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Use of Lutein, *Cissus quadrangularis* and *Curcuma longa* in broiler chickens

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Abstract
This study was conducted to evaluate the use of Lutein, *Cissus quadrangularis* and *Curcuma longa* on production performance and carcass quality of broiler chickens. The trial was conducted on 360 'Cobb 430 Y' straight-run broilers for a period of five weeks. The day-old chicks were randomly divided into four groups of 90 birds each. Each group had six replicates of 15 birds each. Group A was control, receiving corn-soybean diet. Groups B, C and D received diets supplemented with a product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 250 g/T, 500 g/T and 750 g/T, respectively. The product contained 3% Lutein, 55% *Cissus quadrangularis* and 6% *Curcuma longa* extract. The parameters like live weight, gain in weight, feed consumption, feed conversion ratio (FCR), mortality, carcass quality, tibia ash, tibia calcium and phosphorus contents and economics of production were evaluated. It was observed that the birds receiving diet supplement with the product @ 750 g/T showed marginally better live weight, gain in weight and feed consumption. Significantly better feed conversion ratio was recorded by the birds receiving product @ 750 g/T than the control group. The results pertaining to the carcass quality parameters like edible carcass, giblet weight and heart weight percentages indicated comparable results. However, liver weight percentage and gizzard weight percentage were significantly higher for the birds receiving product @ 750 g/T. The tibia ash, calcium and phosphorus contents showed non-significant difference amongst the birds from different group. The net returns were also higher for the birds receiving product @ 750 g/T than all the treatment groups, including control group. Hence, it is concluded that, the supplementation of product containing containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 750 g/T to the diets is beneficial in improving production performance, carcass quality and profit margins in broiler chickens.

Keywords: Lutein, *Cissus quadrangularis*, *Curcuma longa*, broiler

Introduction
In India, the poultry industry is one of the livestock sector's largest and the fastest growing sectors today. Poultry production in India has doubled in the last two decades. Despite substantial advancements in the poultry sector, the industry still faces numerous challenges including bacterial and viral diseases. Currently, enteric diseases in poultry are the root cause of lower productivity and increased mortality. Generally, these infections are treated by using antibiotics but the increasing concern about antibiotic residues and ban on sub-therapeutic antibiotics use in many developed countries generates interest in the development of an alternative method to control poultry associated pathogens in different parts of the world. In recent years, the poultry industry is using phytogenic feed additives in the poultry diet to enhance the broilers' performance. Phytobiotics is a term used to describe plant-derived natural bioactive compounds. Phytogenic feed additives have the potential to promote production performance and productivity (Muthusamy *et al*., 2015) [8] and thus add to the set of non-antibiotic growth promoters such as organic acids and probiotics. Natural medicinal products derived from herbs and spices used in animal and poultry nutrition to enhance performance have been called "phytogenic feed additives" (Windisch *et al*., 2008) [14]. Phytogenic products help in alleviating the problems caused by synthetic products (Windisch *et al*., 2008) [14] and also because of their multiple activities provide a holistic approach to the welfare of the birds. Hence, in the present study, Lutein, *Cissus quadrangularis* and *Curcuma longa* were selected to be used in broiler chickens for their various beneficial effects on production performance and carcass quality.

Lutein is a xanthophyll carotenoid naturally present in marigolds. Numerous studies have shown that lutein can enhance humoral and cellular immunity, increase the phagocytic activities of macrophages, and inhibit tumour cell propagation within animals (Park *et al*., 2012) [9]. Carotenoids are usually lipophilic substances and thus they are stored well in fats. Lutein is widely used in the poultry industry for enhancing the pigmentation of the skin. Marigold flower was one of the most concentrated sources of Lutein (80-90%) (Quackenbush and Miller, 1972) [10].

Cissus quadrangularis has quadrangular stems, small leaves and also root and all these possess medicinal properties. *Cissus quadrangularis* promotes the growth of bone cell mineralization. *Cissus quadrangularis* contains Calcium and Phosphorus in minor amounts required for mineralization. However, it enhances the bioavailability of Calcium and Phosphorus for bone and muscle building thereby increasing body weight. *Cissus quadrangularis* is extensively used in human medicine for fracture healing (Muthusami *et al*., 2011) [15]. Similarly, it has also been used for accelerating the process of healing fractures in dogs (Maiti *et al*., 2007) [5]. Faster growth of broiler in turn, may increase the risk of skeletal abnormalities, bone deformities and fractures with a negative impact on bone health and bone quality (porosity). Other common problems are degenerative joint diseases or bone weakness seen in broilers due to their greater body weight. Skeletal problems not only cause significant economic losses in broiler production but also raise welfare concerns. Feeding *Cissus quadrangularis* can reduce the chances of many bone deformities and abnormalities in chicks. Hence, it was thought that *Cissus quadrangularis* will help broilers reduce the chances of many bone deformities and abnormalities in chicks by improving their calcium metabolism.

Curcuma longa is used as a natural growth promoter having antibacterial, anticoccidial, antioxidant and anti-inflammatory activity. Curcuma longa or turmeric is a medicinal plant widely used and cultivated in tropical regions. Curcumin, which gives the yellow colour to Turmeric rhizomes, is one of the most active ingredients, responsible for biological activity. Curcumin has a beneficial effect on meat quality under thermal stress, improves productivity, enhances meat skin colour which is positively accepted by consumers, increases the antioxidant effect and has an anti-hepatotoxic effect by inhibiting lipid peroxidation in the cell membrane (Marchiori *et al*., 2019) [6].

The use of Lutein, *Cissus quadrangularis* and *Curcuma longa* in broilers has been studied individually for their beneficial effects. However, their use in combination has not been explored in broilers and hence, a study was planned to evaluate the use of the combination product containing these three ingredients together on production performance, carcass quality and economics of broiler chickens.

Materials and Methods

The trial was conducted on 360 'Cobb 430 Y' broilers for five weeks. The day-old straight run chicks are randomly divided into four equal groups of 90 birds each. Each group was further divided into six replicates of 15 birds each. Each group received one of the following treatments

- **Group A:** Control- Corn soybean diet.
- **Group B:** Diet supplemented with product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 250 g/T.
- **Group C:** Diet supplemented with product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 250 g/T.
- **Group D:** Diet supplemented with product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 250 g/T.

The product contained 3% Lutein, 55% *Cissus quadrangularis* and 6% *Curcuma longa* extract.

The live weight of day-old chicks was recorded at arrival and then on weekly intervals. From this data, average weekly live weight and average weekly gain in weight was calculated for each group. The records maintained for daily feed consumption were used to calculate average weekly feed consumption. The week wise and cumulative feed conversion ratio of all the groups was calculated. The daily record of mortality, if any, during the period of experiment was also maintained and compiled on weekly basis. Carcass quality parameters, Tibia ash, Calcium and Phosphorus contents were estimated at the end of the trial. The economics of the production was calculated at the end of the trial.

At the end of the experiment, six birds from each group were selected randomly and housed in separate cages for carcass evaluation studies. The birds fasted for a period of three hours before slaughter. The live weights of the birds were recorded before slaughter. The dressed weight of each bird after complete bleeding and removal of feathers was obtained. To obtain edible carcass yield, the carcass was weighed after the removal of viscera, head and shanks. The weights of the liver, heart and gizzard were recorded for the respective birds. The percentage of dressed weight, edible carcass weight and weight of different organs were calculated over live weight and then compared. At the end of the study, six birds were sacrificed and the left tibia of these birds were removed for estimation.

The data collected from all parameters was subjected to statistical analysis using Completely Randomised Design by using IBM SPSS Statistics for Windows, version 25.0.

Results

Live Body Weights: The average weekly live weights of birds at the day-old stage for groups A to D were 41.61, 41.93, 41.84, and 41.89 g, respectively. At the end of five weeks, the average live weights were 1993.29, 1935.61, 1963.65, and 2001.39 g., for groups A to D, respectively. It is revealed that the average weekly live weights of the birds from the group D were highest at the end of five weeks. This group was closely followed by the birds from group A. The statistical analysis revealed that the differences in weekly live weights of the birds from different groups were statistically non-significant (p>0.05) at the end of fifth week. Similar findings were reported by Wang *et al*. (2015) [12].

Table 1: Weekly live body weights (g) of birds from different groups.

Groups	Treatments	Zero-day	Week 1	Week 2	Week 3	Week 4	Week 5
A	Control-Corn-Soybean diet	41.61	138.10^{a}	346.81	762.21	1273.41	1993.29
B	Diet supplement with product @ 250 g/ T	41.93	141.34^{ab}	342.03	746.83	1237.19	1935.61
C	Diet supplement with product @ 500 g/T	41.84	148.45^{b}	346.86	748.34	1241.19	1963.65
D	Diet supplement with product @ 750 g/ T	41.89	140.60^{ab}	341.15	751.65	1268.87	2001.39

Gain in Weights

From the data, it is observed that the average weekly gain in weights of birds at the end of five weeks were 1951.68, 1893.68, 1921.82 and 1959.50 g for groups A to D, respectively. It is revealed that the average weekly gain in weights of the birds from the group D were highest at the end of five weeks. Thus, a similar trend as seen in case of average weekly live weights was exhibited with respect to average weekly gain in weights. The statistical analysis revealed that the differences in the average weekly gain in weights of the birds from different groups were statistically non-significant (p>0.05) at the end of fifth week. Similar findings were reported by Jadhav *et al*. (2016) [2] and Wang *et al*. (2017) [13].

Table 2: Weekly gain in body weights (g) of birds from different groups.

Groups	Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative
A	Control-Corn-Soybean diet	96.49^{a}	208.71	415.40	511.20	719.89	1951.68
B	Diet supplement with product @ 250 g/ T	99.41^{ab}	200.68	404.80	490.36	698.42	1893.68
C	Diet supplement with product @ 500 g/T	106.62^{b}	198.41	401.48	492.85	722.47	1921.82
D	Diet supplement with product @ 750 g/ T	98.71^{ab}	200.55	410.50	517.22	732.52	1959.50

Feed Consumption

From the data, it is observed that the total average weekly feed consumption of the birds at the end of five weeks was 2942.09, 2940.45, 2875.14 and 2821.57 g for the birds from groups A to D, respectively. It is revealed that the average weekly feed consumption of the birds from group A was the highest at the end of five weeks. The lowest average weekly feed consumption was recorded by the birds from the group D at the end of the five weeks. It was noticed that the average feed consumption by the birds reduced as the dose of the product was increased in the feed from 250 g/T to 750 g/T. The statistical analysis revealed that the differences in average weekly feed consumption of the birds from different groups were statistically non-significant (p>0.05). Similar findings were reported by Wang *et al*. (2015) [12] and Wang *et al*. (2017) [13].

Table 3: Weekly feed consumption (g) of birds from different groups.

Groups	Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative
A	Control-Corn-Soybean diet	124.46	324.51	567.19	828.05	1097.88	2942.09
B	Diet supplement with product @ 250 g/ T	130.52	343.89	588.12	803.33	1074.59	2940.45
C	Diet supplement with product @ 500 g/T	129.05	341.22	549.97	785.95	1068.95	2875.14
D	Diet supplement with product @ 750 g/ T	127.50	324.59	552.34	766.00	1051.14	2821.57

Feed Conversion Ratio

From the data, it is observed that the cumulative weekly feed conversion ratio at the end of five weeks was 1.50, 1.55, 1.49 and 1.43 for the birds from groups A to D, respectively. It is revealed that the birds from group D showed a better cumulative weekly feed conversion ratio as compared to all treatment groups, including control. The data pertaining to the cumulative weekly feed conversion ratios of birds from different groups indicated that the differences within the groups were statistically significant. The cumulative weekly feed conversion ratio of the birds from group D was significantly better than the birds receiving diet supplemented with combination product @ 250 g/T. However, the difference in feed conversion ratio of birds from groups A, B and C were statistically non-significant (p>0.05). Similar findings were reported by Johannah *et al*. (2018) [16], Jadhav *et al*. (2010) [17] and Rajput *et al*. (2012) [11].

Table 4: Anova table for weekly feed conversion ratio of birds from different groups.

Groups	Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Average	Cumulative
A	Control-Corn-Soybean diet	1.29	1.56	1.37^{ab}	1.62	1.53	1.47^{ab}	1.50^{ab}
B	Diet supplement with product @ 250 g/ T	1.31	1.72	1.46^{a}	1.64	1.54	1.53^{a}	1.55^{a}
C	Diet supplement with product @ 500 g/T	1.22	1.72	1.37^{ab}	1.59	1.48	1.47^{ab}	1.49^{ab}
D	Diet supplement with product @ 750 g/ T	1.29	1.63	1.35^{b}	1.48	1.46	1.44^{b}	1.43^{b}

Mortality

From the table, it is observed that the total mortality of birds up to the end of five weeks for groups A to D was 2, 1, 3, and 2 birds, respectively. The mortality of birds from different treatment groups was well within the limit, indicating that there was no ill effect of the diets supplemented with the product on health of the birds.

Table 5: Weekly mortality (No.) of birds from different groups

Groups	Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Total
A	Control-Corn-Soybean diet	1	0	0	1	0	2
B	Diet supplement with product @ 250 g/ T	0	1	0	0	0	1
C	Diet supplement with product @ 500 g/T	2	1	0	0	0	3
D	Diet supplement with product @ 750 g/ T	0	1	0	1	0	2

Carcass Evaluation Studies

The average edible carcass percentage of birds from group A, B, C and D were 65.24, 64.95, 64.33 and 65.63, respectively. It is revealed that the average edible carcass percentage from the group D was highest at the end of five weeks. The statistical analysis revealed that the difference in the average edible carcass percentage of birds from different experimental groups was statistically non-significant (p>0.05).

The average giblet weight percentage of the birds from groups A, B, C and D were 4.76, 4.72, 4.76 and 4.40, respectively. It

is revealed that the average giblet weight percentage of the birds from the group A and group C were highest at the end of five weeks. The statistical analysis revealed that the difference in the average giblet weight percentage of different birds from the experimental groups were statistically non-significant (p>0.05).

The average heart weight percentage of the birds from groups A, B, C and D were 0.52, 0.51, 0.51 and 0.50, respectively. It is revealed that the average heart weight percentage of birds from different treatments were almost comparable with no significant (p>0.05) differences amongst them.

The average liver weight percentage of the birds from groups A, B, C and D were 2.09, 2.28, 2.17 and 1.99, respectively. It is revealed that the average liver weight percentages of the birds from the group B were highest. It was revealed that the average liver weight percentage of birds from group B were significantly higher than the bird from group D. The difference in average gizzard weight percentage of all other groups were statistically non-significant (p>0.05).

The average gizzard weight percentage of the birds from groups A, B, C and D were 2.14, 1.94, 2.08 and 1.90, respectively. It is revealed that the average gizzard weight percentage of the birds from the group A was highest at the end of five weeks. It was revealed that the average gizzard weight percentage of birds from group A were significantly higher than the birds from group D. The difference in average gizzard weight percentage of all other groups were statistically non-significant (p>0.05).

Table 6: Carcass traits evaluation of birds from different groups

Groups	Treatments	Edible carcass %	Giblet weight %	Heart weight %	Liver weight %	Gizzard weight %
A	Control-Corn-Soybean diet	65.24	4.76	0.52	2.09^{ab}	2.14^{a}
B	Diet supplement with product @ 250 g/ T	64.95	4.72	0.51	2.28^{a}	1.94^{ab}
C	Diet supplement with product @ 500 g/T	64.33	4.76	0.51	2.17^{ab}	2.08^{ab}
D	Diet supplement with product @ 750 g/ T	65.63	4.40	0.50	1.99^{b}	1.90^{b}

Tibia Ash, Calcium and Phosphorus Percentage

The average tibia ash percentage were 43.62, 44.54, 43.45 and 43.78 for groups A, B, C and D, respectively. It is revealed that the average tibia ash percentage for the birds from group B was the highest. The statistical analysis of the data revealed that the differences in the average tibia ash percentage of birds from different groups were statistically non-significant (p>0.05). The average tibia calcium percentage were 21.31, 20.24, 21.85 and 22.28 for the birds from groups A, B, C and D, respectively. It is revealed that the average tibia calcium percentage of the birds from the group D was the highest at the end of five weeks. The statistical analysis of the data revealed that the difference in the average tibia calcium percentage of birds from different treatment groups was statistically non-significant (p>0.05).

Table 7: Tibia ash, Calcium and Phosphorus % of birds from different groups

Groups	Treatments	Tibia Ash %	Tibia Calcium %	Tibia Phosphorus %
A	Control-Corn-Soybean diet	43.62	21.31	9.34
B	Diet supplement with product @ 250 g/ T	44.54	20.24	8.93
C	Diet supplement with product @ 500 g/T	43.45	21.85	9.66
D	Diet supplement with product @ 750 g/ T	43.78	22.28	9.84

Economics of Broiler Production

The economics of broiler production for different groups was calculated at the end of fifth week. From the table, it is observed that net cost of production per bird for group A to D were Rs. 168.79, 169.19, 167.03 and 165.33, respectively. The corresponding net cost of production per kg for groups A, B, C and D were Rs. 84.68, 87.41, 85.06, and 82.61. It is noticed that the cost of production per bird was lowest for the birds from group D receiving diet supplemented with product @ 750 g/T followed by groups A, B and C. The sale price for birds from different groups was considered Rs. 90 per kg on live weight basis. Thus, the net profit per bird for groups A to D was Rs. 10.60, 5.02, 9.70 and 14.80, respectively. The corresponding net profit per kg was Rs. 5.32, 2.59, 4.94 and 7.39 for the birds from groups A, B, C and D. It is observed that the group D recorded the highest profit per bird followed by groups A, B and C. The birds from group B receiving diet supplemented with product @ 250 g/T recorded the lowest returns as compared to the birds from other groups.

Table 8: Economics of Broiler Production at the end of five weeks

Parameters	Group A	Group B	Group C	Group D
Chick cost (`)	38	38	38	38
Feed intake (g)				
1. Pre-starter	124.46	130.52	129.05	127.50
2. Starter	891.70	932.01	891.19	876.93
3. Finisher	1925.93	1877.92	1854.90	1817.14
Total feed intake (g)	2942.09	2940.45	2875.14	2821.57
Feed price per kg (`)				
1. Pre-starter	39.03	39.18	39.33	39.48
2. Starter	39.72	39.87	40.02	40.17
3. Finisher	39.21	39.36	39.51	39.66
Feed cost per bird (`)				
1. Pre-starter	4.86	5.11	5.08	5.03
2. Starter	35.42	37.16	35.67	35.23
3. Finisher	75.52	73.91	73.29	72.07

Total feed cost per bird (`)	115.79	116.19	114.03	112.33
Miscellaneous cost per bird (`)	15.00	15.00	15.00	15.00
Net cost of production per bird (`)	168.79	169.19	167.03	165.33
Body weight at the end of the trial (gm)	1993.29	1935.61	1963.65	2001.39
Net cost of production per kg (`)	84.68	87.41	85.06	82.61
Return on sale @ Rs.90 per kg	179.40	174.20	176.73	180.13
Net profit per bird (`)	10.60	5.02	9.70	14.80
Net profit per kg (`)	5.32	2.59	4.94	7.39

Conclusion

It may be concluded that the birds from group D receiving diet supplemented with the product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 750 g/T has shown marginally better growth performance, carcass quality, tibia ash, calcium and phosphorus contents and net returns than all the treatment groups including control group. Thus, the overall result of this experiment suggested that the use of product containing Lutein, *Cissus quadrangularis* and *Curcuma longa* @ 750 g/T is suitable for broiler production with comparable results with the birds from the control group.

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