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GROWTH RESPONSE AND SERUM BIOCHEMICAL INDICES OF STARTER BROILER CHICKS FED GRADED LEVELS OF SOYBEAN CURD RESIDUES WITH ORGANIC ACIDS

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ABSTRACT

Soybean curd residue, a leftover material from producing soybean milk can be added to poultry feed to lower production expenses and reduce the environmental issues caused by improper waste disposal. This research aimed to assess the nutritional value of different levels of soybean curd residue (SCR) and organic acids on the growth performance and serum biochemical parameters of starter broiler chicks. A total of 192 day-old broiler chicks were used in the experiment. The chicks were randomly assigned to eight dietary groups, each with three replicates, following a 2 × 4 factorial experimental layout. The factors included two levels of organic acid supplementation (0 and 4 g/kg) and four inclusion levels of soybean curd residue (0%, 4%, 8%, and 12%). Each replicate contained eight chicks, totaling 24 birds per treatment group. The eight diets were structured as follows: treatments T1 through T4 included 0%, 4%, 8%, and 12% SCR without organic acid, while treatments T5 through T8 had the same levels of SCR combined with 4 g/kg organic acid. The data collected were analyzed using one-way analysis of variance (ANOVA), and the treatment means were compared using Duncan's multiple range test. The final body weight, overall weight gain, average daily weight gain, total feed intake, and daily feed intake were significantly ($P < 0.05$) affected by the interaction between SCR and organic acid. Likewise, serum glucose, creatinine, and uric acid levels were significantly ($P < 0.05$) influenced by this interaction. In summary, incorporating 12% soybean curd residue with organic acid in the diet of starter broiler chicks can enhance growth performance without adverse health effects.

Keywords: soybean curd residue, organic acid, serum biochemistry, broiler performance.

INTRODUCTION

The poultry sector plays a crucial role in ensuring global food security by supplying essential protein in the form of meat and eggs. As the demand for affordable, nutritionally rich poultry feed continues to grow, there is a pressing need to explore alternative feed ingredients that enhances both efficiency and sustainability in production. Soybean meal, a byproduct of oil extraction, has traditionally been a key component in poultry diets due to its high protein levels and favorable amino acid composition (Patterson and Burkholder 2003). However, escalating prices have driven producers to search for more economic options, such as soybean curd residue (SCR) a byproduct from soy sauce or Awara (local soy food) production. SCR is protein-rich and abundantly available, making it a potentially valuable but underutilized feed ingredient (Patterson and Burkholder 2003).

Globally, feed accounts for approximately 65% to 70% of poultry production costs (Desta, 2021). In developing countries like Nigeria, these costs can exceed 75% due to the high prices and limited availability of major feed components like maize and soybean (Amin et al., 2023). SCR is derived from the traditional Nigerian food "Awara." The process involves soaking soybeans overnight, grinding them, adding more water, and sieving the mixture. The curd collected is used to make Awara, while the leftover sieved residue—soybean curd residue is dried for storage. Awara is widely consumed in Nigeria, particularly in the northern regions, and is commonly sold in both urban and rural markets. Unfortunately, large amounts of this byproduct are discarded as waste, creating environmental concerns despite the ongoing shortage of both conventional and alternative feed sources. SCR contains about 25% crude protein (Sudik et al., 2024).

Although soybean curd residue holds potential as an alternative feed resource, limited research exists on its application in animal nutrition. When included in poultry feed, it can supply essential nutrients necessary for growth and development, and may also help reduce feed costs significantly. For this reason, the current study seeks to assess the nutritional and economic value of SCR in the diets of starter broiler chicks by evaluating its effects on growth performance and serum biochemical parameters.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the poultry section of the Teaching and Research Farm, Taraba State University, Jalingo. The location lies between latitudes 6°30′ and 9°30′N, and longitudes 9°00′ and 12°00′E, within the Guinea Savannah region of Northern Nigeria (Kefas et al., 2020). The area receives an annual rainfall between 1000 mm and 1500 mm, and experiences ambient temperatures ranging from 30°C to 35°C, with an average temperature of 29°C.

Source and Preparation of Test Ingredients

The soybean curd residue (SCR) used in the study was sourced from local Awara (soybean cake) producers in Jalingo Local Government Area and nearby communities. The residue was sun-dried until it became dry and brittle. After drying, it was stored in a clean, dry, and cool environment in preparation for use in feed formulation.

The feed additive used in this experiment was a commercially available organic acid blend known as Fysal-MP, produced by Salko International in the Netherlands.

This product contains a mixture of acids including: E200 Sorbic acid, E230 Formic acid, E260 Acetic acid, E270 Lactic acid, E280 Propionic acid, E295 Ammonium formate, and E330 Citric acid.

Experimental Diets

Starter broiler diets were formulated to satisfy the birds' basic nutritional requirements. A total of eight experimental diets were prepared. Diet 1 served as the control, containing neither soybean curd residue nor organic acids. Diets 2, 3, and 4 included soybean curd residue at levels of 4%, 8%, and 12% respectively. Diets 5 through 8 contained the same SCR inclusion levels but were supplemented with 4g/kg of organic acid. The details of the diet formulations are shown in Table 1.

Table 1: Percentage ingredients composition and calculated analyses of starter broiler chicks' diets (1- 28th day)

	Without Organic Acid (0g/kg)				With Organic Acid (4g/kg)			
Soybean curd residues (%):	**0 T1**	**4 T2**	**8 T3**	**12 T4**	**0 T5**	**4 T6**	**8 T7**	**12 T8**
Ingredients:								
Maize	51.00	50.70	48.70	47.70	51.00	50.70	48.70	47.70
Soybean meal	30.00	28.00	26.00	43.00	30.00	28.00	26.00	43.00
Soybean curd residue	0.00	4.00	8.00	12.00	0.00	4.00	8.00	12.00
Groundnut cake	6.70	6.00	7.00	7.00	6.70	6.00	7.00	7.00
Fish meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Maize offal	5.00	4.00	3.00	3.00	5.00	4.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Lime stone	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
L-Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analyses:								
ME (kcal/kg)	2917.58	2876.15	2850.16	2831.20	2917.58	2876.15	2850.16	2831.20
Crude protein (%)	22.83	22.35	22.01	21.65	22.83	22.35	22.01	21.65
Crude fibre (%)	4.00	3.74	3.51	3.33	4.00	3.74	3.51	3.33
Ether extract (%)	4.66	4.46	4.29	4.08	4.66	4.46	4.29	4.08
L-Lysine (%)	1.19	1.12	1.08	1.00	1.19	1.12	1.08	1.00
DL-Methionine (%)	0.55	0.53	0.52	0.50	0.55	0.53	0.52	0.50
Calcium (%)	1.09	1.09	1.09	1.08	1.09	1.09	1.09	1.08
Phosphorus (%)	0.55	0.63	0.62	0.60	0.55	0.63	0.62	0.60

*Premix to supply kg/diet; 9,000,000IU of Vit A; 2,135,000IU of Vit D3; 20,000mg of Vit E; 1,340mg of Vit B1; 5,340mg of Vit B2; 1,670mg of Vit K3; 12,000mg of Pantothenate; 2,670mg of Vit B6; 13.4mg of Vit B12; 30,000mg of Niacin; 100mg of Biotin; 100mg of Folic acid; 63,340mg of Iron; 78,000 of Zinc; 1,17340mg of Manganese; 775mg of Iodine; 180mg of Selenium and 10,000mg of antioxidant.

Experimental birds design and management

A total of 192 day-old broiler chicks of the commercial Cobb 500 strain were obtained from a recognized and reputable hatchery. After weighing, the chicks were randomly distributed into eight dietary treatment groups, each with three replicates. The experimental setup followed a 2 × 4 factorial arrangement consisting of two levels of organic acid inclusion (0 and 4 g/kg) and four levels of soybean curd residue (SCR) inclusion (0%, 4%, 8%, and 12%). Each replicate contained 8 chicks, resulting in 24 birds per treatment group.

The chicks were brooded for the first two weeks using a coal pot as the heat source. Housing was done in compartments for each replicate, with dimensions of 2 meters in length, 1.5 meters in width, and 1 meter in height. The birds were raised on a deep litter system throughout the 28 day experimental period. Vaccination and medication schedules were duly followed. Multivitamin was applied in the morning and antibiotics in the afternoon during 2nd – 4th day. Gumboro vaccine was applied at 8th and 20th day. Lasota vaccine was applied at 13th and 27th day. Feed and water were provided to the birds without restriction (ad libitum).

Data Collection

Serum Biochemical Analysis

Two milliliters of blood were drawn from the wing vein of three birds per treatment group using a sterile syringe and transferred into plain bottles for serum biochemical analysis. The blood samples were allowed to clot and then refrigerated for six hours before being centrifuged at 900 rpm for 20 minutes. The resulting serum was subsequently stored in a freezer at -2°C until analysis. The collected serum samples were tested for biochemical parameters: Total protein, albumin, globulin, glucose, creatinine, and uric acid.

Statistical Analysis

The data obtained were analyzed using one-way Analysis of Variance (ANOVA) based on factorial experimental design, utilizing the Statistix 9 software. Where significant differences were observed, the means were compared using Duncan's Multiple Range Test at a 5% significance level.

RESULTS AND DISCUSSION

Growth performance

The effects of the interaction between different inclusion levels of soybean curd residue (SCR) with or without organic acid on the growth performance of starter broiler chicks are presented in Table 2. A significant ($P < 0.05$) interaction between SCR and organic acids was observed across all measured growth parameters. Parameters measured are body weight, total weight gain, average daily weight gain, total feed intake, and daily feed intake were all significantly influenced by the combined effects of SCR and organic acid. This significant improvement in performance could be due to the synergistic benefits of combining SCR with organic acids.

Chicks fed the control diet without SCR or organic acid (T1) had the lowest ($P < 0.05$) final body weight of 608.33g. The use of organic acids in early brooding can help suppress pathogens and support better growth in chicks, as supported by Waldroup et al. (1995). The trend in weight gain mirrored that of final weight. The lowest weight gain (512.33g) was noted in birds on the control diet (T1). A significant ($P < 0.05$) interaction effect was also seen in feed intake, with the highest value (1639.70g) recorded in birds fed 8% SCR without organic acid (T3). On the other hand, the lowest ($P < 0.05$) feed intake values of 66.63g and 68.25g were observed in birds fed T1 and T6, respectively. These findings corroborated the literature, Abd El-Hack et al. (2020), who reported that higher dietary fiber stimulates increased feed intake to satisfy nutritional needs. However, the interaction between SCR and organic acid did not have a significant ($P > 0.05$) effect on feed conversion ratio (FCR), contrasting with the findings of Asgar et al. (2013), who reported improvements in FCR with organic acid inclusion.

Table 3 presents the main effects of varying SCR and organic acid levels on broiler growth performance. Inclusion of SCR alone did not produce any significant ($P > 0.05$) effects on the measured parameters. This result differs from that of previous studies (Jha and Mishra, 2021; Abd El-Hack et al., 2020), which reported significant positive effects of SCR on broiler growth. However, aside from FCR, all performance parameters showed progressive numerical increases with higher SCR levels. Contrary to earlier findings (Agbede, 2000; Jha and Mishra, 2021; Abd El-Hack et al., 2020), which showed declines in growth metrics at higher SCR levels, this study reported improved outcomes—except for feed intake.

Likewise, organic acid supplementation alone did not significantly ($P > 0.05$) affect any of the growth performance parameters. Nevertheless, there were numerical increases in final weight, total weight gain, and daily weight gain with rising levels of organic acid. This improvement may be linked to enhanced nutrient utilization, possibly due to the organic acids' ability to suppress harmful bacteria by lowering gastrointestinal pH (Adil et al., 2011). Organic acids also help reduce nitrogen loss and ammonia production, contributing to better protein digestibility. These findings support previous studies (Asgar et al., 2013; Mahbuba et al., 2014) that documented improved weight gain and final weight with organic acid inclusion. Although feed intake and feed conversion ratio declined numerically with increasing levels of organic acid, the changes were not statistically significant.

Table 2. Interaction effect of varying levels of soybean curd residue and organic acid on growth performance of starter broiler chicks.

	Organic Acid (0g/kg)				Organic Acid (4g/kg)				
	0%	4%	8%	12%	0%	4%	8%	12%	
Parameters	T1	T2	T3	T4	T5	T6	T7	T8	**SEM**
Initial Weight (g)	96.40	96.0	96.0	96.20	96.02	96.33	96.00	96.00	
Final weight (g)	608.73^{b}	717.00^{ab}	771.00^{a}	804.33^{a}	795.35^{a}	694.33^{ab}	669.00^{ab}	796.00^{a}	49.84
Total weight gain (g)	512.33^{b}	621.00^{ab}	675.00^{a}	708.13^{a}	699.33^{a}	598^{ab}	573.00^{ab}	700.00^{a}	49.84
Daily weight gain (kg/day)	24.39^{b}	29.52^{ab}	32.14^{a}	33.72^{a}	33.30^{a}	28.49^{ab}	27.28^{ab}	33.33^{a}	2.35
Total feed intake (g)	1399.30^{c}	1519.50^{abc}	1619.20^{a}	1516.90^{abc}	1519.60^{abc}	1433.40^{c}	1444.70^{bc}	608.8^{ab}	56.52
Daily feed intake (g/day)	66.63^{c}	73.30^{abc}	78.08^{a}	73.18^{abc}	72.36^{abc}	68.25^{c}	68.79^{bc}	76.60^{ab}	2.69
FCR	2.73^{a}	2.43^{ab}	2.43^{ab}	2.18^{b}	2.21^{b}	2.45^{ab}	2.53^{ab}	2.31^{ab}	0.14

Table 3. Main effect of varying levels of soybean curd residue and organic acid on growth performance of starter broiler chicks.

	Soybean Curd Residue					Organic Acid		
Parameters	0%	4%	8%	12%	**SEM**	0g/kg	4g%	**SEM**
Initial Weight (g)	95.52	96.0	96.0	96.0		96.0	96.0	96.0
Final weight (g)	701.33	705.67	720.00	800.17	34.99	725.17	735.67	24.74
Total weight gain (g)	605.81	609.67	624.00	704.17	34.99	629.17	642.67	24.74
Daily weight gain (g/day)	28.84	29.03	29.71	33.51	1.66	29.96	30.60	1.17
Total feed intake (g)	1459.5	1486.50	1542.20	1572.90	40.00	1528.90	1501.60	28.28
Daily feed intake (g/day)	69.49	70.73	73.43	74.89	1.90	72.80	71.50	1.34
FCR	2.47	2.46	2.48	2.25	0.10	2.45	2.37	0.04

Serum biochemical indices

The interaction effects of varying levels of soybean curd residue (SCR) and organic acid on the serum biochemical parameters of starter broiler chicks are shown in Table 4. A significant ($p < 0.05$) interaction was observed between SCR and organic acids for several serum biochemical indices. Specifically, glucose, creatinine, and uric acid levels were significantly ($p < 0.05$) affected by the combined influence of these two dietary factors. Glucose, being a key metabolite, plays an essential role in maintaining a stable energy supply necessary for animals' physiological and biochemical processes (Hernawan et al., 2012). The elevated glucose levels observed may be attributed to sufficient energy availability in the feed.

The creatinine values did not exhibit a consistent trend across treatments. However, birds fed a diet containing 8% SCR with 4 g/kg organic acid had the lowest ($P < 0.05$) creatinine concentration of 55.07 mmol/L at comparative level across dietary treatments. Uric acid levels varied considerably among the treatments. Birds fed diets with 4% SCR and 4 g/kg organic acid showed an improved least ($p < 0.05$) value of 206.40 for uric acid. Elevated levels of uric acids suggest increased tissue catabolism and indicate that the birds were possibly mobilizing body reserves for survival, as suggested by Adeyemi and Sani (2013).

Other serum biochemical parameters, including total protein, albumin, globulin, aspartate aminotransferase (AST), and alanine aminotransferase (ALT), were not significantly ($P > 0.05$) affected by the interaction of SCR and organic acids. Interestingly, the total serum protein values exceeded the 16.00–34.00 g/dL range reported by Kwari et al. (2011) for broilers. Since serum protein levels are often indicative of dietary protein quality (Eggum, 1970), the elevated values observed in this study suggest that the diets provided adequate protein to maintain normal blood protein concentrations. Previous findings (Awosanya et al., 1999) have shown that serum protein levels are influenced by both the quality and quantity of dietary protein.

Table 5 presents the main effects of SCR and organic acid supplementation on serum biochemical parameters. SCR had a significant ($P < 0.05$) main effect on creatinine and uric acid levels. Birds fed 8% SCR had the lowest ($P < 0.05$) creatinine value of 66.03 mmol/L. For uric acid, the lowest values were observed in birds fed 0% and 4% SCR, recording 296.07 mmol/L and 351.12 mmol/L, respectively, while the highest uric acid values of 598.45 mmol/L and 428.98 mmol/L were found in birds fed 8% and 12% SCR. On the other hand, organic acids had no significant ($P > 0.05$) main effect on any of the serum biochemical parameters measured.

Table 4. Interaction effect of varying levels of soybean curd residue and organic acid on serum biochemical indices of starter broiler chicks.

	Organic Acid (0g/kg)				Organic Acid (4g/kg)				
	0%	4%	8%	12%	0%	4%	8%	12%	
Parameters	T1	T2	T3	T4	T5	T6	T7	T8	**SEM**
Total Protein (g/l)	40.76	39.86	35.96	33.43	28.50	37.56	42.46	42.00	3.35
Albumin (g/l)	23.36	20.93	20.80	23.10	19.53	22.66	25.23	23.73	2.84
Globulin (g/l)	17.43	18.93	15.16	10.33	10.30	14.90	17.23	18.26	2.43
Glucose (mmol/l)	1.26^{ab}	1.80^{ab}	2.30^{a}	1.16^{ab}	1.36^{ab}	2.16^{a}	0.64^{b}	1.10^{ab}	0.30
Creatinine (mmol/l)	102.77^{a}	88.57^{ab}	77.00^{ab}	97.77^{ab}	84.80^{ab}	100.53^{a}	55.07^{b}	101.90^{a}	9.08
Uric acid (mmol/l)	310.67^{bc}	495.83^{abc}	529.33^{ab}	514.70^{ab}	281.47^{bc}	206.40^{c}	667.57^{a}	343.27^{bc}	60.05
ASAT (iu/l)	58.33	48.46	35.00	65.40	46.66	45.03	69.80	56.46	9.06
ALAT (iu/l)	11.26	3.66	5.00	13.00	14.80	10.66	9.73	14.03	3.05

Table 5. Main effects of varying levels of soybean curd residue and organic acid on serum biochemical indices of starter broiler chicks.

	Soybean Curd Residue					**Organic Acid**		
Parameters	0%	4%	8%	12%	**SEM**	0g/kg	4g/kg	**SEM**
Total Protein (g/l)	34.63	38.71	39.21	37.71	2.37	37.50	37.63	1.67
Albumin (g/l)	21.45	21.80	23.01	23.41	2.01	22.05	22.79	1.42
Globulin (g/l)	13.86	16.91	16.20	14.30	1.72	15.46	15.17	1.21
Glucose (mmol/l)	1.30	1.98	1.47	1.13	0.21	1.62	1.31	0.15
Creatinine (mmol/l)	93.78^{a}	94.55^{a}	66.03^{b}	99.83^{a}	6.42	91.52	85.57	4.54
Uric acid (mmol/l)	296.07^{b}	351.12^{b}	598.45^{a}	428.98^{ab}	42.46	462.63	374.68	30.02
ASAT (iu/l)	52.50	46.75	52.40	60.93	6.40	51.80	54.49	4.53
ALAT (iu/l)	13.03	7.16	7.36	13.51	2.15	8.23	12.30	1.52

CONCLUSION AND RECOMMENDATION

i. Incorporating soybean curd residue at levels up to 12% enhanced weight gain, feed consumption, and feed efficiency in starter broiler chicks.
ii. Combining up to 12% soybean curd residue with organic acids resulted in improved growth performance.
iii. Different levels of soybean curd residue up to 12% can be safely included in the diets of starter broiler chicks without causing any adverse effects

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