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Evaluation of lauric acid and L-glutamate individually and in combination as pro-nutrient growth promoters in broiler chickens

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ABSTRACT

This experimental study aimed to elucidate the effect of dietary supplementation of lauric acid and L-glutamic acid on the production performance and carcass characteristics of broilers. Day-old broiler chicks (160) were randomly divided into four groups. The chicks were fed with four experimental diets, such as control diet without antibiotics (T1), control + 0.1% lauric acid (T2), control + 0.5% glutamate (T3), and control + 0.1% lauric acid + 0.5% glutamate (T4). The experiment was performed for five weeks using standard management practices. The production performance and carcass characteristics were determined. The body weight, feed intake, and feed conversion efficiency showed significant improvement in the treatment group fed with 0.5% glutamate. The carcass attributes, such as pre-slaughter weight, de-bleeding weight, eviscerated carcass weight, giblet weight, and abdominal fat weight were comparable among the treatments. No significant difference among the groups on serum biochemical parameters was observed. Further, the intestinal length was significantly higher in the T3 group. It was concluded that supplementation of 0.5% glutamate as a pronutrient improved the production performance and increased intestinal length without affecting the other carcass characters in broiler chicken.

Keywords: Broilers, Carcass characteristics, Glutamate, Intestinal length, Lauric acid, Production performance

The poultry industry is a fast-growing sector in the agricultural sector. In recent years, tremendous growth with a 12% annual growth rate has been observed in the Indian broiler industry and India stood fifth in broiler meat production in 2019. Broiler meat is a good source of protein, minerals and vitamins, and it contributes to about 35% of total animal protein production. Several factors influence the profitability of broiler farming. Feeding is one of the critical factors for the growth and maintenance of broiler production. Targeting genetic potential for improved growth rate resulted in increased nutrient requirement and modification in feed formulations. Therefore, economical and nutritionally balanced efficient feed is critical for profitable broiler farming. Various biochemical/biological agents were added to the feed to enhance the production performance, but some negatively affected the carcass quality and general health. Pronutrients are the micro-ingredients included in feed in relatively small quantities to improve the physiological function by inhibiting the existence and growth of pathogens, and to improve the nutritional value of the feed.

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Pronutrients have several functions, such as intestinal optimization and conditioning, hepatic protection, immune modulation, regulation of mineral absorption, feed conditioning, protecting from free radicals, and working as intestinal prebiotics. Glutamate, one of the pronutrients, was evaluated for improved growth performance and enhanced immunity in broilers in previous studies. Glutamate served as precursors to several non-essential amino acids (Blachier *et al*. 2009), enhanced the nitrogen economy of the system (Young and Ajami 2000) and increased the intestinal villi length and improved the integrity of the intestine (Reeds *et al*. 2000, Newholms *et al*. 2003). Similarly, the organic acids, especially short and medium chain fatty acids are widely used in poultry and swine feeds for better nutrient utilization, improved carcass quality, and alternative to antibiotics. These organic acids reduced the intestinal inflammatory processes thereby increasing nutrient absorption and efficiently transporting into the blood circulation (Pearlin *et al*. 2019). Hence, the present study aimed to evaluate the effect of lauric acid (organic acid) and L-glutamate (amino acid) alone and in combination on the production performance and carcass quality in broiler chickens.

MATERIALS AND METHODS

Ethics approval: The present study was carried out as per the approved protocol of Institute Animal Ethics Committee (IAEC). The IAEC approval number for the study: IAEC/ab/407/214.

Preliminary study: Two preliminary studies were performed to determine the optimal dosage for lauric acid and L-glutamate. Lauric acid was supplemented at 0.1%, 0.3%, and 0.5% in one trial and glutamate was fed at 0.25%, 0.5%, and 1.0% in another trial. The birds were maintained for 21 days, and the optimal dosages were selected for further studies. The supplementation of lauric acid at 0.1% and L-glutamate at 0.5% were optimal for the production performance and selected for the present study.

Experimental design: One hundred and sixty newly hatched commercial broiler chicks (Vencobb 400 breed) were used in this study. The chicks were randomly grouped into four treatment groups with 40 chicks in each group. Each group had five replicates each containing eight chicks. All the birds were reared under standard management practices up to five weeks of age. The four experimental diets were a basal diet without antibiotics (T1), a basal diet with 0.1% lauric acid (T2), a basal diet with 0.5% L-glutamate (T3), and a basal diet with a combination of 0.1% lauric acid and 0.5% L-glutamate (T4). The birds were fed with a pre-starter (0-10 days), starter (11-21 days) and finisher (22-35 days) rations as per the breeder's nutrient recommendations (Table 1).

Data collection: Body weight and feed consumption were recorded every week and mortality was recorded at the occurrence. Weight gain, feed intake, feed efficiency, livability, slaughter yield, and intestinal length were calculated.

Carcass characteristics: At the end of the experimental period (35th day), 35 birds per treatment group were randomly selected, blood samples were collected for analyzing the serum biochemical parameters, and the birds were slaughtered as per a previously described method (Arumugam and Panda 1970). Pre-slaughter weight, New York dressed weight, eviscerated carcass weight, giblets weight (heart without pericardium and liver without a gall bladder), ready-to-cook yield, and abdominal fat weight were determined.

Statistical analysis: The collected data were subjected to statistical analysis using statistical packages for Statistical Package for Social Sciences (SPSS) version 16.0. Single-factor analysis of variance was adopted to analyze various parameters. Arcsine transformation was applied to the percentages wherever needed before performing ANOVA. Tukey test (1957) was used to find means significantly different from each other group and a P value of <0.05 was considered significant.

Table 1. Ingredient and nutrient composition of the experimental broiler diet

Ingredient	Pre-starter	Starter	Finisher
Maize	563.86	562.53	617.56
Rice bran oil	22.05	37.95	47.08
Soybean meal 46%	372.78	361.97	302.06
Calcite	10.65	10.31	9.67
Di-calcium phosphate	15.45	13.58	11.68
DL-Methionine	2.20	2.06	1.78
L-Lysine HCL	3.71	2.40	0.00
NSP enzymes*	0.50	0.50	0.50
Phytase#	0.20	0.20	0.20
Sodium bicarbonate	1.00	1.00	1.00
Salt	3.53	3.44	3.41
Trace minerals†	1.00	1.00	1.00
Vitamins‡	0.50	0.50	0.50
Liver tonic	1.00	1.00	1.00
Toxin binder	1.00	1.00	1.00
Anti-coccidial	0.50	0.50	0.50
Antioxidant	0.06	0.06	0.06
Total	1000.00	1000.00	1000.00
Nutrient composition (%)			
Crude protein	23.06	21.91	20.25
Metabolizable energy (Kcal/kg)	3,003	3,102	3202
Calcium	0.98	0.98	0.95
Available phosphorus	0.45	0.42	0.40
Methionine	0.62	0.58	0.56
Lysine	1.35	1.24	1.14

*Each kg contains (Ultrazyme): Amylase, 3,00,00,000 units; Hemicellulose, 17,82,000 units; Cellulase, 39,60,000 units; Protease, 1,00,00,000 units; Lipase, 16,50,000 units; β-gluconase, 34,980 units; *Lactobacillus* species, 300 Billion viable CFU. #Each g contains (BioPhos-P-FS): 2500 phytase units (FTU)/g. †Each kg contained (Ultra-M): Manganese, 54 g; Zinc, 52 g; Iron, 20 g; Iodine, 02 g; Copper, 02 g; Selenium, 0.3 g. ‡Each 500 g contained (CompliVite-BFS): Vitamin A, 12.5 MIU; Vitamin D3, 3.0 MIU; Vitamin E, 12.0 g; Vitamin K3, 1.5 g; Vitamin B12, 15 mg; Vitamin B1, 1.5 g; Vitamin B2, 7.5 g; Vitamin B6, 2.0 g; Niacin, 15.0 g; Calcium Pantothenate, 10.0 g; Folic acid, 0.5 g; Biotin, 50.0 mg.

RESULTS AND DISCUSSION

Body weight and weight gain: Body weight and weight gain from day old to five weeks of age as influenced by dietary supplementation of glutamate and lauric acid, and their combination are presented in Table 2. Mean body weight (g) of broilers showed significant differences (P<0.05) from the third to fifth weeks of age among treatment groups due to dietary supplementation of glutamate, lauric acid, or their combination. The T3 group had significantly higher mean body weight during the third week (805.00 g), fourth week (1385.30 g), and fifth week (1563.13 g) when compared to all other treatment groups (P<0.05). No significant difference among the experimental groups was noticed in the first two weeks of the trial period. The body weight gain did not differ significantly from the first to fourth week of age among treatment groups. But the body weight gain in the fifth week showed a significant difference among the treatment groups (P<0.05). In this period, the T3 group had significantly higher body weight gain (410.94 g) whereas the T1 group had the lowest body weight gain (300.56 g).

Dietary supplementation of L-glutamate alone and in combination with lauric acid improved the body weight and enhanced the weight gain in broilers in this study. The

Table 2. Effect of lauric acid and L-glutamate supplementation on body weight and weight gain (g), feed consumption (g) and feed conversion efficiency in broilers chickens (n=40)

Group	Weak I	Week II	Week III	Week IV	Week V
Body weight (g)					
T1	153.28±2.30	375.44±7.04	747.31^{b}±15.38	1290.30^{b}±26.60	1473.75^{c}±21.82
T2	151.88±2.05	376.06±5.09	765.78^{ab}±9.67	1326.50^{b}±21.12	1549.69^{b}±24.00
T3	147.03±2.75	378.09±6.99	805.00^{a}±14.16	1385.30^{a}±15.95	1765.94^{a}±28.33
T4	152.03±2.58	390.41±5.76	793.13^{a}±13.41	1317.80^{b}±14.64	1563.13^{b}±23.93
P value	0.283	0.293	0.011	0.010	0.021
Body weight gain (g)					
T1	99.69±3.66	222.16±7.21	371.72±8.21	54316±10.61	300.56^{b}±6.21
T2	98.64±3.14	224.19±7.37	389.72±9.32	560.78±9.32	310.16^{b}±7.34
T3	91.30±2.76	231.38±7.18	423.47±10.11	546.25±11.10	410.94^{a}±8.21
T4	95.42±3.04	239.94±6.43	402.72±9.34	517.50±9.34	340.34^{b}±8.23
P value	0.213	0.538	0.245	0.184	0.021
Feed consumption (g/bird)					
T1	123.12±10.13	305.00±11.04	549.00±9.23	816.23±16.12	676.30±9.21
T2	122.17±9.65	310.00±10.31	546.67±10.41	851.67±10.40	69.27±11.20
T3	121.00±11.32	316.67±9.65	594.00±8.37	821.67±13.19	720.67±6.54
T4	121.03±10.30	312.00±11.78	572.50±9.92	825.70±12.65	702.67±7.32
P value	0.501	0.321	0.310	0.283	0.173
Feed conversion efficiency (g feed : g gain)					
T1	1.27±0.06	1.36±0.03	1.47±0.02	1.50±0.05	2.24^{b}±1.02
T2	1.23±0.04	1.38±0.04	1.40±0.06	1.52±0.02	2.22^{b}±1.10
T3	1.24±0.03	1.36±0.05	1.40±0.03	1.50±0.04	1.75^{a}±0.83
T4	1.26±0.07	1.30±0.02	1.42±0.01	1.59±0.07	2.06^{b}±1.02
P value	0.321	0.529	0.187	0.421	0.031

^{a,b,c}Means bearing different superscripts within the column differs significantly (P<0.05).

outcome of this study was similar to the findings of some previous elucidations (Yi *et al*. 2005, Bartell and Batal 2007, Ajinamoto 2007, Soltan 2009, Maslami 2018).

In these previous studies, dietary supplementation of glutamate increased the growth of connective tissue, and body weight, and improved weight gain. Pappula *et al*. (2021) found that feed supplementation of lauric acid (0.05%) in combination with probiotics enhanced the cumulative weight gain. In contrast, some other studies found that high glutamine supplementation negatively affected body weight and weight gain in broilers (Murakami *et al*. 2007, Soltan 2009).

This contradiction may have been due to flock variation and other confounding variables. But these positive effects are explained by the significance of glutamine as the most abundant free amino acid in the bloodstream, accounting for approximately 25-35% of the total free amino acid pool of the body and over 60% of the total free amino acids in the skeletal muscle (Zaravize *et al*. 2010). Glutamine might have improved intestinal mucosa development and gut health since it is used as an energy substrate in tissues with high proliferation, such as the intestinal mucosa consisting of enterocytes and colonocytes, exhibiting protective and restorative roles. Feed supplementation of increasing levels of lauric acid (0.1% to 0.8%) in fish (black sea bream) showed considerable improvement in growth rate, weight gain, and feed efficiency (P <0.05) (Ullah *et al*. 2022). In short, feed supplementation of L-glutamate and lauric acid could have a positive effect on body weight and weight gain in broilers.

Feed intake and feed conversion efficiency: Feed consumption and feed conversion efficiency from day old to five weeks of age as influenced by dietary supplementation of L-glutamate and lauric acid and their combination are shown in Table 2. Although no statistically significant difference was found in feed consumption among the treatment groups, a numerically higher intake of feed was observed in birds fed with L-glutamate. The feed efficiency was significantly greater in the T3 group (1.75; P<0.05) but no significant difference was seen among the T1, T2, and T4 treatment groups.

Feed supplemented with L-glutamate and lauric acid did not significantly improve the feed intake and feed conversion efficiency in broilers. This result was similar to the findings of some previous studies (Sakamato *et al*. 2006, Murakami *et al*. 2007, Ebadiasl 2011). In those studies, no significant increase in feed intake was observed in broilers fed with a diet containing vitamin E and 1% glutamine. However, feed supplementation of lauric acid enhanced the feed conversion efficiency in commercial broiler chickens in a previous elucidation (Venkatasubramani *et al*. 2014). The positive effect on feed conversion efficiency might have been due to the nature of its antibacterial activity reducing harmful pathogens and multiplying beneficial

Table 3. Effect of lauric acid and L-glutamine supplementation on serum biochemical parameters in broilers chickens (n=40)

Group	Total protein (g/dL)	Total cholesterol (mg/dL)	Triglycerides (mg/dL)	ALP (U/mL)	ALT (U/mL)	AST (U/mL)	Uric acid (mg/dL)
T1	4.66±0.09	77.36±4.92	186.85±8.54	3.34±0.32	18.85±1.84	133.00±2.55	5.58±0.15
T2	4.61±0.10	78.23±10.13	169.10±10.31	3.39±0.24	16.31±1.43	136.91±4.43	6.04±0.53
T3	4.74±0.17	76.71±15.80	191.25±6.05	3.43±0.18	20.40±3.82	133.83±5.64	6.36±0.27
T4	4.72±0.15	75.53±7.34	175.30±9.05	3.32±0.10	19.16±2.94	135.53±7.99	6.31±0.34
P value	0.125	0.218	0.258	0.425	0.746	0.520	0.383

acid tolerant microorganism in the gut (Nava *et al*. 2009).

Livability: The mean (±SE) livability percentage from day old to five weeks of age as influenced by dietary supplementation of L-glutamate, lauric acid, and their combination is presented in Table 4. No significant difference in livability among the treatment groups from the first to the fifth week of age was found. Livability was 100% in all treatment groups up to five weeks of age. However, mortality was noticed in the T1, T3, and T4 groups during the fifth week of age due to nonspecific conditions.

Dietary supplementation of L-glutamate, lauric acid, and their combination did not significantly affect the livability among treatment groups. Livability was 100% in all treatment groups up to five weeks of age. Nevertheless, mortality was observed in the T1, T3, and T4 groups during the fifth week of age due to some nonspecific conditions. This result was similar to the findings of a previous study (Yi *et al*. 2005). However, that study reported that dietary supplementation of 1% L- glutamine decreased the mortality in broilers. L-glutamine supplementation may have aided the body fight against the invaded microbes by enhancing the protection against secondary adverse effects on the immune system, such as peroxide production (Huang *et al*. 2007).

Serum biochemical parameters: The results of serum total protein, total cholesterol, triglycerides, ALP, AST, ALT and uric acid of serum samples of broilers fed with L-glutamate and lauric acid individually and combination are presented in Table 3. No significant difference was noticed on serum sample in broilers fed with lauric acid and L-glutamate. This result was in accordance with the findings of Xue *et al*. (2018), who reported that supplementation of L-glutamate did not show any significant effect on serum glucose, total protein and ALT than the control group.

Carcass characteristics: The carcass characteristics as influenced by dietary supplementation of L-glutamate, lauric acid, and their combination at the sixth week of age are presented in Table 4. Pre-slaughter weight, de-bleeding weight, eviscerated carcass weight, giblet weight, and abdominal fat weight did not differ significantly due to dietary supplementation of L-glutamate, lauric acid, and their combination. But the highest eviscerated carcass numerical yield was observed in birds fed with 0.5% L-glutamate. Likewise, the numerically lowest abdominal fat (13.50 g) was noticed in the L-glutamate-supplemented group and the highest (22.50%) abdominal fat was seen in birds fed with 0.1% lauric acid.

Dietary supplementation of L-glutamate, lauric acid, and their combination did not significantly affect the pre-slaughter weight, de-bleeding weight, eviscerated carcass weight, giblet weight, and abdominal fat weight. But numerically highest eviscerated carcass yield was observed in birds fed with 0.5% glutamate. Likewise, numerically lowest abdominal fat (13.50 g) was observed in the glutamate-supplemented group and the highest abdominal fat (22.50%) was seen in birds fed with 0.1% lauric acid. This result was contrary to the findings of a previous report (Zeiger *et al*. 2017).

Intestinal length: The mean (±SE) intestinal length at the 5th week of age as influenced by dietary supplementation of L-glutamate, lauric acid, and their combination are given in Table 3. The intestinal length differed significantly among the treatment groups (P<0.05). The T3 group had the highest intestinal length (175.50 cm), which differed significantly from that of T2 (166.00 cm), T4 (164.50 cm), and T1 (151.50 cm).

The intestinal length significantly differed among treatment groups in this present study. The birds fed with 0.5% glutamate had the highest intestinal length than other treatment groups. This result was similar to the findings of a previous elucidation (Ebadiasl 2011).

Table 4**.** Effect of lauric acid and L-glutamine supplementation on livability and carcass characteristics in broiler chickens

Group	Live weight (g)	De-bleeding weight (g)	Carcass weight (g)	Intestinal length (cm/kg bwt)	Giblet weight (g/kg bwt)	Abdominal fat weight (g/kg bwt)	Livability (%)
T1	1480.54±30.22	1440.21±30.31	995.25±22.90	151.50^{b}±3.12	57.50±2.50	20.00±2.50	99.98
T2	1520.18±70.44	1480.48±70.43	1060.50±56.57	166.00^{ab}±6.99	62.50±2.50	22.50±2.50	100.00
T3	1600.15±90.09	1549.54±80.12	1202.50±32.43	175.50^{a}±5.07	621.50±2.99	13.50±2.99	99.98
T4	1590.84±50.21	1550.85±50.11	1012.25±24.37	164.50^{ab}±3.33	60.00±4.08	20.50±4.08	99.98
P value	0.534	0.522	0.147	0.033	0.547	0.691	-

^{a,b,c}Means bearing different superscripts within the column differs significantly (P<0.05).

Dietary supplementation of 0.5% L-glutamate significantly increased the body weight, weight gain, caused better feed conversion efficiency, and lengthened the intestine, compared to other treatments. However, supplementation of 0.1% lauric acid alone did not influence the production performance in broiler chicken. Hence, supplementation of L-glutamine alone at the level of 0.5% had beneficial effects on production performance in broiler chickens.

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