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Adeep Keshav
M.V.Sc Scholar, Department of Poultry Science, Veterinary college Hebbal, Bengaluru, Karnataka Veterinary Animal and Fisheries Sciences University, Karnataka, India

TN Krishnamurthy
Professor and Head, Department of Poultry Science, Veterinary college Hebbal, Bengaluru, Karnataka Veterinary Animal and Fisheries Sciences University, Karnataka, India

HC Indresh
Assistant Professor, Department of Poultry Science, Veterinary college Hebbal, Bengaluru, Karnataka Veterinary Animal and Fisheries Sciences University, India

D Ramesh
Assistant Professor, Department of Veterinary Physiology and Biochemistry, Veterinary College Hassan, Karnataka Veterinary Animal and Fisheries Sciences University, Karnataka, India

PL Dakshith
M.V.Sc scholar, Department of Poultry Science, Veterinary college Hebbal, Bengaluru, Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, Karnataka, India

Corresponding Author:
Adeep Keshav
M.V.Sc Scholar, Department of Poultry Science, Veterinary college Hebbal, Bengaluru, Karnataka Veterinary Animal and Fisheries Sciences University, Karnataka, India

Effect of exogenous emulsifier (Glycerol Polyethylene Glycol Ricinoleate) in energy reduced diet on growth performance in broilers

Adeep Keshav, Krishnamurthy TN, HC Indresh and Ramesh D

Abstract
A study investigated the impact of exogenous emulsifier in energy reduced diet on growth performance like body weight gain, feed intake, feed conversion ratio (FCR) and survivability in 128 Cobb broilers till the end of the experiment (42 days). The experiment included a control group (T_1) fed a standard diet prepared following Bureau of Indian Standards (2007) and three experimental groups receiving 350 ppm of exogenous emulsifier with energy reduced basal diet by - 60 kcal, - 90 kcal and - 120 kcal in T_2, T_3 and T_4 respectively. The results showed that there was a significant improvement in body weight and FCR during the experimental period and no significant difference was observed in feed intake and survivability.

Keywords: Broilers, exogenous emulsifier, growth performance, body weight, feed conversion ratio, feed intake, survivability

1. Introduction
Reducing feed expenses is a major concern for the poultry sector, especially in developing nations, as feed costs make up more than 70% of total production expenditures. This financial burden directly affects the sustainability of poultry farming. Creating a well-balanced and economical poultry feed requires meticulous ingredient selection to guarantee the appropriate proportions of vital nutrients.

In chickens, the small intestine is primarily responsible for fat digestion. With the aid of bile salts, lipases, deoxycholates, phospholipids and other agents. Fats and oils are broken down into diglycerides, monoglycerides and fatty acids. Fatty acids are absorbed as hydrophobic components after passing through the small intestine's liquid phase and aggregating to form micelles. Bile salts are examples of endogenous emulsifiers that naturally mediate this process. The natural emulsifiers are bile salts. Young chicks are unable to efficiently break down lipids during the first week after hatching because of insufficient bile and lipase secretion (Upadhaya *et al*., 2017) [17]. Dietary emulsifiers can help compensate for the gastro intestinal tract physiological incapacity to use dietary lipids efficiently. Emulsifiers are utilized to boost lipase activity during lipid hydrolysis and function as a catalyst to break down dietary fats (Upadhaya *et al*., 2018) [18]. Emulsifier usage also promotes the chick's lipase enzymatic activity during lipid digestion, improving the efficiency of lipid absorption.

Emulsifiers are surface-active substances that work on the interface between two immiscible media, such as water and oil (Tan *et al*., 2016) [14]. Animals dietary lipids are insoluble in the watery environment of their gastrointestinal tracts and must be broken down by the enzymes lipase and bile (Siyal *et al*., 2017) [15]. Emulsifiers work by raising fat molecules active surface area, which permits lipase to break down triglyceride molecules into monoglycerides and fatty acids.

Emulsion droplets, which create high levels of monoglycerides in the colon, induce the production of micelles, decrease surface tension and facilitate the nutrient transport through the membrane (Melegy *et al*., 2010) [11]. An emulsifier breaks the fat globules into small micelles, which are easily digested, absorbed and assimilate into the system, resulting in availability of extra metabolizable energy to the birds.

2. Materials and Methods

A study was conducted using one hundred and twenty-eight Cobb broiler chicks, aged one day, to explore methods for enhancing feed quality and maximizing the birds' genetic potential. Cobb broilers were specifically chosen due to their efficient feed conversion and genetic characteristics that could contribute to effective fat utilization. Following initial weighing, the chicks were randomly assigned to four experimental groups. Each group was then divided into four replicates, with eight chicks in each replicate. From hatch to six weeks old, the birds were raised in a deep litter system with unrestricted access to feed and water, and standard management practices were followed. The experiment adhered to the ethical guidelines established by the Institutional Animal Ethics Committee at KVAFSU, Bidar, Karnataka.

Based on the BIS-2007 guidelines, standard rations for broiler pre-starter, starter, and finisher phases were developed using common feed components. The experiment included a control group (T_1) fed a standard diet prepared following Bureau of Indian Standards (2007) and three experimental groups receiving 350 ppm of exogenous emulsifier with energy reduced basal diet by - 60 kcal, - 90 kcal and - 120 kcal in T_2, T_3 and T_4 respectively. This approach allowed for the evaluation of the potential to reduce feed cost and improvement in fat utilization in birds.

2.1 Growth performance

2.1.1 Body weight: Individual bird weights were measured weekly to track their growth rate. These measurements were taken in the early hours of the day before feeding. Cumulative body weights were recorded at weekly intervals throughout the trial, as well as at the end of the trial, to monitor the overall growth progress of the birds.

2.1.2 Feed intake: For each replicate, the average weekly cumulative feed consumption was recorded. Weekly feed consumption was calculated by subtracting the remaining feed from the total feed provided during the respective week. The leftover feed was then added to the feed consumption of the following week to obtain the cumulative feed consumption.

2.1.3 Feed conversion ratio (FCR): The feed conversion ratio (FCR) expressed as the ratio between the quantities of feed consumed (kg) to the body weight gain (kg) under each treatment of birds was determined. To calculate the FCR for a weekly period, you divide the average amount of feed consumed per bird during the week by the average weight gain per bird during the same week. For the cumulative FCR, you divide the average amount of feed consumed per bird at the end of the trial period by the average weight gain per bird at the end of the trial period.

2.1.4 Survivability

Survivability in respective group was recorded as and when the birds died mortality percentage in each treatment during the course of the experiment was recorded. The dead birds were subjected to detailed post-mortem examination to ascertain the cause of death. To determine the survivability percentage, multiply the number of birds that survived by 100, and then divide the result by the total number of birds housed at the beginning of the period.

2.2 Statistical evaluation

The study employed a completely randomized design (CRD) with a one-way analysis approach. Data for different parameters from the biological trial were analysed according to the standard methods detailed. Statistical analysis was performed using SPSS 20 software. Differences among treatment groups were evaluated using Tukey's Range Test, with a significance level of $p \leq 0.05$.

3. Results

3.1 Body weight: Throughout the six-week study, there were notable differences in the average body weights of chicks among various treatments. Treatments T_2, T_3, and T_4 consistently exhibited significantly higher body weights compared to T_1 at the end of each week. However, there were no significant differences observed among treatments T_2, T_3, and T_4 themselves. This trend continued until the end of the study, with treatments T_2, T_3, and T_4 consistently showing higher body weights than T_1, while no significant differences were found among T_2, T_3, and T_4.

Table 1: Body weight

Treatments	Weeks					
	I	II	III	IV	V	VI
T_1	168.34±2.32^b	440.94±9.90^b	924.38±24.84^b	1452.81±22.54^b	1904.38±38.21^b	2295.63±39.47^b
T_2	199.09± 2.99^a	481.56± 9.92^a	1018.75±14.55^a	1635.94±27.81^a	2057.19±38.48^a	2473.09±38.08^a
T_3	194.28 ± 3.70^a	481.56± 8.57^a	1016.88±21.70^a	1674.06±27.66^a	2060.00±39.09^a	2536.56±48.64^a
T_4	190.44 ± 4.13^a	483.13± 10.31^a	1047.63±20.86^a	1667.66±35.08^a	2060.94±42.86^a	2554.69±36.94^a

3.2 Feed intake

Over the six-week period, there were variations in the average feed intake among different treatments. In the first week, treatments T_2, T_3, and T_4 showed significantly higher feed intake compared to T_1. However, there were no significant differences among T_2, T_3, and T_4 themselves.

From the second to the sixth week, although there were fluctuations in feed intake among treatments, statistical analysis did not reveal any significant differences among them. Despite some variations, no treatment consistently showed significantly higher or lower feed intake compared to others throughout the study.

Table 2: Feed intake

Treatments	Weeks					
	I	II	III	IV	V	VI
T_1	136.17±2.33^b	492.75±20.98	1234.29±35.84	2177.43±14.06	3241.94±76.73	4099.23±92.31
T_2	171.99± 2.32^a	528.39± 7.03	1300.16±24.00	2233.30±28.89	3228.32±49.49	4157.43±81.57
T_3	165.08± 7.30^a	528.91±4.22	1255.53±35.11	2266.37±65.42	3219.02±72.01	4183.79±52.28
T_4	161.66± 7.74^a	533.74± 11.38	1295.44±40.86	2253.7±40.57	3214.25±39.28	4214.47±32.32

3.3 Feed conversion ratio (FCR)

In the first two weeks, there were no significant differences in feed conversion ratio (FCR) among treatments T_1, T_2, T_3, and T_4. However, by the end of the third week, significant differences emerged. Treatments T_3 and T_4 showed significantly better FCR values compared to the control group (T_1). Additionally, there were no significant differences among treatments T_2, T_3, and T_4, nor between T_1 and T_2.

By the fourth week, significant differences in FCR were observed among treatments. T_2, T_3, and T_4 exhibited significantly better FCR values compared to T_1. Furthermore, T_3 and T_4 showed significantly better FCR than T_2 and T_2 performed significantly better than T_1. However, no significant differences were found between T_3 and T_4.

Table 3: Feed conversion ratio

Treatments	WEEK					
	I	II	III	IV	V	VI
T_1	1.122± 0.001	1.206±0.009	1.408± 0.001^{a}	1.552±0.001^{a}	1.744±0.005^{a}	1.822±0.009^{a}
T_2	1.120± 0.004	1.212± 0.005	1.336±0.002^{ab}	1.404±0.005^{b}	1.612±0.005^{b}	1.713±0.009^{b}
T_3	1.122± 0.004	1.218± 0.007	1.294± 0.002^{b}	1.393±0.006^{b}	1.599±0.001^{b}	1.680±0.004^{c}
T_4	1.112±0.003	1.221± 0.008	1.292± 0.002^{b}	1.391±0.006^{b}	1.596±0.005 ^{b}	1.680±0.005^{c}

3.4 Survivability

The survivability or liveability (%) values were 100% in all groups T_1, T_2, T_3 and T_4, respectively.

4. Discussion

The findings of the present results were in agreement with Roy *et al*. (2010) [13] who conducted a study to evaluate the impact of an external emulsifier, glyceryl polyethylene glycol ricinoleate. The researchers added the emulsifier to the diet at varying dose rates: 0% (control), 1% and 2% of added fat, specifically saturated palm oil. This study highlighted that supplementing diets containing moderate levels of added vegetable fats with exogenous emulsifiers had improved broiler average weight gain.

The findings of the present results were in agreement with Kaczmarek *et al*. (2015) [9] they studied the effect of glyceryl polyethylene glycol ricinoleate on nutrient utilization and the performance of broiler chickens. Birds that were fed diets supplemented with glyceryl polyethylene glycol ricinoleate showed significantly higher body weight gain compared to chickens that received diets without glyceryl polyethylene glycol ricinoleate. This may be due to that glyceryl polyethylene glycol ricinoleate may enhance the absorption and utilization of nutrients from the diet. This can lead to better growth rates and increased body weight gain in broiler chickens.

The findings of the present results were in agreement with An *et al*. (2020) [3] they studied the impact of exogenous emulsifier supplementation at concentrations of 0.1% and 0.2% on the growth performance. Their findings indicated that the inclusion of 0.1% exogenous emulsifier in broiler feed led to significant improvement in body weight gain.

The findings of present results were in disagreement with Patra *et al*. (2011) [12] they conducted an eight-week trial to investigate the effects of various fat sources supplemented with an external emulsifier (lecithin) on the performance of Khaki campbell ducks. The ducks were provided with a basal diet containing 3% soybean oil without emulsifier, 3% palm oil without emulsifier, 3% soybean oil with emulsifier, 3% palm oil with emulsifier and 3% lard with emulsifier. The researchers concluded that supplementing lecithin as an emulsifier to diets containing different fat sources did not have a significant influence on body weight of Khaki campbell ducks.

The findings of present results were in disagreement with Cho *et al*. (2012) [6] they carried out an experiment aiming to assess the impact of an emulsifier and a multi-enzyme blend containing α-galactosidase, galactomannase, xylanase and β-glucanase in various energy density diets on growth performance in broiler chickens. Their findings suggested that the inclusion of both the emulsifier and multi-enzyme in low-density diets resulted in non- significant improvement in average body weight.

The findings of the present results were in agreement with Aguilar *et al*. (2013) [2] they conducted a study on the growth performance of broiler chicks, by feeding three levels of metabolizable energy in the diets: 12.13 MJ/kg (starter) and 12.80 MJ/kg (finisher) (T_1); 12.38 MJ/kg (starter) and 13.05 MJ/kg (finisher) (T_2); 12.64 MJ/kg (starter) and 13.51 MJ/kg (finisher) (T_3). The group receiving supplementation of an exogenous emulsifier with a liquid dose of 0.5 g/ton on diets (T_4), having the same ingredients and contributions as T_1. The study observed that feed intake were not significantly affected by the experimental diets during any of the experimental periods.

The findings of the present results were in agreement with Abbas *et al*. (2016) [1] they conducted an experiment in broiler chickens. The experimental diets were formulated with 1%, 2% or 3% fat, both with and without the inclusion of a fat emulsifier (Lecithin) at a rate of 350 mg/kg. The findings indicated that feed intake remained unaffected by the presence of fat or the fat emulsifier.

The findings of the present results were in agreement with Srinivasan *et al*. (2020) [16] they investigated the impact of crude soya oil and an emulsifier in the diet on the production performance of broilers. The first group (T_1) was fed a basal diet with crude soya oil as the energy source, the second group (T_2) received the basal diet supplemented with a fat emulsifier at a rate of 250 grams per metric tonne of feed, and the third group (T_3) had an 80 kcal reduction in energy from the basal diet with emulsifier added at the rate of 250 grams per metric tonne of feed. Their findings on cumulative feed intake suggested that, by the 6th week of age, there was no significant difference in feed intake among the treatment groups.

The findings of the present results were in disagreement with Melegy *et al*. (2010) [11] they examined the effects of dietary fortification with a natural biosurfactant on broiler performance. Group I, Group II, the positive control, was fed the basal diet recommended by the breed catalogue without lysophospholipid. Groups III and IV were provided with the negative control diet, but supplemented with lysophospholipid at rates of 250 g and 500 g per ton of feed, respectively. Their findings indicated that Group I, the negative control lacking the lysophospholipid, exhibited significantly higher feed

intake compared to both the positive control and the lysophospholipid supplemented groups.

The findings of the present results were in disagreement with Kulkarni *et al*. (2019) [10] they assessed the effects of two emulsifiers, Orffa energizer-01 (OE1) and Orffa energizer-02 (OE2), in diets containing two distinct oil sources, namely soybean oil and rice bran oil, on the performance of broiler chicks over a six-week period. Their findings indicated that, the feed intake remained comparable among different treatment groups during the starting phase (0-3 weeks). However, a notable increase in feed intake was observed during the finishing phase (3-6 weeks).

The findings of the present results were in agreement with Kaczmarek *et al*. (2015) [9] they conducted a study using a glyceryl polyethylene glycol ricinoleate on performance of broiler chickens. Birds that were fed diets supplemented with glyceryl polyethylene glycol ricinoleate showed significantly better feed conversion ratio (FCR) compared to chickens that received diets without glyceryl polyethylene glycol ricinoleate.

The findings of the present results were in agreement with Dabbou *et al*. (2019) [7] they conducted a trial involving broiler a basal diet supplemented with 0.05% Globin a natural emulsifier. Their findings revealed that the inclusion of Globin provided significantly better feed conversion ratio (FCR).

The findings of the present results were in agreement with An *et al*. (2020) [3] they conducted an experiment to investigate the impact of exogenous emulsifier supplementation at concentrations of 0.1% and 0.2% on the growth performance in broiler chicks. Their findings indicated that the inclusion of 0.1% exogenous emulsifier in broiler feed led to significant improvement in feed conversion ratio (FCR).

According to Kaczmarek *et al*. (2015) [9] this may be due to that glyceryl polyethylene glycol ricinoleate may enhance the absorption and utilization of nutrients from the diet. This can lead to better growth rates and increased body weight gain in broiler chickens which in turn enhances the feed efficiency.

The findings of the present results were in disagreement with Azman *et al*. (2004) [4] they conducted a study examining the effects of substituting soybean lecithin for either soybean oil or beef tallow in broiler diets concerning growth performance. The diets fed at the rates of 0% (control group), 25% (soyabean lecithin 1 group), and 50% (soyabean lecithin 2 group). Additionally, another group received a dietary fat mixture comprising 50% beef tallow and 50% soyabean lecithin. There was no significant enhancement in food conversion ratio in lecithin added group compared to other groups.

The findings of the present results were in disagreement with Guerreiro Neto *et al*. (2011) [8] they investigated that there was no significant effect of the interaction between fat and fat emulsifier on overall feed conversion ratio (FCR) in broilers.

The findings of the present result were in agreement with Aguilar *et al*. (2013) [2] they conducted a study on the growth performance of broiler chicks, by feeding three levels of metabolizable energy in the diets: 12.13 MJ/kg (starter) and 12.80 MJ/kg (finisher) (T_1); 12.38 MJ/kg (starter) and 13.05 MJ/kg (finisher) (T_2); 12.64 MJ/kg (starter) and 13.51 MJ/kg (finisher) (T_3). The group receiving supplementation of an exogenous emulsifier with a liquid dose of 0.5 g/ton on diets (T_4), having the same ingredients and contributions as T_1. Their findings showed that survivability were not affected by the experimental diets in any experimental period.

The findings of the present result were in agreement with Zampiga *et al*. (2016) [19] they conducted an experiment to assess the productive performance of broiler chickens provided with diets supplemented with an exogenous emulsifier derived from lysophospholipids, obtained through the enzymatic conversion of soy lecithin. At the conclusion of the 42-day trial, birds that received the emulsifier exhibited no significant difference in survivability among different groups.

The findings of the present result were in disagreement with Melegy *et al*. (2010) [11] they examined the effects of dietary fortification with a natural biosurfactant on broiler performance. Group I, Group II, the positive control, was fed the basal diet recommended by the breed catalogue without lysophospholipid. Groups III and IV were provided with the negative control diet, but supplemented with lysophospholipid at rates of 250 g and 500 g per ton of feed, respectively. Their findings showed that the negative control had a significant higher survivability compared to the lysolecithin supplemented groups.

5. Conclusion

The interpretation of the findings led to the following conclusion. Inclusion of 350 ppm of exogenous emulsifier (Glycerol Polyethylene Glycol Ricinoleate) to the basal diet with energy reduced by 60 kcal, 90 kcal and 120 kcal resulted in significant improvement in body weight and feed efficiency whereas feed intake and survivability showed no significant difference among different treatment groups compared to control group at the end of the experiment (42nd day).

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