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Assessment of growth, nutrient digestibility and productive efficiency of broiler fed diet with phytogenic herbal supplement

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ABSTRACT

The study assessed effect of phytogenic herbal supplement (PHS) on growth, nutrient digestibility and productive efficiency of broilers birds. Two hundred forty one-day old (Cobb 400) broiler chicks were assigned 6 dietary treatments (T-1 to T- 6) dividing into 6 homogenous groups with 4 replicates in each. T-1 was fed rations without any supplement, T-2 was fed rations supplemented with AGP (*Bacitracin Methylene Disalicylate*) @ 0.5g/kg, and T-3, T-4, T-5 and T-6 were fed rations supplemented with PHS at 0.50%, 0.75%, 1.00% and 1.25%, respectively. The feeding trial was conducted for 42 days housing the birds under deep litter system following standard managemental protocols. Deworming and vaccination were done as per schedule. Daily feed intake and weekly body weight were recorded. Productive efficiency was calculated at 42nd day of age as FCR, PEI and ERS. Findings revealed no significant effect of PHS on feed consumption and body weight gain during the first 3 weeks. Body weight gain was significantly ($P<0.01$) higher in PHS fed groups during 4th, 5th and 6th weeks. Metabolizability of nutrients differed significantly ($P<0.05$) among the treatments. The FCR, PEI and ERS were significantly ($P<0.05$) better in PHS fed groups with highest value recorded in T-6. Based on the findings, it may be concluded that PHS could be recommended at 1.25% level for optimum growth, nutrient digestibility and productive efficiency of broiler birds. Further, the PHS at 1.25% could also be recommended as alternative to antibiotics growth promoter i.e. BMD for broiler birds.

Keywords: Broilers, Growth, Nutrient digestibility, Phytogenic herbal supplement, Productive efficiency

Poultry farming is rapidly expanding with 8 and 10 percent annual growth rate in egg and broiler production, respectively (USDA 2021). With 851.81 million poultry (Indian Livestock Census 2019), India ranks 3rd and 18th position in egg and broiler production in the world (APEDA, 2021). India is currently one of the world's top producers of poultry meat and contributes nearly 50% of total meat production (DAHD 2021) in India.

The Indian poultry industry, despite rapid growth, experiences setbacks from increased feeding cost and resurgence of existing/new diseases. Feeding cost accounts for nearly 65-70% of total broiler production cost and therefore, optimal feed quality to ensure maximum feed efficiency is a top priority for profitable broiler enterprise. To improve nutrient utilization, many feed additives and supplements are incorporated in broilers rations. Amongst them, antibiotics are utilized as growth promoters for their favourable regulatory effects on gut microbiota and gastrointestinal health (Torok *et al*. 2011, Singh *et al*. 2013). However, progressive withdrawal of antibiotics from poultry rations since 2006, owing to public concerns in developing antibiotic resistance and residues, has negatively affected broiler production through increased incidence of bacterial infections, thereby, accelerating antibiotics uses at prophylactic and therapeutic doses (Solis-Cruz *et al*. 2019). Besides, antibiotic-free broiler production can also imply public health problems like associated food-borne pathogens. These issues have forced the broiler producers to search for suitable alternatives with benefits similar to antibiotics for poultry production.

There has been growing interest in herbs and phytogenic compounds for utilizing as low-cost feed additives substitutes to antibiotics in broiler and other monogastric species in the past ten years (Abdelli *et al*. 2021). Compounds originating from plants, called phytogenic feed additives (PFA), are added to feeds to increase productive efficiency by enhancing digestibility, improving nutrient absorption, and removing pathogens from the animal's gastrointestinal tract (Alloui *et al*. 2014). PFAs include essential oils, spices, herbs or plant extracts, other bioactive ingredients and flavouring substances (Steiner and Syed 2015). Amongst different phytogenic herbs, use of ginger (*Zingiber officinale*), garlic (*Allium sativum*), and turmeric (*Curcuma longa*) is common in broiler rations owing to their multiple beneficial effects. The herbs have

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well known anti-inflammatory, antibacterial, antifungal, antioxidant, neuroprotective, respiratory protective, immunomodulatory, hepatoprotective effects (Mbaveng and Kuete 2017, Mao *et al*. 2019, Tung *et al*. 2019, Shang *et al*. 2019, Batiha *et al*. 2020).

Many studies have already been conducted on turmeric, ginger and garlic at various levels in broiler rations, the minimum effective level being 1% of the ration as reported by Eltazi (2014) and Choudhary *et al*. (2022). When supplemented alone, requirements of herbs are high, which may increase the feeding cost affecting profitability. It is, therefore, postulated that the three herbs i.e. ginger, turmeric and garlic, if used as blend, may reduce their requirements for their potential synergistic effects and will be more cost-effective. However, studies on combined uses of these herbs in broiler rations are not available. Therefore, the present study was conducted with the aim to exploit the synergistic effects of ginger, garlic, and turmeric as feed additives in the rations of broilers on growth, nutrient utilization and production efficiency.

MATERIALS AND METHODS

The study was carried out from October to November, 2023 for 42 days at experimental animal shed, Department of Animal Nutrition, College of Veterinary Sciences & Animal Husbandry, Central Agricultural University (Imphal), Selesih, Aizawl, Mizoram. The study was approved by the Institutional Animal Ethics Committee via approval no. CVSC/CAU/IAEC/22-23/P-6 dated 31/10/2023.

Design of the experiment: Two hundred and forty one-day-old broiler chicks (Cobb 400) were homogenously divided into six groups (T-1 to T-6) following completely randomized block design with 40 chicks in each group. T-1 was fed rations formulated following BIS (2007) recommendations. Rations for T-2 to T-6 were also formulated following BIS (2007) recommendations, but were supplemented with antibiotic growth promoter (*Bacitracin Methylene Disalicylate*) @ 0.5 g/kg ration, phytogenic herbal supplement (*Curcuma longa*, *Zingiber officinale* and *Allium sativum* powder *at* 1:1:0.5, w/w) @ 0.5%, 0.75%, 1.0%, 1.25% of ration, respectively (Supplementary Table 1).

Preparation of phytogenic herbal supplement (PHS): Ginger (*Zingiber officinale*), turmeric (*Curcuma longa*) and garlic (*Allium sativum*) were procured from Aizawl city, Mizoram, thoroughly washed with water, sliced into small pieces, dried in hot air oven at 60^0 C for 12 hrs., ground into powder and stored in airtight containers until use. The phytogenic herbal supplement was prepared by mixing powdered ginger, turmeric and garlic at 1:1:0.5 (w/w) ratio.

Housing and management of birds: Experimental birds were reared in deep litter system following standard management procedures. Chicks were kept in well-ventilated battery brooder for the first 7 days, and from 8th day onward, they were kept in deep litter house in separate 24 replicate pens. Twenty four hrs. lighting was provided and proper ventilation was maintained during the trial. Vaccination for Newcastle Disease was given on 7th (Lasota) and 21st day (R_2B), and Infectious Bursal Disease on 14th day; and deworming as per standard schedule. *Ad libitum* feed and water were provided during the trial.

Analytical method: The proximate analysis of feed ingredients and compounded rations was done following AOAC (2000); calcium and phosphorous by Talapatra *et al*. (1940) and AOAC (2000).

Parameters recorded: Daily feed intake and weekly body weight gain were recorded. At the end of 42nd day of age, a metabolic trial for 3 days was conducted with 2 days initial adaptation period for calculation of metabolizability of nutrients.

Calculation of productive efficiency: The productive efficiency was calculated as feed conversion ratio (FCR), productive efficiency index (PEI), and economic return score (ERS). The FCR was calculated by dividing the total feed consumed by the body weight gained during a certain length of time. The PEI was calculated using the following formula.

$$\text{PEI (\%)} = \frac{\text{Body weight (kg)} \times \text{Livability (\%)}}{\text{Age (days)} \times \text{FCR}} \times 100$$

The economic return score (ERS) was calculated using the following formula:

$$\text{ERS} = \frac{\text{Livability \%} \times \text{Average final weight (kg)}}{\text{Age of birds} \times \text{FCR} \times \text{Cost of feed (Rs/kg)}} \times 100$$

Statistical analysis: The statistical approach outlined by Snedecor and Cochran (1994) was followed for analyzing the data using one-way ANOVA in SPSS in a completely randomized design. Probability values $P \leq 0.05$ were considered as significant and the values of $0.05 > P \leq 0.01$ were considered as trend. When the treatment effect was found to be significant, the Duncan's test was used to evaluate the difference between the treatment means.

RESULTS AND DISCUSSION

Nutritional composition of phytogenic herbal supplement and rations: The phytogenic herbal supplement contained 91.6% DM, and 13.1% CP, 2.99% EE, 6.4% CF, 6.72% TA and 70.79% NFE on DM basis. The pre-starter, starter and finisher rations of all the treatments were isonitrogenous and isocaloric and nutrients were as per BIS (2007) standards for broilers (Supplementary Table 2).

Feed consumption: There was no significant differences ($P>0.05$) in feed consumption upon incorporating PHS in the rations of broilers, instead higher average daily feed intake was recorded in PHS fed groups from the 2nd week onwards (Fig 1). The increasing trend in feed consumption nullified any negative effect of PHS and can be opined that its incorporation instead improved feed consumption. This improvement might be associated with improved gut health for balanced microbiota and other beneficial effects

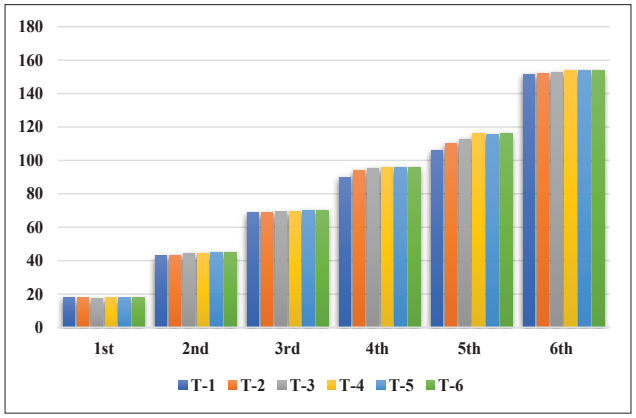

Fig. 1. Weekly feed consumption (g) of broilers under different treatments

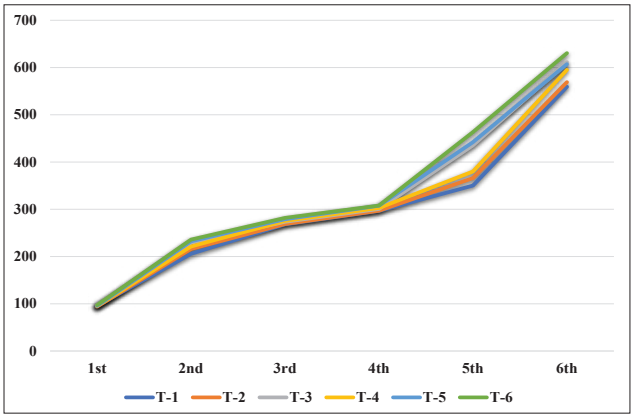

Fig. 2. Weekly body weight changes (g) of the broiler birds

stimulated by synergistic effects of PHS. Phytogenic herbs are known to enhance palatability and prevent rancidity of feed thereby delaying generation of hazardous oxidation products and retaining nutritional quality of feeds (Alem 2024). Similar findings regarding non-significant effects of ginger, garlic and turmeric powder supplementation on feed consumption were also reported by Khan *et al.* (2017), Saleem *et al*. (2020), Ekine *et al*. (2020) and Duwa *et al.* (2020) in broilers.

Growth performance of broiler birds: Records of weekly body weight changes indicated no significant difference (P>0.05) during the initial 1st to 3rd week of age. However, from 4th week onwards, the average body weight of broilers of T-3, T-4, T-5 and T-6 was significantly (P<0.01) higher than T-1 and T-2. Among the PHS-fed groups, highest body weight was recorded in T-6 followed by T-5 and T-3 (Fig 2). The average body weight at 42nd days of age (Table 1) was significantly (P<0.01) higher in T-6 followed by T-5, T-3 and T-4. The observations, thus, confirmed that supplementation of PHS could significantly improve body weight of broilers as compared to the AGP. Similar findings were also reported by Sarap (2020) in broilers after feeding 1% ginger powder and Sangilimadan *et al.* (2019) who reported that garlic paste supplementation in broilers resulted higher body weight (P<0.05) than those in control group. Improved growth rate as compared to the control and AGP supplemented group might be due to synergistic effect of the herbs improving gut health and immunity of birds, thereby improving the utilization of dietary nutrients. Significantly higher body weight in PHS-fed groups might also be due to the synergistic effect of bioactive compounds of the herbs having anti-microbial and antioxidant activities, alongwith improved digestion for increased secretion of digestive enzymes (Engida *et al.* 2023).

The findings of ADG corresponded with the weekly body weight changes without any significant differences (P>0.05) during the first three weeks and significant (P<0.01) improvement in subsequent weeks indicating positive effects of feeding PHS on growth performance of the broiler birds. Phytogenic herbs are appetizing and digestive stimulants having antimicrobial properties (Maidala *et al*. 2017) and might have contributed to improved gut health and immunity of birds, thereby increasing nutrient utilization. Unigwe and Igwe (2022) also reported that supplementation of 1% garlic and ginger powder significantly (P<0.05) improved body weight gain of broilers.

Metabolisability of nutrients: The metabolizability of nutrients were significantly (P<0.05) variable amongst treatments (Table 2). The metabolizability of DM was significantly higher in T-4, T-5 and T-6 as compared to other groups. The CP metabolizability was significantly highest in T-6, followed by T-3 and T-4. Similarly, EE and NFE metabolizability were also significantly higher in PHS fed groups. The findings might be an indication of positive effect of phytogenic herbs on digestibility of nutrients and could be attributed to the active compounds of the herbs and their synergistic effect stimulating secretions of digestive enzymes, establishing favourable microbiota leading to healthy gut (Rajput *et al*. 2013, Risdianto *et al*. 2019, Al-Khalaifah *et al.* 2022, Elbaz *et al.* 2022). Phytogenic herbs

Table 1. Effect of phytogenic herbal supplement on growth performance of broiler birds

Attribute	T-1	T-2	T-3	T-4	T-5	T-6	SEM/p-value
Initial BW (g)	35.54±1.14	37.57±1.98	35.55±1.76	36.25±1.74	35.65±1.43	35.15±1.10	0.62/0.90
ADG in BW (g)	42.27^{c}±0.68	43.10^{c}±0.12	46.31^{ab}±0.40	44.51^{b}±0.50	46.74^{ab}±1.01	48.01^{a}±0.82	0.54/0.001**
BW at 42nd day of age (g)	1810.92^{f}±6.94	1847.98^{e}±5.64	1980.86^{c}±7.81	1905.96^{d}±7.98	1998.87^{b}±7.54	2051.59^{a}±3.06	6.80/0.001**

Means bearing different superscripts (a, b, c, d, e, f) in a row differ significantly [BW: Body weight; ADG: Average daily gain; *means (P<0.05); **means (P<0.01)].

Table 2. Effect of PHS on Metabolizability of nutrients (%) in broilers

Attribute	T-1	T-2	T-3	T-4	T-5	T-6	SEM/p-value
DM	74.12^{b}±0.22	74.15^{b}±0.23	74.43^{b}±0.14	75.55^{a}±0.05	75.40^{a}±0.01	76.03^{a}±0.01	0.13/0.01*
CP	75.07^{e}±0.25	77.24^{cd}±0.06	78.67^{b}±0.05	77.76^{c}±0.03	76.80^{d}±0.20	79.87^{a}±0.22	0.16/0.01*
CF	56.20^{c}±0.20	56.76^{b}±0.20	56.23^{c}±0.06	56.55^{bc}±0.03	58.04^{a}±0.01	56.70^{b}±0.01	0.05/0.01*
EE	73.68^{c}±0.03	75.74^{a}±0.01	74.68^{b}±0.04	75.73^{a}±0.14	75.33^{a}±0.32	74.67^{b}±0.02	0.12/0.01*
NFE	76.00^{e}±0.04	72.87^{f}±0.02	76.42^{d}±0.08	76.71^{c}±0.01	77.42^{b}±0.03	78.74^{a}±0.01	0.01/0.01*

DM: Dry matter, CP: Crude protein, CF: Crude fibre, EE: Ether extract, NFE: Nitrogen free extract; Means bearing different superscripts (a, b, c, d, e, f) in a row differ significantly [*means (P<0.05), **means (P<0.01)].

Table 3. Effect of phytogenic herbal combination on productive efficiency of broiler birds

Attribute	T-1	T-2	T-3	T-4	T-5	T-6	SEM/p-value
FCR	1.88^{a} ±0.01	1.80^{ab}±0.03	1.71^{b}±0.02	1.73^{b}±0.02	1.71^{b}±0.03	1.68^{b}±0.02	0.02/0.01*
PEI	216.32^{e}±1.28	238.64^{d}±0.44	268.39^{b}±0.40	255.86^{c}±0.24	270.66^{b}±0.57	281.30^{a}±2.09	3.47/0.001**
ERS	3.32^{d}±0.02	3.43^{d}±0.05	3.53^{c}±0.05	3.61^{c}±0.02	3.83^{b}±0.02	4.01^{a}±0.01	0.07/0.01*

Means bearing different superscripts (a, b, c, d, e, f) in a row differ significantly [*means (P<0.05), **means (P<0.01)].

generally improve gastrointestinal morphology positively impacting secretions of digestive enzymes, thereby enhancing nutrient digestibility. Bioactive compounds of phytogenic herbs have laxative, spasmolytic and anti-flatulence effects on gastrointestinal tract, and improves nutrient digestibility by enhancing health status of broiler birds (Upadhaya and Kim 2017).

Productive efficiency: The productive efficiency of experimental broilers was assessed in terms of feed conversion ratio (FCR), performance efficiency index (PEI) and economic return score (ERS) at 42nd day of age.

The FCR was significantly (P<0.01) better in all the PHS fed groups than the control and AGP supplemented groups (Table 3) at 42nd day. Amongst the PHS-fed groups, FCR was better in T-6 followed by T-5, T-3 and T-4. The PEI at 42nd day of age was significantly (P<0.05) better in T-6 followed by T-5 and T-4 and was indications of better body weight gain, FCR and survivability in broilers when supplemented PHS. Saiyed *et al*. (2015) and Karangiya *et al*. (2016) also reported significantly higher (P<0.05) PEI in broilers fed phytogenic herbs. The findings were associated with significantly improved growth performance of broiler birds which might be due to better absorption and utilization of dietary nutrients attributable to improved intestinal morphology, optimal gut microbial status and immune status of the broiler birds contributing better average body weight and improved liveability. Phytogenic herbs improve feed efficiency by modulation of intermediary lipid and protein metabolism – related signaling pathways (Flees *et al*. 2021). It may also be due to antioxidant activity of the bioactive compounds stimulating the activity of alimentary tract, inhibition of pathogenic bacteria and thereby improved absorption and utilization of dietary nutrients.

Calculated ERS also showed similar trend as FCR and PEI. ERS is affected by liveability, growth rate and FCR of a particular period. Thus, better ERS for supplementation of PHS might be an indication of their favourable effect contributing to performance efficiency of broiler birds.

Supplementation of phytogenic herbal supplement significantly improved the growth performance of the broiler birds favouring nutrient metabolizability and feed efficiency. The findings of the study thus proved that PHS (*Zingiber officinale*, *Curcuma longa* and *Allium sativum at 1:1:0.5*) could be an effective additive alternative to AGP for broiler birds and might be recommended at 1.25% for improved growth performance, nutrient digestibility, and productive efficiency of broiler birds.

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