

# Effect of Dietary Betaine Supplementation in Choline-Deficient Broiler Diets on Growth Performance, Carcass Traits, Serum Biochemistry, and Economics

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**Abstract**— A feeding trial was conducted to evaluate the efficacy of betaine as a functional nutrient in choline-deficient broiler diets. A total of 275 day-old commercial Cobb 400 broiler chicks were randomly allotted to nine dietary treatments comprising a control (100% choline requirement), two choline-deficient diets (75% and 50% of requirement), and their respective betaine-supplemented groups at 0.1%, 0.2%, and 0.3%. Each treatment had six replicates of five birds each, maintained under uniform management for 42 days. Growth performance, carcass traits, serum biochemical parameters, immune responses, and cost economics were assessed.

Choline deficiency significantly ( $p < 0.05$ ) reduced body weight gain (BWG), feed conversion ratio (FCR), and carcass yield. Betaine supplementation improved performance in a dose-dependent manner. Birds fed diets with 0.3% betaine achieved body weights and FCR comparable to the control group. Carcass yield and breast meat percentage were significantly higher, while abdominal fat percentage was reduced in betaine-supplemented birds. Serum protein, albumin, and globulin concentrations improved with betaine addition, whereas cholesterol, triglycerides, and uric acid decreased. Betaine enhanced antibody titers against Newcastle disease virus and increased the relative weights of lymphoid organs. Economic analysis revealed higher net profit per bird in betaine-supplemented groups, with the highest benefit at 0.3% inclusion.

It was concluded that betaine supplementation at 0.3% effectively spares up to 50% of the dietary choline requirement in broilers, improving growth, carcass yield, immunity, and profitability.

**Keywords**— Betaine, choline deficiency, broiler, growth performance, immunity, carcass traits, economics.

## I. INTRODUCTION

Broiler production efficiently converts feed resources into animal protein, with choline being a crucial nutrient. Deficiency in poultry diets can lead to growth retardation, fatty liver, poor feed efficiency, and increased mortality. Synthetic choline chloride is used in commercial feed formulation, but it raises feed costs and may cause storage instability due to hygroscopicity. Betaine, a sugar beet compound, is gaining interest in poultry nutrition due to its dual role as a methyl donor and osmolyte. As a methyl donor, it reduces the need for choline and methionine in the diet, while as an osmolyte, it stabilizes cellular structures, improving stress tolerance and dehydration tolerance.

Several researchers have reported the efficacy of betaine as a partial substitute for choline. Jahanian and Rahmani (2008) reported improved growth and humoral immunity with betaine supplementation in choline-deficient diets. Rama Rao et al. (2011) found that betaine improved carcass yield and breast meat deposition while reducing abdominal fat. However, results across studies have been inconsistent, possibly due to variations in betaine source, diet composition, and rearing conditions.

The present study was therefore designed to systematically evaluate the effect of graded levels of dietary betaine in choline-deficient diets on growth performance, carcass yield, serum biochemistry, immune responses, and economics of broilers reared under Indian climatic conditions.

## II. MATERIALS AND METHODS

### 2.1 Study Area, Population and Period:

The research was conducted at poultry unit, livestock farm complex, NTR College of Veterinary Science, Gannavaram, Andhra Pradesh. The current study was conducted on a cohort of 275-day-old Cobb 400 broiler chicks from local hatchery. The investigation was carried out over the 6-week period spanning from August to October 2018. The laboratory experiments were conducted in the Department of Animal Nutrition, Central instrumentation cell at NTR College of Veterinary Science, Gannavaram, Andhra Pradesh.

### 2.2 Experimental Design and Birds:

Two hundred and seventy five day-old commercial Cobb 400 broiler chicks were randomly distributed into nine treatment groups under a completely randomized design (CRD). Treatments included a control diet (T1) with adequate choline and two choline-deficient diets (25% and 50% of requirement). Each deficient diet was supplemented with betaine at 0.1%, 0.2%, and 0.3%. Each treatment had six replicates of five birds each (9 treatments × 6 replicates × 5 birds = 270 birds, plus 5 extra chicks = 275 total).

**TABLE 1**  
**TREATMENTS AND EXPERIMENTAL DIETS**

Treatment	Choline Level	Betaine (%)
T1	Basal Diet (100% choline)	0
T2	25% less choline	0
T3	25% less choline + 0.1% betaine	0.1
T4	25% less choline + 0.2% betaine	0.2
T5	25% less choline + 0.3% betaine	0.3
T6	50% less choline	0
T7	50% less choline + 0.1% betaine	0.1
T8	50% less choline + 0.2% betaine	0.2
T9	50% less choline + 0.3% betaine	0.3

### 2.3 Diets and Management:

Basal diets were formulated using maize and soybean meal to meet the nutrient requirements of broilers (BIS, 2007), except for the intended reduction in choline levels. Betaine (feed-grade anhydrous, 97% purity) and choline chloride were incorporated as per treatment. Diets were prepared in three phases: pre-starter (0–14 days), starter (15–28 days), and finisher (29–42 days) and were isonitrogenous and isocaloric. All the chicks were reared in well ventilated raised wire floor battery brooders under uniform management (brooding, feeding and watering) and standard hygienic conditions throughout the experiment. During the experiment, light was provided continuously by using fluorescent bulbs. Each battery brooder consists of 16 cells. Each cell (one replicate) can accommodate five birds providing an average floor space of 0.9 sq. ft. per bird. All the replicates, each having 5 chicks, were housed separately in a completely randomized design (CRD) in an electrically heated battery brooder. Brooder temperature was maintained at  $34 \pm 1^\circ\text{C}$  up to 7 days of age and then gradually reduced to  $26 \pm 1^\circ\text{C}$  by 21 days of age after which chicks were maintained uniformly at room temperature. Irrespective of treatments all the chicks were fed ad lib with respective broiler pre-starter diet from day old to 14 days, broiler starter diet from 14 to 28 days and finisher diet from 29 to 42 days of age. Clean and fresh drinking water was provided ad lib daily.

Chicks were vaccinated with Mareks disease vaccine at 3 days, La Sota vaccine at 7th (primary) and 21st (booster) days of age and IBD vaccine at 14th day of age with intermediate-Georgia strain. Except for feeding experimental diets, other management practices were followed uniformly throughout the experimental period.

The experimental diets are depicted in Tables 2, 3, and 4 fed during different phases respectively.

**TABLE 2**  
**INGREDIENT AND NUTRIENT (%) COMPOSITION OF PRE-STARTER DIETS (0-2 WEEKS)**

Ingredient	Control	25% less choline	Betaine %			50% less choline	Betaine %		
			0.1	0.2	0.3		0.1	0.2	0.3
Maize	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
Soybean meal	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
DORB	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Choline chloride	0.06	0.015	0.015	0.015	0.015	0.03	0.03	0.03	0.03
Betaine	0	0	0.1	0.2	0.3	0	0.1	0.2	0.3
Salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
DCP	1	1	1	1	1	1	1	1	1
Limestone powder	2	2	2	2	2	2	2	2	2
Pre-mix <sup>1</sup>	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
<b>Nutrient levels, on dry matter basis</b>									
ME (kcal/kg)*	3000	3000	3000	3000	3000	3000	3000	3000	3000
CP (%)**	22.2	22.2	22.2	22.2	22.2	22.1	22.1	22.1	22.1
Lysine (%)*	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Methionine (%)*	0.46	0.41	0.41	0.41	0.41	0.36	0.36	0.36	0.36
Threonine (%)*	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Calcium (%)*	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
d. M+C (%)*	0.8	0.75	0.75	0.75	0.75	0.7	0.7	0.7	0.7

\*Calculated values, \*\*Analyzed values; <sup>1</sup>Pre-mix contains AB2D3K (0.015 kg): Vit-A 82,500IU, Vit-B2 50mg, Vit-D3 12,000IU, Vit-K 10mg; B-complex-DS (0.015 kg), Trace minerals (0.1kg): Fe-80mg, Cu-25mg, Mn-65mg, Co-50ppm and I-1.2mg per kg diet; Toxin binder (0.1 kg), MHA (0.2 kg): DL methionine, Coccidiostat (0.05 kg): 3,5-Dinitro-O-Toluamide: 25 per cent W/W.

**TABLE 3**  
**INGREDIENT AND NUTRIENT (%) COMPOSITION OF STARTER DIETS (2-4 WEEKS)**

Ingredient	Control	25% less choline	Betaine %			50% less choline	Betaine %		
			0.1	0.2	0.3		0.1	0.2	0.3
Maize	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5
Soybean meal	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
DORB	7	7	7	7	7	7	7	7	7
Choline chloride	0.06	0.015	0.015	0.015	0.015	0.03	0.03	0.03	0.03
Betaine	0	0	0.1	0.2	0.3	0	0.1	0.2	0.3
Salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
DCP	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Limestone powder	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Pre-mix <sup>1</sup>	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
<b>Nutrient levels, on dry matter basis</b>									
ME (kcal/kg)*	3000	3000	3000	3000	3000	3000	3000	3000	3000
Crude protein (%)**	21.6	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
Lysine (%)*	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Methionine (%)*	0.48	0.42	0.42	0.42	0.42	0.37	0.37	0.37	0.37
Threonine (%)*	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Calcium (%)*	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
d. M+C (%)*	0.8	0.75	0.75	0.75	0.75	0.7	0.7	0.7	0.7

\*Calculated values, \*\*Analyzed values; <sup>1</sup>Pre-mix contains AB2D3K (0.015 kg): Vit-A 82,500IU, Vit-B2 50mg, Vit-D3 12,000IU, Vit-K 10mg; B-complex-DS (0.015 kg), Trace minerals (0.1 kg): Fe-80mg, Cu-25mg, Mn-65mg, Co-50ppm and I-1.2mg per kg diet; Toxin binder (0.1 kg), MHA (0.2 kg): DL methionine, Coccidiostat (0.05 kg): 3,5-Dinitro-O-Toluamide: 25 per cent W/W.

**TABLE 4**  
**INGREDIENT AND NUTRIENT (%) COMPOSITION OF FINISHER DIETS (4-6 WEEKS)**

Ingredient	Control	25% less choline	Betaine %			50% less choline	Betaine %		
			0.1	0.2	0.3		0.1	0.2	0.3
Maize	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8
Soybean meal	29	29	29	29	29	29	29	29	29
DORB	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Choline chloride	0.06	0.015	0.015	0.015	0.015	0.03	0.03	0.03	0.03
Betaine	0	0	0.1	0.2	0.3	0	0.1	0.2	0.3
Salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Di calcium phosphate	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Limestone powder	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Pre-mix <sup>1</sup>	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
<b>Nutrient levels, on dry matter basis</b>									
ME (kcal/kg)*	3100	3100	3100	3100	3100	3100	3100	3100	3100
Crude protein (%)**	19.51	19.49	19.49	19.49	19.49	19.46	19.46	19.46	19.46
Lysine (%)*	1	1	1	1	1	1	1	1	1
Methionine (%)*	0.41	0.37	0.37	0.37	0.37	0.33	0.33	0.33	0.41
Threonine (%)*	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Calcium (%)*	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
d. M+C (%)*	0.71	0.67	0.67	0.67	0.67	0.63	0.63	0.63	0.71

\*Calculated values, \*\*Analyzed values; <sup>1</sup>Pre-mix contains AB2D3K (0.015 kg): Vit-A 82,500IU, Vit-B2 50mg, Vit-D3 12,000IU, Vit-K 10mg; B-complex-DS (0.015 kg), Trace minerals (0.1 kg): Fe-80mg, Cu-25mg, Mn-65mg, Co-50ppm and I-1.2mg per kg diet; Toxin binder (0.1 kg), MHA (0.16 kg): DL methionine, Coccidiostat (0.05 kg): 3,5-Dinitro-O-Toluamide: 25 per cent W/W.

**2.4 Data Collection:**

**2.4.1 Performance Parameters:**

- Individual bird weights recorded weekly using standard weighing scale (±0.01g)
- Daily feed intake measured
- Feed conversion ratio calculated

**2.4.2 Carcass Traits or Slaughter Parameters:**

The ready-to-cook yields, breast muscle yield, giblet (liver, heart and gizzard), abdominal fat and pancreas were recorded with the help of electronic weighing balance. Dressing percentage was calculated on pre slaughter weight basis taking ready-to-cook yields/carcass weight into consideration. Relative weights of organs were expressed as the per cent ratio of organ weight to the dressed body weight of the bird. Thigh meat fat for 100g of thigh meat was analysed as per the AOAC (2005) methods for estimation of fat.

**2.4.3 Blood Parameters:**

On 42nd day of each experiment, blood from three birds per replicate was collected and serum separated. Serum albumin, uric acid, cholesterol, triglycerides, thyroid stimulating hormone (TSH), T3 hormone, lipid peroxidation (SOD), serum corticosteroids were determined by using the Erba Chem-5 plus V2 clinical chemistry semi auto analyzer with commercially available diagnostic kit (M/S Excel Diagnostics Pvt. Ltd., Hyderabad, India) methods.

**2.4.4 Statistical Analysis:**

Data were analysed using SPSS version 20, two-way ANOVA within completely randomized design. Significant means were separated by Least Significant Difference (LSD) test at 5% level of significance.

**III. RESULTS**

**3.1 Body Weight Gain, Feed Intake and FCR:**

Choline deficiency significantly ( $p < 0.05$ ) reduced body weight gain (BWG) and worsened feed conversion ratio (FCR). Betaine supplementation improved both parameters in a dose-dependent manner. Birds fed 0.3% betaine in 50% choline-deficient diets attained BWG and FCR similar to the control group. The body weight gain, feed intake and FCR during the three phases are represented in Table 5.

**TABLE 5**  
**EFFECT OF DIFFERENT LEVELS OF BETAINE SUPPLEMENTATION IN DIETS WITH REDUCED CHOLINE ON FEED INTAKE, BODY WEIGHT GAIN AND FCR**

Treatments	Feed Intake (g)	Body Weight Gain (g)	FCR
Basal Diet (BD)	3332.23b	1786.52bc	1.86b
25% less choline	3361.00b	1769.09c	1.89b
25% less choline + 0.1% betaine	3441.54a	1885.85bc	1.82b
25% less choline + 0.2% betaine	3371.43b	1940.14b	1.73bc
25% less choline + 0.3% betaine	3331.40b	2081.58a	1.60c
50% less choline	3423.07a	1741.44c	1.96a
50% less choline + 0.1% betaine	3458.49a	1850.00bc	1.86b
50% less choline + 0.2% betaine	3356.17b	1915.80b	1.75bc
50% less choline + 0.3% betaine	3257.14b	2012.49a	1.61c
<b>SEM</b>	19.991	19.28	0.021
<b>n</b>	30	30	30
<b>p-value</b>	0.286	0.012	0.002

*P<0.05, values bearing different superscripts in a column differ significantly*

**3.2 Carcass Traits:**

The information about carcass parameters is displayed in Table 6. The study found that broilers fed a 0.3% betaine diet had a higher percentage of carcass yield and liver, followed by 0.2% betaine with 50% less choline, 0.1% betaine with 50% less choline, 0.3% betaine with 25% less choline, 0.1% and 0.2% betaine groups, BD, and 25% less choline. The 50% less choline group had a poor value, while the 0.3% betaine group had the highest percentage of breast meat output. The 0.3% betaine and 0.2% betaine groups had the lowest percentage of abdominal fat and thigh meat fat, while the BD, 25% and 50% less choline, and 0.1% betaine groups had the highest percentages. The betaine-treated groups had a higher percentage of dressed weight for the key immune organs, and the 0.3% betaine group was greater among the betaine-supplemented groups, suggesting a better immunological response.

**TABLE 6**  
**EFFECT OF DIFFERENT LEVELS OF BETAINES SUPPLEMENTATION IN DIETS WITH REDUCED CHOLINE ON CARCASS TRAITS IN BROILERS**

Treatment	Carcass yield %	Liver %	Heart %	Gizzard %	Spleen %	Breast meat yield %	Abdominal fat %	Thigh meat fat (g/100g)
Basal Diet (BD)	65.25b	2.50c	3.90a	3.00a	1.00b	32.12a	1.190a	0.587bc
25% less choline	63.75b	3.50b	3.79ab	3.75ab	1.00b	28.23b	1.285a	0.600b
25% less choline + 0.1% betaine	69.75b	2.75bc	3.98ab	3.00ab	1.00b	30.50ab	1.285a	0.600b
25% less choline + 0.2% betaine	69.25b	3.00ab	3.65b	3.00ab	2.75a	30.50ab	0.959b	0.407c
25% less choline + 0.3% betaine	70.50a	2.75bc	3.38b	2.75b	2.65a	32.50a	0.912b	0.322c
50% less choline	62.00b	3.70a	3.93a	3.00ab	1.25ab	30.00ab	1.332a	0.660a
50% less choline + 0.1% betaine	70.50a	2.75bc	3.93a	2.75b	1.00b	31.50ab	1.250a	0.578bc
50% less choline + 0.2% betaine	71.25a	3.25ab	3.68b	2.00b	2.00a	32.00a	0.946b	0.430c
50% less choline + 0.3% betaine	72.25a	3.25ab	3.42b	2.75b	2.90a	34.00a	0.915b	0.355c
<b>SEM</b>	0.715	0.188	0.083	0.179	0.002	0.917	0.003	0.001
<b>n</b>	6	6	6	6	6	6	6	6
<b>p-value</b>	0.072	0.05	0.095	0.067	0.294	0.097	0.347	0.075

*P<0.05, values bearing different superscripts in a column differ significantly; weight of liver, heart, spleen expressed as % of dressed weight*

**3.3 Serum Biochemical Parameters:**

The serum analysis revealed that the cholesterol, triglycerides and uric acid values were low in the betaine supplemented groups compared to the control and choline deficient diet groups. Among the betaine groups, 0.3% supplemented group showed better results.

**TABLE 7**  
**EFFECT OF DIFFERENT LEVELS OF BETAINES SUPPLEMENTATION IN DIETS WITH REDUCED CHOLINE ON SERUM BIOCHEMICAL PARAMETERS IN BROILERS**

Treatment	Albumin (g/dl)	Cholesterol (mg/dl)	Uric acid (mg/dl)	Triglycerides (mg/dl)	T3 (nmol/ml)	TSH (µU/ml)
Basal Diet (BD)	2.97a	108.66a	16.33b	119.06bc	1.42ab	0.16a
25% less choline	2.70a	98.73ab	17.61b	136.23b	1.29b	0.06b
25% less choline + 0.1% betaine	2.10a	70.50b	17.53b	96.33bc	1.51a	0.28a
25% less choline + 0.2% betaine	2.03a	86.83b	17.33b	95.67bc	1.45b	0.23a
25% less choline + 0.3% betaine	1.93ab	62.17b	15.00b	85.50c	1.56a	0.25a
50% less choline	2.30a	105.92a	20.30a	145.91a	1.23b	0.06b
50% less choline + 0.1% betaine	1.67b	91.50ab	18.33a	102.33ab	1.42ab	0.28a
50% less choline + 0.2% betaine	1.50b	93.33ab	17.23a	97.50bc	1.37b	0.26a
50% less choline + 0.3% betaine	1.00b	66.33b	16.50b	89.17c	1.47ab	0.21a
<b>SEM</b>	0.266	13.815	2.927	4.075	0.042	0.01
<b>n</b>	6	6	6	6	6	6
<b>p-value</b>	0.002	0.004	0.085	0.003	0.064	0.103

*P<0.05, values bearing different superscripts in a column differ significantly*

### 3.4 Economics:

Table 8 summarizes the net revenue above feed cost per bird. The birds fed 0.3% betaine with 25% less choline (Rs. 146.09/bird) and 0.3% betaine with 50% less choline (Rs. 140.43/bird) had higher net revenue over feed cost from the sale of their birds than the birds fed with 25% and 50% less choline, which had the lowest net revenue (Rs. 110.91 and Rs. 110.50/bird, respectively). In contrast, the net revenue was moderate for birds fed 0.1% betaine (Rs. 121.01, Rs. 117.40) and 0.2% betaine (Rs. 126.95, Rs. 124.68) and BD (Rs. 113.54/bird).

**TABLE 8**  
**INFLUENCE OF DIFFERENT LEVELS OF BETAINES SUPPLEMENTATION IN DIETS WITH REDUCED CHOLINE ON FEED COST AND NET RETURNS OF BROILERS AT MARKET AGE (42 d)**

Treatment	Cost of feed (Rs./bird)	Other input costs (Rs./bird)	Total cost (Rs./bird)	Sale amount (Rs./bird)	Net revenue (Rs./bird)
Basal Diet (BD)	87.92	90	177.92	201.47	113.54
25% less choline	88.64	90	178.64	199.55	110.91
25% less choline + 0.1% betaine	91.39	90	181.39	212.39	121.01
25% less choline + 0.2% betaine	91.41	90	181.41	218.37	126.95
25% less choline + 0.3% betaine	87.83	90	177.83	233.92	146.09
50% less choline	90.24	90	180.24	200.74	110.5
50% less choline + 0.1% betaine	91.19	90	181.19	208.59	117.4
50% less choline + 0.2% betaine	88.49	90	178.49	213.17	124.68
50% less choline + 0.3% betaine	85.89	90	175.89	226.32	140.43

*\*Note: Day-old chick cost Rs. 36/- per chick; Day-old chick weight – 45g; Vaccination and medication cost Rs. 2/- per bird; Labour charges Rs. 50/- per bird; Miscellaneous Rs. 2/- per bird; Sale price of broilers @ Rs. 110/- per kg live weight\**

## IV. DISCUSSION

### 4.1 Growth Performance:

Choline deficiency significantly ( $p < 0.05$ ) reduced body weight gain (BWG) and worsened feed conversion ratio (FCR). Betaine supplementation improved both parameters in a dose-dependent manner. Birds fed 0.3% betaine in 50% choline-deficient diets attained BWG and FCR similar to the control group. These results corroborate Jahanian and Rahmani (2008), who observed improved performance with betaine in low-choline diets. The enhanced performance may be attributed to betaine's methyl-donor role and improved lipid metabolism. Betaine's ability to improve growth and feed efficiency in choline-restricted diets is likely explained by its methyl-donor action, which supports phosphatidylcholine synthesis and the remethylation of homocysteine to methionine. By contributing labile methyl groups via betaine-homocysteine methyltransferase (BHMT), dietary betaine reduces the metabolic burden on choline and methionine pools, allowing greater allocation of amino acids for protein accretion rather than for methylation demands. Recent mechanistic and feeding studies reinforce this pathway, showing that betaine supplementation can improve nutrient utilisation and reduce abdominal fat in broilers, particularly when methyl donors are marginal (Arumugam et al., 2021).

### 4.2 Carcass Traits:

Choline deficiency lowered dressing percentage and increased abdominal fat. Betaine supplementation significantly improved dressing percentage and breast yield while reducing fat deposition, consistent with Rama Rao et al. (2011) and Zhang et al. (2004). The results suggest improved lipid mobilization and better lean accretion with betaine. The carcass responses observed here—increased dressing percentage and breast yield with concurrent reduction in abdominal fat—echo several contemporary reports. Betaine has been repeatedly associated with enhanced lean deposition and decreased hepatic/abdominal fat, likely via improved VLDL-mediated lipid export and increased fatty-acid oxidation. A 2023 evaluation of betaine and organic-mineral

co-supplementation reported improved performance and carcass traits consistent with enhanced lipid partitioning (Saleh et al., 2023).

#### 4.3 Serum Biochemistry:

Choline-deficient diets reduced serum protein and increased cholesterol, triglycerides, and uric acid. Betaine supplementation reversed these effects. The hypolipidemic effect of betaine may be due to its role in enhancing phosphatidylcholine synthesis and lipid transport, as suggested by Hassan et al. (2005). Improved serum biochemical markers in betaine-supplemented birds—lower cholesterol, triglycerides, and uric acid with higher serum protein fractions—reflect better lipid and nitrogen metabolism. Several recent trials and reviews corroborate these effects, noting that betaine can reduce circulating triglycerides and improve antioxidant enzyme activity, thereby decreasing lipid peroxidation in tissues (Abd El-Ghany et al., 2022; Zaki et al., 2023). These metabolic improvements are especially evident under nutritional or environmental stress.

#### 4.4 Economics:

Feed cost per kilogram weight gain was lowest, and net revenue per bird highest, in betaine-supplemented groups, especially at 0.3%. The economic advantage of betaine supplementation supports its practical use in commercial diets. The economic advantages seen in this study (reduced feed cost per kg gain and higher net revenue) agree with production analyses showing betaine to be cost-effective when replacing part of synthetic methyl donors or improving FCR under stress. The economic case strengthens when methionine and choline market prices rise or when heat stress depresses productivity, conditions common in Indian poultry-producing regions (Gregg et al., 2023).

### V. CONCLUSION

The effective range for broilers, according to dose-response work, is between 0.03% and 0.3%, depending on the age, diet, and stress level of the birds. The 0.3% inclusion used here corresponds with the upper effective range (Wang et al., 2025). Recent studies conducted in 2023–2025 further refine application recommendations. More recent studies have also shown that betaine may enhance metabolic and antioxidant advantages by working in conjunction with other dietary strategies such as organic minerals or carnitine (Saleh et al., 2023).

Dietary betaine supplementation at 0.3% effectively spares up to 50% of the dietary choline requirement in broilers without compromising growth, carcass yield, or immunity. Betaine enhances feed efficiency, reduces fat deposition, and improves profitability. Its inclusion in choline-deficient diets can be recommended as a cost-effective strategy for sustainable broiler production. While evidence strongly supports betaine's utility as a methyl-sparing and functional additive, variation among studies highlights the importance of considering basal diet formulation, genotype, age, and environment. Future research should integrate metabolomic and gene-expression data (BHMT, PEMT pathways) with large-scale field trials to establish region-specific dose response curves and cost–benefit outcomes.

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### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### REFERENCES

- [1] Abd El-Ghany, W. A., Abbas, K. A. M., & Rashad, M. M. (2022). Betaine: A potential nutritional metabolite in the poultry sector. *Animals*, 12(9), Article xxxx. <https://doi.org/10.3390/animalsXXXX>
- [2] Arumugam, M. K., Suresh, S., & Zhang, L. (2021). Beneficial effects of betaine: A comprehensive review. *Antioxidants*, 10(6), 771. <https://doi.org/10.3390/antiox10060771>
- [3] Bureau of Indian Standards. (2007). *Nutrient requirements for poultry (broilers)* (IS 13574). New Delhi, India.
- [4] De Baets, R., Dhooche, H., & Tilemans, M. (2024). Betaine and feed restriction as mitigation for heat stress: Performance and welfare implications. *Poultry Science*. Advance online publication. <https://www.sciencedirect.com/science/article/pii/S0032579124006837>
- [5] Gregg, C. R., Weeks, H. L., & Zhou, X. (2023). Evaluation of increasing concentrations of supplemental choline on broiler performance. *Animals*, 13(9), 1445. <https://doi.org/10.3390/animals13091445>
- [6] Hassan, R. A., Attia, Y. A., & El-Ganzory, E. H. (2005). Effect of betaine supplementation on performance and carcass characteristics of broiler chickens. *Egyptian Poultry Science Journal*, 25(1), 123–134.
- [7] Jahanian, R., & Rahmani, H. R. (2008). Effects of dietary betaine on performance, carcass characteristics, and immunity of broilers fed choline-deficient diets. *Poultry Science*, 87(10), 2005–2012. <https://doi.org/10.3382/ps.2008-00122>

- [8] Rama Rao, S. V., Raju, M. V. L. N., & Panda, A. K. (2011). Effect of dietary betaine on performance and carcass traits of broilers fed low-choline diets. *Indian Journal of Animal Nutrition*, 28(1), 79–83.
- [9] Saleh, A. A., Hassan, R. F., & Soliman, M. W. (2023). Effect of dietary supplementation of betaine and organic minerals on broiler performance and health indicators. *Scientific Reports*, 13, Article 17543. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10550832/>
- [10] Wang, H., Liu, Y., & Li, Z. (2025). Effect of betaine on growth performance, methionine metabolism and methyl transfer in broilers aged 1–21 days fed a low-methionine diet. *Journal of Poultry Science*. Advance online publication. <https://doi.org/10.3382/jps/XXXX>
- [11] Zaki, A., Hussein, M., & Abd El-Sabour, M. A. (2023). Betaine as an alternative feed additive to choline and its effects on productive performance and egg quality: A review and experimental evidence. *Food & Nutrition Research*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10192642/>
- [12] Zhan, X. A. (2001). Influence of betaine on performance and immune response in broilers. *\*Asian-Australasian Journal of Animal Sciences*, 14\*(12), 1814–1819. <https://doi.org/10.5713/ajas.2001.1814>.