



Efficiency of Dietary Supplementation of Flavonoid (Quercetin), Vegetable Oil and Its Combination on Growth Traits and Feed Conversion in Broilers

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ABSTRACT

The study was conducted to investigate the efficiency of dietary supplementation of Flavonoid (Quercetin) compound, vegetable oil and its combination on feed intake, growth traits and feed conversion in broiler chickens. Four dietary treatments were assigned in to 192 Vencob-400 strain broiler chicks for the 35 days duration (7th-42nd days). The treatments were control (T1) without any supplementation, whereas T2, T3 and T4 supplemented with Quercetin (1g kg⁻¹), vegetable oil (>10% of ME recommendation) and combination of Quercetin with vegetable oil, respectively. Each group comprised of four replicates (12 birds in each). All the treatment groups were fed similar corn soya based basal diet. Daily and weekly feed intake throughout the experimental period was found comparable among the dietary treatment groups except the period of 4th week, where higher (P<0.05) feed intake was observed in control (T1). During starter phase weekly body weight gain (g/bird/week) and weekly growth rate (g/bird/d) was significantly (P<0.01) differ amongst the group, which was highest in T4; while these parameters were found comparable in finisher phase. However, the cumulative weight gains and cumulative growth rate were significantly (P<0.01) higher in T3 and T4 group. Similarly, Quercetin supplementation (T2) had also revealed higher cumulative weekly weight gain and growth rate over control group (P<0.01). The feed conversion ratio was revealed better (P<0.05) in T4 group during 4th and 6th week and also for overall experiment. Thus, the supplementation of Quercetin or vegetable oil or its combination in broilers had shown a better growth performance and improvement in feed conversion ratio.

HIGHLIGHTS

- Growth performance was better due to supplementation of Flavonoid (Quercetin) or vegetable oil or its combination.
- The FCR was improved in broilers fed combination of Flavonoid (Quercetin) and vegetable oil.

Keywords: Broilers, Feed conversion ratio, Growth, Quercetin, Vegetable oil

Poultry industry is recognized as one of the phenomenal industries due to its low cost investment, early assure return, limited land intake and short generation intervals. Progressively it becomes more popular to fight against unemployment, poverty and malnutrition (Yadav, 2018). Within the poultry sector, two thirds of the output (about 66.7 per cent) is contributed by the broiler sector and the other third (about 33.3 per cent) by egg production (BAHS, 2017). Current intensive poultry sector aims to

produce the ready broiler chicken within six weeks of age, as commercial broiler bird having a dynamic growth, development process and is one of the fastest growing birds (Patane *et al.*, 2017). Feed contributes a 75% production

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cost and is the major influencing factor in broiler rearing. Inclusion of oil sources in poultry ration has often been practiced for early growth, in addition oil incorporation raised the energy density of diet, absorption of fat soluble vitamins, hydrolysis of essential fatty acids and resultant enhanced the energy consumption (Parmar *et al.*, 2019a).

Flavonoids are polyphenolic group of compounds, created an eye catching interest owing to its multiple biological actions and suited the best as a “functional phyto-ingredient” in the absence of banned antibiotic growth promoters for animals and poultry birds (Parmar *et al.*, 2019b). Quercetin is a flavonoid compound of class flavonols and has very strong antioxidant potential, along with anti-inflammatory, gut health promoter, growth enhancers and immune modulating properties (Sikder *et al.*, 2014). Poultry birds are very sensitive to various physiological and metabolic stresses thus need to be supplied a plant based additives with having different biological activities. Therefore, considering the facts, the study was conducted to evaluate the effect of Quercetin, as a flavonoid compound and the vegetable oil supplementation on feed consumption, growth traits and feed conversion ratio of broiler chickens.

MATERIALS AND METHODS

The experiment was carried out at Department of Animal Nutrition, College of Veterinary Science & Animal Husbandry, Navsari Agricultural University, Navsari, Gujarat with using 192 Vencob-400 strain Broilers (*Gallus gallus domesticus*). The experiment was conducted with the standard rules and permission of Institutional Animal Ethics Committee (IAEC). One day old chicks were provided with one week adaptation period and after that from the 7th day onwards birds were assigned in to four dietary treatment groups, each group comprises four replicates which contains 12 birds in each (48 Birds Group⁻¹). All the birds were fed with corn-soya based basal diet formulated as per BIS (2007) recommendation for starter (8-21 days) and finisher phase ration (22-42 days), respectively in all the treatment groups. The birds under control group (T1) were fed only basal diet without any supplementation, while other three treatment groups were fed similar basal diet along with Quercetin (1 g Kg⁻¹), Vegetable oil (>10% of ME recommendation) and combination of Quercetin (1 g Kg⁻¹) + Vegetable oil

(>10% of ME than recommendation) in T2, T3 and T4, respectively. The treatment diets were supplemented for 35 days duration (7-42 days of age). The basal diet was formulated with maize (50%), maize gluten (7.3%), De-oiled rice bran (9.0%), Rice polish (5.0%), de-oiled soya cake (8.7%), ground nut cake (9.0%), Protolive (7.9%) and mineral mixture, Di-calcium phosphate, salt, Biometh, lysine, toxin binder, choline and Meriplex (2.9%). Details of treatment regimen are given in Table 1. The nutritional composition of experimental feed was estimated according AOAC (2008). The birds were provided with similar environmental and managerial condition throughout entire experimental period in all the treatment groups. Clean, fresh, wholesome *ad libitum* drinking water was provided to all experimental birds throughout the experimental period. Commercially available hydrogenated vegetable oil was acquired from local market and the Quercetin (≥95% (HPLC) solid (Lot#SLBS2349V)2(3,4-Dihydroxyphenyl)-3,5,7-trihydroxy-4h-1-benzopyran-4one,3,3',4',5,6 pentahydroxyflavone) natural powder was acquired from Sigma Aldrich (P) Ltd.

Table 1: Feeding and treatment regimen of broiler chickens under experiment

Treatment Group	Diet	Supplementation
I: T1 (CON)	Basal diet	None
II: T2 (Q)	Basal diet	Quercetin @1.0 g/kg of feed
III: T3 (HFD)	Basal diet	*Vegetable oil @ (Starter diet-34 g/kg of feed, Finisher diet-35 g/kg of feed)
		*Vegetable oil @ (Starter diet-34 g/kg of feed, Finisher diet-35 g/kg of feed) + Quercetin @1.0 g/kg of feed
IV: T4 (HFD+Q)	Basal diet	Quercetin @1.0 g/kg of feed

(T: Treatment; CON: Control; Q: Quercetin; HFD- High fat diet; *>10% of ME recommendation of BIS, 2007).

Daily weighted quantity of feed was offered in each pen and leftover feed was recorded to estimate the voluntary feed intake. At weekly interval, the difference in weight of feed offered and that of leftover indicated consumption of feed by particular group of birds. Average feed intake in gram/chick/week was calculated by dividing the total amount of feed consumed by the number of chicks in the particular

pen for respective week. Cumulative feed consumption for experimental period was worked out based on voluntary feed intake of birds. Individual body weight of all the chicks was recorded with standard electronic weighing balance (Scale-Tec, Digital Weighing Balance) on the day of their procurement, at beginning of experimental period and thereafter at weekly interval for each replication/treatment groups during experimental period. The average weekly body weight gain was calculated by subtracting the body weight of previous week from that of current. Further, average daily body weight gain and cumulative body weight gain were also worked out accordingly. Feed conversion ratio (FCR) was calculated based on the amount of feed consumed to unit weight gain by standard formula.

The data were analyzed statistically using statistical significance using package for the social sciences (SPSS, version 20.0 Chicago, USA) following the Duncan's multiple range test for comparisons of means (Duncan, 1955).

RESULTS AND DISCUSSION

Feed intake

The average weekly feed consumption (g/bird/week) and

daily feed consumption (g/bird/day) data are presented in Table 2. Daily and weekly feed intake was comparable throughout the experimental period except 4th week. During 4th week, the feed intake was significantly ($P < 0.05$) low in Quercetin supplemented group (T2) as compared to control (T1). However, values in vegetable oil supplemented group either alone (T3) or in combination with Quercetin (T4) was comparable with T1 and T2. This indicated that supplementation of 10% high fat than the BIS (2007) recommendations didn't make any significant difference on feed consumption of broilers. Moreover, data pertaining to starter phase and finisher phase feeding was also revealed alike. Similarly, comparable feed intake at different level of oil supplementation (Olive oil (2%, 5%), Palm oil (2%, 4%, 6%), Sunflower oil (2%, 4%, 6%) was reported in previous studies (Zhang *et al.*, 2013; Khatun *et al.*, 2018). Feed intake shown apparently lower in oil supplemented groups that might be due to the greater impact of higher energy- yielding capacity of saturated fatty acid (SFA), however fatty acid profile of oil sources might have influenced feed intake of broiler birds (Attia *et al.*, 2020).

The feed intake of birds was not influenced on incorporation of Quercetin (flavonoid compound) as anti-oxidant and/or lypolytic agent with (T4) or without fat (T2). This finding

Table 2: Effects of dietary Flavonoid (Quercetin) and vegetable oil supplementation on weekly feed intake and daily feed intake in broilers

Week	Treatment Group				SEM	P- Value
	T1	T2	T3	T4		
Weekly feed intake (g/bird/d)						
2	341.71 ± 8.96	347.17 ± 16.76	346.32 ± 5.86	350.78 ± 4.11	4.618	0.937
3	622.55 ± 28.7	616.71 ± 14.57	639.75 ± 11.66	595.79 ± 13.60	9.183	0.439
Starter	482.13 ± 18.80	481.94 ± 11.83	493.03 ± 7.30	473.28 ± 8.56	5.567	0.741
4	977.89 ± 38.27 ^a	866.86 ± 35.42 ^b	902.77 ± 17.40 ^{ab}	872.21 ± 37.30 ^{ab}	18.747	0.051
5	1088.24 ± 23.62	1022.88 ± 35.46	1059.02 ± 20.28	1040.19 ± 36.24	14.704	0.477
6	1091.18 ± 10.82	1119.33 ± 59.43	1011.49 ± 30.10	1030.34 ± 23.74	19.599	0.168
Finisher	1052.44 ± 22.27	1003.03 ± 30.39	991.10 ± 12.05	980.91 ± 31.10	13.299	0.244
Daily feed intake (g/bird/d)						
2	48.81 ± 1.27	49.59 ± 2.39	49.47 ± 0.83	50.11 ± 0.58	0.659	0.937
3	88.93 ± 4.1	88.10 ± 2.08	91.39 ± 1.66	85.11 ± 1.94	1.310	0.439
Starter	68.87 ± 2.68	68.85 ± 1.69	70.43 ± 1.04	67.61 ± 1.22	0.836	0.741
4	139.69 ± 5.46 ^a	123.84 ± 5.05 ^b	128.96 ± 2.48 ^{ab}	124.60 ± 5.32 ^{ab}	2.678	0.081
5	155.46 ± 3.37	146.12 ± 5.06	151.28 ± 2.89	148.59 ± 5.17	2.100	0.477
6	155.88 ± 1.54	159.90 ± 8.49	144.50 ± 4.30	147.19 ± 3.39	2.800	0.168
Finisher	150.34 ± 3.18	143.28 ± 4.34	141.58 ± 1.72	140.13 ± 4.44	1.900	0.244

SEM- standard error mean, ^{ab}Means with different superscript in a row differ significantly ($P < 0.05$).

was corroborated with the results of Goliomytis *et al.* (2014) and Sohaib *et al.* (2015) who supplied flavonoid compound in chickens at varying level with different sources and concentration of fat.

Growth traits

The data of growth traits are presented in Table 3 and 4. The weekly body weight gain (g) and weekly growth rate (g/d) of birds shown a significant ($P < 0.05$) difference during starter phase (Table 3), however it was found comparable from 4th to 6th weeks and overall finisher phase. The cumulative weight gain (g) and cumulative growth rate (g/d) was significantly ($P < 0.05$) differ in each week (Table 4), which was found higher in oil supplemented group either with (T4) or without Quercetin (T3). Moreover, Quercetin supplementation also revealed higher cumulative weekly weight gain and growth rate than control group ($P < 0.01$).

In agreement with the present findings, increase in weight gain and growth rate of broiler chickens was reported by Kang and Kim (2016) and Attia *et al.* (2020) on supplementation of rice bran oil (5, 10, 20 g/kg) and canola

oil (0.5, 1.5 %), coconut oils (0.5, 1.5 %) higher than the recommendations (BIS, 2007) in broilers, respectively. Significant ($P < 0.05, 0.01$) difference in weekly body weight gain (g) and weekly growth rate (g/d) was revealed up to starter phase whereas comparable in finisher phase (4th and 6th week). It was possible due to the widening of calorie: protein ratio (Ayad *et al.*, 2015) which favors the fat deposition in T3 and T4 during finisher phase, in contrary there was muscular growth in T1 and T2 at recommended

level of calorie: protein ratio. Quercetin as a polyphenolic compound inhibits the pathogenic bacterial flora with increased lactate organisms, thus made healthy gut environment and positively impacted on digestion of birds which might reflected in increased weight gain of birds (Sohaib *et al.*, 2015; Hassan *et al.*, 2018) under T2 group. Increased weight and growth rate of bird on high dietary fat might be due to the deposition of unutilized fat in abdominal region. The body fat mass (adjusted for fat-free mass) or fat deposition was positively correlated with dietary fat, saturated or unsaturated fat and age of birds (Larson *et al.*, 2012). Moreover, saturated fat has an independent effect on body fat mass and the effect

Table 3: Effects of dietary Flavonoid (Quercetin) and vegetable oil supplementation on weekly body weight gain and weekly growth rate in broilers

Week	Treatment Group				SEM	P- Value
	T1	T2	T3	T4		
Weekly body weight gain (g/bird)						
2	219.12 ± 3.81 ^c	224.67 ± 3.64 ^{bc}	236.02 ± 3.83 ^b	237.17 ± 3.90 ^a	2.599	0.014
3	359.27 ± 5.55 ^b	368.85 ± 6.08 ^{ab}	370.21 ± 5.14 ^a	373.07 ± 4.76 ^a	2.765	0.066
Starter	289.20 ± 1.22 ^c	296.76 ± 1.89 ^b	303.11 ± 2.09 ^a	305.12 ± 1.24 ^a	1.769	0.000
4	455.71 ± 6.81	459.18 ± 4.164	465.42 ± 3.78	453.36 ± 4.93	2.540	0.411
5	584.90 ± 6.43	587.52 ± 6.06	586.50 ± 6.98	585.21 ± 5.00	2.771	0.989
6	574.87 ± 3.43	570.49 ± 7.07	581.63 ± 8.86	585.90 ± 6.28	3.369	0.406
Finisher	538.49 ± 2.12	539.06 ± 1.28	544.45 ± 2.05	541.49 ± 2.27	1.027	0.184
Weekly growth rate (g/bird/d)						
2	31.30 ± 0.54 ^b	32.09 ± 0.52 ^b	33.72 ± 0.54 ^a	33.88 ± 0.55 ^a	0.371	0.003
3	51.32 ± 0.79 ^b	52.69 ± 0.86 ^{ab}	52.88 ± 1.46 ^a	53.29 ± 0.68 ^a	0.395	0.021
Starter	41.31 ± 0.17 ^c	42.39 ± 0.26 ^b	43.30 ± 0.59 ^a	43.58 ± 0.17 ^a	0.252	0.000
4	65.10 ± 0.97	65.60 ± 0.59	66.46 ± 0.54	64.76 ± 0.70	0.362	0.331
5	83.56 ± 0.92	83.93 ± 0.86	83.78 ± 0.99	83.60 ± 0.71	0.395	0.989
6	82.12 ± 0.49	81.50 ± 1.01	83.09 ± 1.26	83.70 ± 0.89	0.481	0.407
Finisher	76.93 ± 0.30	77.00 ± 0.18	77.78 ± 0.29	77.35 ± 0.32	0.136	0.181

SEM- standard error mean, ^{abc}Means with different superscript in a row differ significantly ($P < 0.05$).

Table 4: Effects of dietary Flavonoid (Quercetin) and vegetable oil supplementation on cumulative weekly body weight gain and cumulative weekly growth rate in broilers

Week	Treatment Group				SEM	P- Value
	T1	T2	T3	T4		
Cumulative weekly body weight gain (g/bird)						
2	219.12 ± 3.81 ^c	224.67 ± 3.64 ^{bc}	236.02 ± 3.83 ^{ab}	237.17 ± 3.90 ^a	2.599	0.014
3	578.39 ± 2.45 ^c	593.53 ± 3.78 ^b	606.23 ± 4.19 ^b	610.25 ± 2.49 ^a	3.539	0.000
4	1034.10 ± 5.58 ^c	1052.71 ± 4.81 ^b	1071.46 ± 3.28 ^a	1063.61 ± 3.26 ^{ab}	4.110	0.000
5	1619.01 ± 3.03 ^c	1640.24 ± 4.85 ^b	1657.97 ± 3.96 ^a	1648.83 ± 2.61 ^{ab}	4.079	0.000
6	2193.88 ± 4.41 ^c	2210.73 ± 5.53 ^b	2239.60 ± 5.00 ^a	2234.73 ± 4.57 ^a	5.256	0.000
Cumulative growth rate (g/bird/d)						
2	31.30 ± 0.54 ^c	32.09 ± 0.52 ^{bc}	33.72 ± 0.54 ^{ab}	33.88 ± 0.55 ^a	0.371	0.014
3	41.31 ± 0.17 ^c	42.39 ± 0.26 ^b	43.30 ± 0.29 ^a	43.58 ± 0.17 ^a	0.252	0.000
4	49.24 ± 0.26 ^c	50.12 ± 0.22 ^b	51.02 ± 0.15 ^a	50.64 ± 0.15 ^{ab}	0.195	0.000
5	57.82 ± 0.11 ^c	58.58 ± 0.17 ^b	59.21 ± 0.14 ^a	58.88 ± 0.09 ^{ab}	0.145	0.000
6	62.88 ± 0.12 ^c	63.16 ± 0.15 ^b	63.99 ± 0.14 ^a	63.84 ± 0.13 ^a	0.150	0.000

SEM- standard error mean, ^{abc}Means with different superscript in a row differ significantly (P<0.05).

Table 5: Effects of dietary Flavonoid (Quercetin) and vegetable oil supplementation on weekly feed conversion ratio (FCR) in broilers

Week	Treatment Group				SEM	P- Value
	T1	T2	T3	T4		
Weekly feed conversion ratio (FCR)						
2	1.56 ± 0.05	1.54 ± 0.09	1.47 ± 0.04	1.48 ± 0.03	0.029	0.665
3	1.73 ± 0.08	1.67 ± 0.03	1.72 ± 0.04	1.59 ± 0.05	0.028	0.325
Starter	1.64 ± 0.06	1.61 ± 0.04	1.60 ± 0.02	1.53 ± 0.03	0.022	0.409
4	2.14 ± 0.06 ^a	1.89 ± 0.08 ^b	1.94 ± 0.03 ^{ab}	1.92 ± 0.69 ^b	0.039	0.045
5	1.86 ± 0.03	1.74 ± 0.06	1.80 ± 0.03	1.77 ± 0.07	0.026	0.485
6	1.89 ± 0.01 ^{ab}	1.96 ± 0.10 ^a	1.74 ± 0.10 ^b	1.75 ± 0.02 ^b	0.035	0.058
Finisher	1.97 ± 0.03 ^a	1.86 ± 0.05 ^{ab}	1.82 ± 0.01 ^{ab}	1.81 ± 0.05 ^b	0.025	0.049

SEM- standard error mean, ^{ab}Means with different superscript in a row differ significantly (P<0.05).

was greater than that of total dietary fat, which might be responsible for increased in body internal fats and ultimate higher body weight in present study, because offered extra fat contained 62% saturated fatty acids (SFA). In contrarily, Ayed *et al.* (2015) found significantly lower body weight on energy dense diet in chicken and suggested substantial effect of fatty acid composition significantly affect the feed consumption of birds and thereby growth performance.

Feed conversion ratio

The findings of weekly feed conversion ratio (Table 5) was found comparable up to the starter phase, however major difference (P<0.05) was observed during finisher phase. Supplementation of Quercetin in combination with

vegetable oil (T4) performed better in respect to FCR in finisher phase.

Against the lower apparent feed intake there was increase in weight gain and growth rate on oil supplementation resulted in to the improvement of FCR. Energy sources provide an extra caloric effects (Aguar *et al.*, 2016), raised the net energy for utilization. Quercetin, as a flavonoid compound balancing a gut environment led to a better energy utilization efficiency.

CONCLUSION

It is concluded that inclusion of vegetable oil at 10% higher than recommendation level didn't have any impact on feed intake. Supplementation of flavonoid (Quercetin)

or vegetable oil or in combination of both exerted better growth performance in broiler birds. Moreover, Quercetin has potential to improve gut health, therefore along with vegetable oil supplementation in diet showed improvement in feed conversion ratio of broilers.

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