti *et al.*, 1992).

The significant ( $P<0.05$ ) variations in phosphorus digestion showed the mineral binding effect associated with different alkalis and their concentration levels. Similar observations have been reported by Freidman and Master (1984) and Ayanwale (1999) on the formation of nutrient complexes with the use of high alkaline concentration in soybeans treatment.

The observed differences in all the traits measured are indications of the effects of the different alkaline treatments on nutrient intake and utilization by broilers as earlier reported by Offiong *et al.*, (1982); Ayanwale and Kolo (2001) among other workers. However, the results obtained in this study showed significant ( $P<0.05$ ) variations in final weight feed intake, weight gain and FCR which were contrary to the report of Ayanwale (1999) who observed no significant ( $P>0.05$ ) variations in the parameters on broilers fed diets containing soybean treated with different concentration levels of alkali salt (trona).

The cost benefit analysis of feeding broilers with alkali- treated soybean based diets are presented Table 3 as cost, benefit and gross profit tables. Cost per kilogram feeds, metabolisable energy and crude protein at both starter and finisher phase were lowest in diet 3. The highest production cost value of N37151.40 was recorded in diet 2 while the least total cost of production was recorded in diet 1 with the total cost value of N33168.60.

Total income value of N42505.00 was the highest figure recorded in the 1%  $K_2CO_3$  while soaking in water gave the least income of N36168.00 Gross profit of N83253.00 was highest while the least was N1954.20 was recorded for diet 4. Benefit/cost ratios were as follows: 0.83, 0.92, 0.92 and 0.95, respectively, Diets 3,1,2, and 4 groups, respectively.

The cost/benefit ratio obtained as follows: 0.83, 0.92, 0.92 and 0.95 representing, diets 3, 1, 2 and 4 respectively can be accounted for by feed cost, feed intake and utilization.

**Table 3.: Effect of diets containing Alkali-treated Soybeans on Nutrient Digestibility in Broilers**

	Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Total Ash	NFE	Ca	P
Starter Phase								
Control (T1)	69.22 <sup>b</sup>	80.63	89.98	82.79	79.58	84.45	82.30 <sup>a</sup>	54.78 <sup>c</sup>
T2	83.46 <sup>a</sup>	80.96	72.30	80.27	71.25	93.78	79.45 <sup>a</sup>	75.73 <sup>a</sup>
T3	69.77 <sup>b</sup>	82.50	75.37	79.15	73.41	94.18	59.81 <sup>b</sup>	61.24 <sup>b</sup>
T4	74.52 <sup>b</sup>	81.39	82.81	76.30	71.49	92.17	58.28 <sup>b</sup>	43.30 <sup>c</sup>
SEM	1.97*	0.21NS	2.07NS	0.70NS	1.01NS	1.19NS	3.31*	3.53*
Finisher Phase								
Control (T1)	82.29	80.62	72.16	94.62	18.90	85.97	40.20 <sup>b</sup>	55.36
T2	82.44	79.26	83.19	93.32	44.50	85.49	73.56 <sup>a</sup>	46.50
T3	82.38	80.96	65.52	95.06	67.55	88.54	73.60 <sup>a</sup>	80.85
T4	82.43	75.10	74.17	94.63	40.34	94.83	56.54 <sup>b</sup>	67.03
SEM	0.02NS	0.70NS	1.90NS	0.20NS	5.21NS	1.12NS	4.18*	3.88NS

<sup>a,b,c</sup>: Means in the same column with the same superscript are not significantly (P>0.05) different

SEM Standard Error of Means

\* Significant

NS Not Significant

### Conclusions

The use of alkaline solutions in the treatment of soybeans was found to be advantageous in the nutritional improvement of soybeans for utilization in the diets of broiler chickens as observed in the findings of this experiment. The alkaline treatment methods showed varied effect on both the performance traits, nutrient retention and cost benefit of the experimental broilers.

The use of potassium carbonate (1% K<sub>2</sub>CO<sub>3</sub>) and sodium carbonate (1% Na<sub>2</sub>CO<sub>3</sub>) in the processing of soybean recorded greater improvement in the removal of ANFs and preservation of nutrient quality, gave better performance traits, nutrient retention and economic returns. These factors accounted for the overall best performance recorded in 1% (K<sub>2</sub>CO<sub>3</sub>) potassium carbonate treatment of soybeans which was closely followed by 1% Na<sub>2</sub>CO<sub>3</sub>.

### Acknowledgement

The authors sincerely acknowledge the support of Mr. Sylvester and Mallam Aliyu of the Microbiology and Biochemistry laboratories of the National Veterinary

Research Institute (NVRI) Vom; Mr Yau Agade and Munir Mohammed of the Animal Science laboratory, College of Agriculture, Lafia. The financial support received from FIMs Services, Abuja for this research is acknowledged.

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**Table 4: Cost/Benefit Analysis of the Effect of diets containing Alkali-treated Soybeans on the Performance of Broilers**

Parameters	Alkaline Treatment			
	T1	T2	T3	T4
Cost of Birds @ 200/DOC (N)	12,000	12,000	12,000	12,000
Housing Cost @ 50k/bird/day (N)	1,500	1,500	1,500	1,500
Brooding Cost	2,750	2,750	2,750	2,750
Drugs & Vaccines	912	912	912	912
Personnel Cost @ 200/man day	1,000	1,000	1,000	1,000
Total cost	18,162	18,162	18,162	18,162
Feed Cost				
Price/kg Starter Feed*	51.72	51.68	50.75	51.38
Price/kg Finisher Feed*	52.04	52.29	50.85	52.51
Price/ME Starter*	17.19	17.19	16.86	17.11
Price/ME Finisher*	17.00	16.93	16.36	16.89
Price/CP Starter*	2.15	2.15	2.10	2.13
Price/CP Finisher*	2.37	2.39	2.30	2.39
Feed Consumed Starter	373.00	661.33	371.00	425.00
Feed Consumed Finisher	984.33	928.00	1,140.67	1,144.67
Price/Feed Consumed Starter	19.29	34.18	18.83	21.84
Price//Feed Intake (5 wks)	96.45	170.90	94.15	109.20
Price/Feed Consumed Finisher	51.22	48.53	58.00	60.11
Price/Feed Intake (3 wks)	153.66	145.59	174.00	180.33
Cost of feed Consumed	250.11	316.49	268.15	289.53
Number of Birds Fed	60	60	60	60
Total Cost of Feed Consumed	15006.60	18989.40	16089.00	17371.80
* Calculated as output from Feedwin Software				
<b>B. Benefit</b>				
Average Weight/bird	1.37	1.53	1.61	1.42
Cost/KG bird	550	550	550	550
Number of Birds Sold	48	48	48	48
Total Income	36168.00	40392.00	42504.00	37488.00
<b>C. Cost</b>				
Total Income	36168.00	40392.00	42504.00	37488.00
Total Cost	33168.60	37151.40	35251.00	35533.80
Gross Profit	2999.4	3240.6	8,253.00	1954.20
Cost/Benefit	0.92	0.92	0.83	0.95

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**Ari, M. M., Ayanwale, B. A., Adama, T. Z. and Olatunji, E. A. 2012** .Nutrient composition, amino acids profile and anti nutritional factors of alkali-treated Soybean (*Glycine max*) Pakistan Journal of Nutrition, 11 (x): xx-xx, in Press.  
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*Received: 12th december, 2011*

*Accepted: 15th October, 2012*