RESEARCH ARTICLE

Effect of Bael (*Aegle marmelos*) Fruit Pulp Powder Supplementation on Growth Performance, Carcass Traits and Haemato-Biochemical Indices of Broiler Chickens

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Abstract

This study was conducted to determine the effect of Bael (*Aegle marmelos*) fruit pulp powder supplementation on growth performance, carcass traits and haemato-biochemical indices of broiler chickens. A total of 192 unsexed day-old broiler chicks were divided into four treatment groups with 48 birds per treatment. The dietary treatments were T_1: Control-Basal diet, while T_2, T_3 and T_4 were Basal diet with 0.5%, 1.0%, and 2.0% Bael fruit pulp powder in feed, respectively. The parameters studied were growth performance, feed intake, feed conversion ratio, protein intake and efficiency ratio, production efficiency factor, carcass characteristics and haemato-biochemical indices. Results revealed that the mean final body weight and body weight gain in broiler chickens were significantly ($p<0.05$) higher in the T_3 group than other treatments. The total feed and protein intake in broiler chickens did not show any significant ($p>0.05$) differences among the treatments. The overall FCR was significantly ($p<0.05$) better in T_3 (1.60) group as compared to T_1 (1.69), T_2 (1.67) and T_4 (1.68) groups. The mean protein efficiency ratio and production efficiency factor were significantly ($p<0.05$) higher in T_3 group as compared to other treatments. The dietary Bael fruit pulp powder had no effect on carcass traits of broiler chickens. The serum glucose levels linearly decreased with increased level of Bael fruit pulp powder supplementation, but no influence ($p>0.05$) on other biochemical parameters was noted. It may be concluded that Bael (*Aegle marmelos*) fruit pulp powder supplementation at 1% level in feed significantly improved growth performance, FCR, protein and production efficiency in broiler chickens without altering haemato-biochemical profile, hence can be recommended as a promising natural growth promoter.

Key words: Bael fruit, Blood metabolites, Broilers, Carcass quality, Performance.

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Introduction

The poultry sector in India has expanded quickly in recent years, fundamentally because it requires comparatively low capital and land, provides quick and guaranteed returns, and has short generation intervals. The poultry contributed about 49% of total meat production of the country during the year 2024-25 (Anonymous, 2025). The use of antibiotic growth promoters as feed additive in poultry nutrition for improving the growth performance and protection from diseases has become a public health concern because of the risk of antibiotic carry-over through meat and eggs along with the emergence of antibiotic resistance and environmental pollution (Kalia *et al.,* 2022; Wickramasuriya *et al.,* 2024). Globally, poultry nutritionists are attempting the use of natural phyto-additives as eco-friendly and safe antibiotic replacers for improving production and health of poultry (Ashry *et al.,* 2024). With increasing health awareness, consumers are demanding high-quality, safe, and nutritious food products. In light of this, recently several phyto-additives have been studied to replace antibiotic growth promoters in poultry to improve growth performance, product quality and health (Gosai *et al.,* 2023; Chaudhary *et al.,* 2026). Among the various phyto-additives, Bael (*Aegle marmelos*) fruit could be explored as growth promoter in broiler chickens.

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In India, Bael (*Aegle marmelos*) is being grown throughout the country. Bael fruit is one of the most nutritious fruits. Bael fruit is a useful medicinal plant due to its high concentration of phytochemicals and antioxidant activity (Rahman *et al.,* 2024). The nutritional composition of Bael fruit pulp contain 67% moisture, 8.81% protein, 1.04% fat, 1.23% crude fibre and 3.08% total sugar (Khanal *et al.,* 2023). The Bael fruit pulp contains various bioactive compounds such as polyphenols, flavonoids, carotenes, vitamins, organic acids and essential minerals (Hazra *et al.,* 2020). The mucilaginous pulp of Bael fruit contains psoralen and marmelosin, which are therapeutically important compounds (Jha *et al.,* 2025). It also contains a good source of dietary fibre (Dasaroju *et al.,* 2025), and possesses multiple biological activities (Sarkar *et al.,* 2021). Moreover, it is beneficial in stomach related diseases and acts as laxative as well as diuretic. Very few studies (Kumar *et al*., 2024; Tati *et al*., 2025) have been conducted on dietary Bael fruit powder supplementation in broiler chickens. Therefore, this study was carried out to evaluate the effect of Bael fruit pulp powder supplementation on growth performance, carcass traits and haemato-biochemical indices of broiler chickens.

Materials and Methods

The study was conducted at Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Sardarkrushinagar, Gujarat, India during September-October, 2025 following approval of the protocol by the Institutional Animal Ethics Committee of the College (No. VETCOLL/IAEC/2024/23/P-10).

One hundred ninety two unsexed day-old broiler (Vencobb-430Y) chicks were procured from local hatchery. On arrival chicks were weighed and uniformly divided into four treatment groups with 48 chicks per treatment and each treatment had four replicates of 12 birds. The experimental period was of 42 days. The treatments groups were as - T1 (CON): Basal diet (BIS, 2007), whereas in groups T_2, T_3 and T_4 Basal diet was supplemented with 0.5%, 1.0% and 2.0% of Bael fruit pulp powder, respectively. The green, unripen Bael fruits were collected from local area. The pulp was separated from fruit, dried under the shade and ground to a fine powder using a grinder and screened through a plastic mesh sieve, with a mesh size of 1 mm particle size.

Representative samples of pre-starter, starter, finisher feeds and orange peel powder were analysed for proximate composition as per the methods described by AOAC (2023). Body weights were recorded on day one and thereafter at weekly intervals. The average daily body weight gain (g), daily feed intake (g/bird/day), feed conversion ratio (FCR), protein intake, and protein efficiency ratio (PER) were calculated using standard formulae. Production efficiency factor (PEF) was calculated using formula. PEF = [Final body weight (kg) x Livability (%) x 100] / [Age in days x FCR].

On 42nd day, eight birds from each treatment (2 birds from each replicate) were selected randomly and kept off feed for 12 h and the live weight of birds as pre-slaughter weight were recorded. The birds were sacrificed using inhalation anesthesia by decapitation and feathers were carefully plucked after scalding. Eviscerated carcass along with giblet was weighed for calculating dressing percentage as described by Chaudhary *et al.* (2025). The organs like liver, heart, spleen, kidney and gizzard were weighed separately using electronic balance. At the end of experiment, the blood samples were collected from eight birds per treatment. The haemato-biochemical parameters were estimated as described by Kharadi *et al.* (2025). The blood samples were analyzed for haemoglobin and hematocrit. The serum samples were analyzed for glucose, total proteins, albumin, cholesterol, triglycerides, serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) levels using diagnostic kits.

The data obtained were statistically analysed as per the standard statistical methods (Snedecor and Cochran, 1994). The differences among the treatment means were assessed using Duncan's multiple range test. The differences were considered significant at level of $p<0.05$.

Results and Discussion

The proximate composition of feeds and Bael fruit pulp powder is given in Table 1. The crude protein content was 23.12, 22.67 and 20.36% in pre-starter, starter and finisher feed, respectively. The nutrient contents of pre-starter, starter and finisher feed given to broiler chickens were as per the BIS (2007) specification. The dry matter, crude protein, crude fibre, ether extract, total ash and nitrogen free extract content in Bael fruit pulp powder were 92.2, 4.26, 5.67, 4.53, 4.38 and 81.16%, respectively. Similarly, Tati *et al.* (2025) reported that the content of crude protein, fat and fibre in Bael fruit pulp was 4.09, 1.36 and 5.23%, respectively.

The data on effect of Bael fruit pulp powder supplementation on growth performance of broiler chickens is presented in Table 2. The mean final body weight and overall weight gain were significantly ($p<0.05$) higher in the

Table 1: Proximate composition of feeds and Bael fruit pulp powder

Composition (%)	Pre-starter	Starter	Finisher	Bael fruit pulp powder
Dry matter	93.78	93.24	92.38	92.21
Crude protein	23.12	22.67	20.36	4.26
Crude fibre	3.32	3.84	3.74	5.67
Ether extract	3.68	3.52	4.69	4.53
Ash	7.18	7.26	6.48	4.38
Nitrogen free extract	62.06	62.95	64.82	81.16

T_3 group as compared to T_1 (CON) and T_2 groups, while it was lowest in T_4 group. The improved weight gain in T_3 group could be attributed to the optimal biological functions of the bioactive compounds (marmelosin, coumarins, skimmianine and pectins) present in the Bael fruit pulp, which enhances the growth of beneficial probiotic microbes in gut and inhibit the growth of pathogenic microbes. So, it results into better digestion, absorption of nutrients and led to increase in weight gain of broiler chickens (Kumar *et al.,* 2024; Rahman *et al.,* 2024). The present findings are in line with the findings of Tati *et al.* (2025), who reported significantly higher cumulative body weight gain in broilers fed graded levels (1, 1.5 and 2%) of Bael fruit pulp powder. Similarly, Kumar (2024) observed improved growth performance in broilers supplemented with Bael fruit pulp powder at 0.1% and 0.2% levels, particularly when combined with probiotics. However, 2% supplemental level of Bael fruit pulp powder in feed had adverse effect on growth performance in broiler chickens.

The data of effect of Bael fruit pulp powder supplementation on feed intake and feed conversion ratio in broiler chickens are shown in Table 3. The total feed intake did not differ ($p>0.05$) among the treatment groups; indicating that inclusion of Bael fruit pulp powder at different levels in feed had no adverse effect on feed palatability in broiler chickens. The results of the present study are supported by earlier work of Tati *et al.* (2025), who reported non-significant differences in feed intake in broiler chickens fed diet supplemented with 1, 1.5 and 2% of Bael fruit powder. Also, Kumar (2024) reported similar feed intake in broiler chickens supplemented with Bael fruit powder alone or in combination with probiotics.

The mean feed conversion ratio was significantly ($p<0.05$) better in T_3 (1.60) group as compared to T_1, T_2 and T_4 groups (Table 3). The improved FCR observed in T_3 group was attributed by the significantly higher body weights without affecting feed intake. Kumar (2024) reported a similar significant improvement in overall FCR in broilers supplemented with Bael fruit powder. On the contrary, Tati *et al.* (2025) reported non-significant difference in FCR in broiler chickens fed graded levels (1, 1.5 and 2%) of Bael fruit pulp powder.

Table 2: Effect of Bael fruit pulp powder supplementation (0, 0.5, 1 & 2 %) on growth performance of broiler chickens

Parameter	Age in wks	T_1	T_2	T_3	T_4	SEM	P value
Body weight (g/bird)	Initial	43.36	44.48	43.31	43.11	0.294	0.371
	I	162.02	167.31	167.71	162.54	1.212	0.198
	II	435.71	451.48	456.83	429.04	5.269	0.206
	III	822.00	835.35	882.29	814.36	12.319	0.208
	IV	1273.30^{a}	1294.71^{ab}	1350.30^{b}	1264.58^{a}	11.977	0.028
	V	1782.79^{a}	1805.96^{a}	1874.75^{b}	1772.91^{a}	12.720	0.004
	VI	2399.40^{b}	2413.53^{b}	2511.27^{c}	2357.51^{a}	15.304	0.004
Body weight gain (g/bird)	I	118.67	122.83	124.40	119.44	1.179	0.274
	II	273.69	284.17	289.13	266.50	5.089	0.424
	III	386.29	383.88	425.46	385.31	11.485	0.554
	IV	451.30	459.35	468.01	450.23	14.553	0.977
	V	509.49	511.25	524.46	508.33	14.990	0.984
	VI	616.61	607.58	636.52	584.60	8.174	0.150
	Overall	**2356.04^{b}**	**2369.06^{b}**	**2467.96^{c}**	**2314.41^{a}**	**15.354**	**0.003**

Means with different superscripts within a row differ significantly ($p<0.05$).

Table 3: Effect of Bael fruit pulp powder supplementation at different levels (0, 0.5, 1 & 2 %) in feed on feed intake and feed conversion ratio in broiler chickens

Parameter	Age in wks	T_1	T_2	T_3	T_4	SEM	P value
Feed intake (g/ bird)	I	128.64	128.64	128.64	128.64	-	-
	II	352.17	354.54	340.65	341.29	6.800	0.867
	III	582.11	559.37	556.42	579.75	7.229	0.504
	IV	801.39	798.69	797.90	796.11	4.575	0.986
	V	1041.03	1004.77	1005.56	1028.33	12.875	0.740
	VI	1079.80	1110.06	1117.83	1023.50	15.504	0.113
	Overall	**3985.13**	**3956.08**	**3946.99**	**3897.62**	**19.743**	**0.508**
Feed conversion ratio	I	1.09	1.05	1.04	1.08	0.010	0.279
	II	1.30	1.25	1.18	1.29	0.037	0.670
	III	1.52	1.47	1.32	1.53	0.045	0.354
	IV	1.79	1.78	1.73	1.80	0.058	0.977
	V	2.07	2.02	1.92	2.04	0.061	0.860
	VI	1.76	1.84	1.76	1.75	0.034	0.802
	Overall	**1.69^{b}**	**1.67^{b}**	**1.60^{a}**	**1.68^{b}**	**0.013**	**0.033**

Means with different superscripts with in a row differ significantly ($p<0.05$).

The overall protein intake did not differ (p>0.05) among the treatment groups (Table 4). However, the mean protein efficiency ratio in broiler chickens was significantly (p<0.05) higher in T_3 group than the other dietary treatments. The total mortality was 4.17% in T_1 and T_2, while it was 2.08% in T_3 and T_4 groups. The overall production efficiency factor was significantly (p<0.05) higher in the group T_3 (366.21) than the T_1 (323.76), T_2 (330.06) and T_4 (326.48) groups. Production efficiency factor is all-inclusive index that indicates the collective effect of dietary treatments on body weight gain, FCR and livability of broiler chickens. The higher production efficiency observed in T_3 group could be attributed to improved body weight gain, feed conversion efficiency and lower mortality recorded during the feeding trials. An increased production efficiency factor signify better production efficiency, suggesting that inclusion of Bael fruit pulp powder at 1% level in feed positively influence overall performance in broiler chickens.

Among the carcass traits, there was no significant (p>0.05) difference in pre-slaughter weight, dressing weight and percentage of broiler chickens among the treatments. No effect (p>0.05) was observed on liver, heart, gizzard, kidney and spleen weights in broiler chickens due to dietary supplementation of Bael fruit pulp powder. The absence of significant differences in carcass traits could be attributed to the fact that although Bael fruit contains bioactive phytochemicals with growth-promoting and gut-modulating properties, these effects primarily influence nutrient utilization and performance efficiency rather than altering carcass composition or organ development. Similar to the present findings, earlier researcher reported no effect of Bael fruit pulp or leaves powder supplementation in feed on carcass characteristics of broiler chickens (Sharma *et al.,* 2022; Bhatt *et al.,* 2024).

Table 4: Effect of Bael fruit pulp powder supplementation at different levels (0, 0.5, 1 & 2 %) in feed on protein intake, efficiency and production efficiency factor in broiler chickens

Parameter	Age in wks	T_1	T_2	T_3	T_4	SEM	P value
Protein intake	I	29.86	29.86	29.86	29.86	-	-
(g/bird)	II	77.90	78.42	75.35	75.49	1.504	0.867
	III	128.76	123.73	123.08	128.24	1.599	0.504
	IV	162.92	162.38	162.21	161.85	0.930	0.986
	V	211.64	204.27	204.43	209.06	2.618	0.740
	VI	219.53	225.68	227.26	208.08	3.152	0.112
	Overall	**830.61**	**824.34**	**822.19**	**812.58**	**4.075**	**0.513**
Protein efficiency	I	3.97	4.12	4.17	4.00	0.040	0.271
ratio	II	3.57	3.63	3.84	3.55	0.098	0.751
	III	3.02	3.10	3.46	3.01	0.099	0.337
	IV	2.78	2.83	2.89	2.78	0.090	0.976
	V	2.41	2.50	2.57	2.44	0.072	0.882
	VI	2.82	2.71	2.80	2.81	0.050	0.876
	Overall	**2.84^a**	**2.88^a**	**3.00^b**	**2.85^a**	**0.023**	**0.020**
Production	I	505.04^a	525.84^a	566.14^b	510.28^a	7.632	0.004
efficiency factor	II	432.77	441.90	497.27	430.78	13.252	0.249
	III	365.69	377.12	448.04	365.38	13.861	0.087
	IV	309.05	316.20	343.81	310.49	10.734	0.678
	V	267.67	280.40	306.00	272.43	8.961	0.475
	VI	313.71	303.26	333.63	313.98	6.380	0.433
	Overall	**323.76^a**	**330.06^a**	**366.21^b**	**326.48^a**	**5.012**	**0.022**

Means with different superscripts with in a row differ significantly (p<0.05).

Table 5: Effect of Bael fruit pulp powder supplementation at different levels (0, 0.5, 1 & 2 %) in feed on haemato-biochemical profile of broiler chickens

Particulars	T_1	T_2	T_3	T_4	SEM	P value
Haemoglobin (g/dL)	8.67	8.44	8.44	8.65	0.164	0.939
Haematocrit (%)	26.03	25.34	25.33	25.94	0.493	0.939
Glucose (mg/dL)	285.43^d	262.16^c	244.24^b	225.74^a	8.669	0.043
Total protein (g/dL)	4.03	4.20	4.07	4.14	0.101	0.940
Albumin (g/dL)	1.58	1.57	1.59	1.46	0.042	0.659
Globulin (g/dL)	2.45	2.63	2.47	2.68	0.095	0.797
Triglycerides (mg/dL)	112.31	116.04	110.32	101.92	4.460	0.738
Cholesterol (mg/dL)	174.52	175.50	172.29	205.52	6.304	0.197
SGPT (U/L)	7.56	7.40	7.27	6.72	0.240	0.653
SGOT (U/L)	337.90	298.55	321.54	320.19	7.215	0.298

SGPT: Serum glutamic pyruvic transaminase; SGOT: Serum glutamic oxaloacetic transaminase. Means with different superscripts with in a row differ significantly (p<0.05).

There was no effect (p>0.05) on haemoglobin and haematocrit due to Bael fruit powder supplementation (Table 5). A significant difference (p<0.05) was observed in serum glucose levels among the treatment groups, with birds in T_1 had the highest glucose concentration, followed by T_2 and T_3 showing intermediate values, while the lowest concentration was noted in the T_4 group. The linearly lower blood glucose levels observed with increased Bael fruit pulp powder supplementation could be attributed to the combined action of its bioactive compounds, particularly flavonoids, coumarins, and alkaloids such as aegeline, which enhance insulin secretion and improve insulin sensitivity by protecting and partially restoring pancreatic β-cell function (Kamalakkannan and Prince, 2005). Similar observations were reported by Tati *et al.* (2025), who found significant decrease in blood glucose level in broiler chickens fed with an increased level of Bael fruit powder supplementation. Moreover, Bhatt *et al*. (2024) also reported a reduction in serum glucose at higher inclusion levels of Bael leaf powder. There was no influence (p>0.05) on serum concentrations of total protein, albumin, globulin, triglycerides, total cholesterol, SGPT and SGOT due to dietary Bael fruit pulp powder supplementation. These results indicate that Bael fruit pulp powder supplementation did not alter protein metabolism and liver function in broiler chickens.

Conclusion

Based on the results of the present study, it may be concluded that Bael (*Aegle marmelos*) fruit pulp powder supplementation at 1% level in feed significantly improved growth performance, feed conversion ratio, protein and production efficiency in broiler chickens without affecting feed intake. However, 2% supplemental level in feed had adverse effect on growth performance in broiler chickens with numerical reduction in feed intake. Moreover, Bael fruit pulp powder supplementation at 0.5, 1 and 2% level in feed had no effect on carcass characteristics and haemato-biochemical profile of broiler chickens, except glucose level. The serum glucose level was linearly decreased with increased level of Bael fruit powder supplementation. Therefore, Bael fruit pulp powder supplementation at the dose of 1% in feed of broiler chickens is recommended as a promising natural growth promoter.

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