



Comparative efficacy of synthetic and herbal emulsifiers in broiler chicken fed energy-restricted diet

AJIT SHEKHAR¹, PANKAJ KUMAR SINGH^{1✉}, KAUSHALENDRA KUMAR¹, SANJAY KUMAR¹,
PRAMOD KUMAR¹ and BHASKAR GANGULY²

Bihar Animal Science University, Patna, Bihar 800 014 India

Received: 22 October 2022; Accepted: 6 April 2023

ABSTRACT

The digestive system of young birds is very poor and inefficient in digestion and absorption of fat due to less lipase production and low rate of bile formation, which can be overcome by the use of exogenous emulsifier. This study aimed to evaluate the comparative efficacy of exogenous herbal and synthetic emulsifiers on growth performance, nutrients utilization, haemato-biochemical profile, and carcass quality in broiler chickens fed energy restricted diet during a 35-days feeding trial. 180 one day-old Cobb400Y chicks were assigned into four treatment groups, each with three replicates. T0(control) received a basal diet without emulsifier, group T1 received a basal diet with 3% less metabolizable energy, group T2 received a basal diet with 3% less metabolizable energy + synthetic emulsifier @250 g/tonne of feed and group T3 received a basal diet with 3% less metabolizable energy + herbal emulsifier @ 250 g/tonne of feed. Supplementation of exogenous emulsifier enhanced growth performance and economics of broiler chicken. There was no significant effect of exogenous emulsifiers on dry matter, crude protein, calcium and phosphorus retention in broiler chickens, however, retention of ether extract improved significantly. Haematological parameters, carcass characteristics and overall acceptability of meat of broiler chicken fed diets supplemented with emulsifiers in energy restricted diets didn't differ. Emulsifier supplementation didn't change villi length and crypt depth. It was concluded that decrease in 3% metabolizable energy of broiler chicken diet depressed growth performance and economics of broiler chicken whereas, dietary supplementation of emulsifier @ 250 g/tonne of energy restricted based broiler feed improved the growth performance, ether extract utilization, intestinal morphology and economics without affecting haemato-biochemical profile, and carcass quality of broiler chickens.

Keywords: Broiler, Carcass, Emulsifier, Growth, Haemato-biochemical

Poultry diets are usually required to supply high nutrient and energy concentrations in order to meet the nutrient requirements of modern intensively reared birds. Commercial poultry feeds are frequently added with fats and oils to fulfill the energy requirements of poultry and to give high energy to support the growth performance (Blanch *et al.* 1996). Dietary fats and oils offer 2.25 times more energy than carbohydrate and they are also supplier of essential fatty acids and fat soluble vitamins. In recent years, due to the increased feed costs, there is greater interest in maximizing the use of fats to increase the dietary energy concentration to fulfill the necessities of high-performing birds. It has been reported that fat absorption increases with bird age, as young broilers have a physiological inadequacy to absorb that nutrient (Kussabati *et al.* 1982). The young birds are not able to absorb fat efficiently, which attributes to its less production of natural lipase, low rates

of bile formation and poor emulsification ability; however, these biological processes improve with the age and adapt to cope with higher unsaturated fatty acids (Meng *et al.* 2004). Such physiological boundaries of the digestive system of poultry can be conquered through the use of exogenous emulsifier.

Commercial exogenous emulsifiers which are usually used in the feed industry can be categorized into two groups, viz. natural emulsifier and synthetic emulsifiers. Natural emulsifier ones are those produced in the animal body such as bile and phospholipids, and those from food materials such as soylécithin, whereas synthetic emulsifiers are modified emulsifiers such as lysolécithin or lysophosphatidylcholine (Zhang *et al.* 2011). Herbal emulsifiers like soylécithin obtained from soyabean cause absorption of fatty acids into micelles and improves fat digestion in chicks, resulting in improved growth performance and decrease in LDL level in broiler chicken (Siyal *et al.* 2017). Lecithin structure contains choline which is also effective in preventing perosis in birds (Schaible 1970). Similarly, exogenous supply of synthetic emulsifiers like polyethylene glycol mono and dioleates and sodium stearoyl-2-lactylate

Present address: ¹Department of Animal Nutrition, Bihar Veterinary College, Bihar Animal Science University, Patna, Bihar. ²Research and Development Unit, Ayurvet Limited, Baddi, Himachal Pradesh. ✉Corresponding author email: vetpank@gmail.com

in poultry diets improve body weight, feed intake and utilization efficiency of fat, protein and metabolisable energy (Roy *et al.* 2010). There are very few reports on comparative efficacy of herbal and synthetic emulsifiers in poultry. The present experiment was, therefore, conducted to study the comparative efficacy of herbal and synthetic emulsifier on growth performance, nutrients utilization, haemato-biochemical profile, and carcass quality in broiler chicken.

MATERIALS AND METHODS

Experimental birds and management: This study aimed to evaluate the efficacy of herbal exogenous emulsifiers (AV/PFE/15, M/s Ayurvvet Limited, India) in comparison to synthetic emulsifier on growth performance, nutrients utilization, haemato-biochemical profile, and carcass quality in broiler chickens fed energy restricted diet during a 35-days feeding trial. 180 one day-old Cobb 400Y broiler chicks were used for study. This study has been approved by the Institutional Animal Ethical Committee (IAEC) of Bihar Veterinary College, Bihar Animal Sciences University, Patna, India, vide proposal No. IAEC/BVC/21/09 and performed in accordance with the ethical standard laid down. The brooder house and equipment were thoroughly disinfected, before the arrival of the chicks. All the standard managemental practices were followed during experimental period including vaccination schedule. The chicks were raised in a deep litter system. The lighting pattern in the first week was 23 h light: 1 h dark and then 2 h of darkness and 22 h light up to the end of the experiment. Chicks had *ad lib.* access to feed and water throughout the feeding trial. All diets were formulated to meet the requirements for the energy, protein, calcium, and phosphorus that have been established for broiler chicken as per Bureau of Indian Standards (BIS 2007). Feeding was done in three phased manner, viz. Pre-starter (0-7 days), Starter (8-21 days), Finisher (22-35 days). The representative samples of feed were analyzed for proximate principles (AOAC 2007), phosphorus, and calcium (Talapatra *et al.* 1940). The composition of the basal diet and the nutrient composition of the feed ingredients are shown in Table 1.

Experimental design: Chicks were individually weighed, wing banded and randomly allotted to either of four treatment groups. Each treatment group consisted of three replicates of 15 chicks. T0 (control) received a basal diet without emulsifier, group, T1 received a basal diet with 3% less metabolizable energy (ME), group T2 received a basal diet with 3% less ME + synthetic emulsifier @ 250 g/tonne of feed and group T3 received a basal diet with 3% less ME + herbal emulsifier @ 250 g/tonne of feed. The representative samples of pre-starter, starter and finisher feed of broiler were analyzed for proximate principles (AOAC 2007), phosphorus, and calcium (Talapatra *et al.* 1940).

Growth performance: Performance parameters such as body weight (BW), feed intake (FI) recorded and feed

Table 1. Ingredient and nutrient composition of experimental ration as fed basis

Ingredient (kg/tonne of feed)	0-7 days		8-21 days		22-35 days	
	T0	T1	T0	T1	T0	T1
Maize	587	535	645	607	687	647
Soybean meal	310	300	240	230	204	195
Mustard deoiled cake	15	15	20	20	18	20
Maize gluten meal	20	20	20	20	25	25
Rice polish	14.95	17.85	18.6	20.4	14.5	51.2
Deoiled rice bran	0	59	0	54	0	18
Soybean oil	7	7	15	7	15	7
Common salt	2.2	2.2	1.8	1.8	1.5	1.5
Monocalcium Phosphate	10.2	10.2	7.8	7.8	6.3	6.3
Limestone	16.4	16.4	15.2	15.2	12.6	12.6
Additives and Supplements ¥	6.95	6.95	6.95	6.95	6.95	6.95
Total	1000	1000	1000	1000	1000	1000
<i>Chemical composition (% dry matter basis)</i>						
Dry matter (%)	90.18	90.14	90.18	90.22	90.26	90.28
Crude protein (%)	23.02	22.96	21.68	21.72	20.41	20.57
Ether extract (%)	3.47	3.41	4.78	4.03	4.84	4.41
Crude fiber (%)	4.54	5.24	4.38	5.03	4.32	4.79
Metabolizable energy (kcal/kg)*	3002	2908	3103	2992	3165	3073
Total ash (%)	5.05	5.94	4.59	5.40	4.42	4.14
Calcium (%)	1.11	1.11	1.01	1.02	1.01	0.99
Total phosphorus (%)	0.79	0.80	0.72	0.73	0.68	0.70
Available phosphorus (%)*	0.55	0.56	0.49	0.49	0.45	0.45
Lysine (%)*	1.61	1.60	1.43	1.44	1.34	1.34
Methionine (%)*	0.66	0.67	0.59	0.59	0.54	0.54
Feed cost per kg (₹)*	33.52	32.78	32.00	29.77	30.38	28.91

*Calculated values; ¥ Additives and supplements (kg/tonne of feed): Vitamin premix-0.5, Trace mineral premix-0.5, Liver tonic-0.5, Choline chloride-0.9, Toxin binder-1.0, Sodium bicarbonate-2.4, Coccidiostat-0.5, Fiber degrading enzyme-0.5, Phytase enzyme-0.15.

conversion ratio (FCR) and feeding economics were calculated. Mortality and bird's health status were observed daily and overall mortality percentage was calculated at the end of experiment.

Metabolic trial: A metabolism trial was conducted after the feeding trial ended. Two birds from each replicate were transferred to metabolism cages and placed there for 7 days including a collection period of 5 days. During the metabolism trial, the amount of feed offered and that of the residue left were measured in replicate wise. The total amount of excreta obtained in a 24 h period was weighed and put in zipped polyethylene sachets. The excreta were manually mixed and a sub sample measuring 1/5th of the total excreta volume was kept daily in a hot air oven at

80°C for 16 h to determine the dry matter, and dried excreta was stored in replicate wise for analysis of nutrients. Another sub sample measuring 1/10th of the total excreta was collected in plastic containers for 5 days, pooled in replicate wise and frozen at -20°C until analysis of crude proteins (CP). The representative samples of feed offered to broiler and excreta obtained during metabolism trial were analyzed for proximate principles (AOAC 2007), phosphorus, and calcium (Talapatra *et al.* 1940).

Haematological and biochemical analyses: Blood samples were collected from six experimental birds of each group i.e. two broiler chicks from each replicate on 35th days of experimental feeding for haematological analysis. Blood samples were collected with and without anticoagulants. Haematological analysis, viz. haemoglobin (Hb), packed cell volume (PCV), Total Erythrocyte Count (TEC), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH) were determined in whole blood samples of chicken in different experimental groups following standard methods as described by Weiss and Wardrop (2011). The serum was separated by centrifuging blood at 2500 rpm for 10 min (Remi Research Centrifuge, Model R8C, Remi Research Laboratories Mumbai, India) and harvested into polystyrene tubes and stored at -20°C until performing the serum biochemical analysis. Glucose, total cholesterol (CHO), high-density lipoprotein cholesterol (HDL), triglycerides (TGs), alkaline phosphatase (ALP), and aspartate aminotransferase (AST), concentration were determined in serum using a diagnostic kit (Span Diagnostic Ltd., Bengaluru- 560003, India). For the estimation of alanine transaminase (ALT), 4 - DNPH method of Reitman and Frankel (1957) was used. Total protein and albumin concentration in serum was estimated by biuret method (Johnson *et al.*, 1999). The serum albumin content was subtracted from serum total protein content to calculate globulin:

$$\text{Globulin (g/dl)} = \text{Total protein (g/dL)} - \text{Albumin (g/dL)}.$$

Serum low density lipoprotein (LDL) cholesterol was calculated by using the formula:

$$\text{LDL cholesterol} = \text{Total cholesterol} - \text{HDL cholesterol} - \text{triglyceride LDL}.$$

Serum catalase activity was estimated spectrophotometrically as per the method described by Cohen *et al.* (1970). Lipid peroxidation was measured by determining the malondialdehyde (MDA) production using thiobarbituric acid (TBA) as per method given by Suleiman *et al.* (1996). Reduced glutathione (GSH) level was estimated using the method described by Lin *et al.* (1988). Serum superoxide dismutase (SOD) activity was measured using the method as given by Madesh and Balasubramanian (1998).

Carcass characteristics: At the end of the experiment on 35th day, two representative birds from each replicate were sacrificed for evaluation of carcass characteristics and sensory evaluation. The birds were sacrificed after an

overnight fast by decapitation, and processed for carcass characteristics. Birds were scalded, defeathered and eviscerated. Weight of the carcass was recorded as dressed yield by the formula:

$$\text{Dressing yield} = \text{live weight} - (\text{weight loss as blood, feathers, head, shank and viscera}).$$

The weight of different cut up parts, viz. thigh, breast, drumstick, back, neck and wings were recorded by separating them from carcass and expressed as a percentage. The sensory quality of cooked meat samples was evaluated by the standard sensory evaluation method (Keeton and Foegeding 1984). A sensory panel (semi trained) of eight judges drawn from post graduate students and teaching staff were requested to evaluate the meat sample for different sensory attributes, viz. appearance, flavour, texture, juiciness and overall acceptability. The samples were coded and presented in random order and panelists were asked to rate their unbiased assessment of color, taste, texture and overall acceptability on a 9-point hedonic scale. A score of 5 was considered a limit of acceptability for all sensory attributes tested.

Intestinal histomorphology: On day 35, a section of mid-jejunum was collected from birds (9 birds per treatment) directly after slaughter and fixed in 10% neutralized formalin three birds per cage. Fixed intestinal samples were dehydrated with graded ethanol solutions (50, 70, 80, 95, and 100%), cleared with xylene, and embedded in paraffin. Histological slides were prepared from 3 cross-sections (4 µm thick) of each intestinal sample and stained with hematoxylin and eosin. The villus height was measured from the villus tip to the valley between individual villus. The crypt depth and width was measured from the valley between individual villus to the basolateral membrane. The 3 longest and straightest villi and associated crypts were measured from each segment (Xu *et al.* 2003). The height of villi and their associated crypts were measured using a camera fitted in an inverted microscope. Two measurements of villus height (VH) and crypt depth (CD) were made from each slide, and the average value of these measurements was used for statistical analysis. The ratio of villus height: crypt depth (VH:CD) for each replicate was calculated from the average measurement.

Statistical analysis: The experimental data obtained were analyzed statistically (Snedecor and Cochran 1994) as a completely randomized design by analysis of variance (ANOVA) by using general linear model (GLM) procedure of statistical package for the social sciences (SPSS). Differences between the means of treatments were compared using Duncan's Multiple Range Test (Kramer 1957). Statistical significance was declared at $p < 0.05$.

RESULTS AND DISCUSSION

This study aimed to evaluate the efficacy of herbal exogenous emulsifiers on growth performance, nutrients utilization, haemato-biochemical profile, and carcass quality in broiler fed energy-restricted diet during a 35-days feeding trial. The effects of synthetic and herbal emulsifier

Table 2. Effect of synthetic and herbal feed emulsifiers on growth performance and nutrient utilization of broiler chicken

Parameter	T0	T1	T2	T3	SEm	p-value
Growth performance (0-35 days)						
Body weight gain (g)	1925.53 ^c ±16.32	1681.00 ^a ±14.04	1801.43 ^b ±12.25	1823.93 ^b ±13.22	26.89	0.001
Feed intake (g)	3084.04 ^b ±17.27	3239.33 ^c ±20.64	2995.13 ^a ±25.84	3037.10 ^{ab} ±11.77	29.07	0.001
FCR	1.60 ^a ±0.017	1.92 ^b ±0.031	1.66 ^a ±0.043	1.66 ^a ±0.027	0.040	0.001
Mortality (%)	4.44	0	2.22	2.22		----
Feed cost (₹/ kg weight gain)	49.85	56.84	49.13	49.19		---
Nutrients utilization						
Dry matter (%)	74.28±2.40	70.62±1.15	72.72±1.60	73.60±1.32	0.83	0.489
CP (%)	64.77±3.19	63.55±2.72	64.78±3.00	65.60±1.52	2.41	0.828
EE (%)	76.66±0.93	73.34±0.68	75.93±0.90	75.44 ^{ab} ±0.69	0.47	0.041
Calcium (%)	17.06±0.58	16.74±0.14	16.76±0.17	18.03±0.48	0.23	0.147
Phosphorus (%)	14.40±0.80	10.63±1.65	11.12±0.60	13.53±1.30	0.69	0.139

^{a,b,c} Mean values with different superscripts within a row differ significantly ($p < 0.05$).

on production traits, viz. body weight (BW), feed intake (FI), feed conversion ratio (FCR), mortality, and feed economics of broiler chicken are shown in Table 2.

The final body weight was significantly ($p < 0.05$) higher in T2 (synthetic emulsifier) and T3 (herbal emulsifier) as compared to T1 (3% less ME), but significantly lower than the T0 (control). Feed intake was significantly higher in T1 followed by T0, T3 and T2. The FCR was not differed significantly between T0, T2 and T3 groups. FCR was significantly increased in T2 and T3 as compared to T1. Mortality percent was differed non-significantly ($p > 0.05$) among the all groups.

Results of the experiment revealed that decrease in dietary ME decreased growth performance in terms of body weight gain, feed conversion ratio and performance index as compared to control. After adding the synthetic emulsifier or herbal emulsifier, the performance index of the broiler chicken improved. This agrees with Tikare *et al.* (2021) and Gole *et al.* (2022) who reported that addition of

emulsifier in broiler diets improved body weight gain during starter and finisher phase. Kaczmarek *et al.* (2015) found that glyceryl polyethyleneglycol ricinoleate addition was characterized by higher body weight gain and lower feed conversion ratio in chickens compared to receiving diets without GPR. Hu *et al.* (2019) evaluated supplementation of emulsifier in soybean and poultry fat based diet in Cherry Valley ducks and reported that emulsifier improved growth performance in negative control diets. The main function of adding emulsifier in feed is to promote emulsification of fat, production of bile acid and generation of lipase in the digestive tract of poultry, which promote the maximum utilization of oil by the birds (Allahyari-Bake and Jahanian 2017, Zhao and Kim 2017, Bontempo *et al.* 2018). Exogenous emulsifiers are capable of improving fat digestibility and subsequently sustaining or enhancing the growth performance of broiler chickens fed a low energy diet (Wickramasuriya *et al.* 2020).

There was no significant effect of exogenous emulsifiers

Table 3. Effect of synthetic and herbal feed emulsifiers on haemato-biochemical parameters of broiler chicken at 35 days of age

Parameter	T0	T1	T2	T3	SEm	p-value
Haemoglobin (g/dL)	8.44±0.12	8.33±0.16	8.46±0.05	8.46±0.14	0.13	0.280
Packed cell volume (%)	25.35±0.24	25.03±0.37	25.10± 0.38	25.08±0.30	0.15	0.905
TEC (million/mm ³)	2.25±0.029	2.24±0.018	2.27±0.026	2.28±0.015	0.011	0.641
Glucose (mg/dL)	249.15±1.19	245.20±0.82	244.16±1.89	246.91±2.34	0.87	0.197
Total protein (g/dL)	4.10±0.046	4.01±0.053	4.01±0.068	4.08±0.027	0.025	0.491
Albumin (g/dL)	3.13±0.021	3.17±0.069	3.22±0.025	3.28±0.067	0.026	0.238
Globulin (g/dL)	1.83±0.025	1.77±0.022	1.80±0.025	1.82±0.026	0.012	0.322
Total cholesterol (mg/dL)	149.44±1.55	146.18±0.57	147.33±1.73	146.00±0.67	0.63	0.291
Triglyceride (mg/dL)	89.59±0.609	88.69±0.545	90.89±0.773	90.55±0.503	0.339	0.081
HDL (mg/dL)	99.25±0.59	99.68±0.72	99.61±0.17	99.38±0.64	0.280	0.606
LDL (mg/dL)	35.64±0.94	35.15±0.74	36.26±1.24	35.69±0.69	0.435	0.987
ALT (IU/L)	28.46±1.30	28.37±1.15	26.87±1.10	27.42±1.50	1.37	0.126
AST (IU/L)	167.87±1.00	168.00±1.31	171.51±1.69	170.50±1.53	0.73	0.205
ALP (IU/L)	216.82±0.87	213.37±3.42	217.94±1.53	214.87±0.92	0.99	0.392
GSH (U/mL)	251.0±11.78	249.6±4.25	255.0±14.43	257.0±5.77	4.34	0.948
CAT (U/mL)	2.39±.075	2.19±.058	2.31±.057	2.31±.037	0.032	0.197
SOD (U/mL)	421.33±1.76	415.33±3.17	415.66±1.45	412.33±5.92	1.80	0.397

on dry matter, crude protein, calcium and phosphorus retention in broiler chickens, however, retention of ether extract improved significantly in T0, T2 and T3 as compared to T1 (Table 2). Emulsifier helps in digestion and utilization of dietary fat in broiler chicken. Improved utilization of ether extract in the emulsifier supplemented birds indicated positive effects of the emulsifier on digestion and absorption of fat in broiler chicken. Similar response in ether extract retention indicated that herbal and synthetic emulsifier was equally effective in utilization of fat in broiler chickens. Results of this study are in agreement with Huang *et al.* (2007), Kim *et al.* (2008) and Zampiga *et al.* (2016). Polin and Hussein (1982) observed an increase in lipid retention in 7 day-old broiler chicks when bile salts (sodium taurocholate at 0.4%) was incorporated in the diets, whereas the absence of bile salt supplementation reduced fat utilization up to 25% as seven days of age. Huang *et al.* (2007) observed significant effect of soy-lecithin as emulsifier on utilization of ether extract in broiler chicken during 42 days research trial.

The hematological examination and serum biochemical analysis of collected samples from experimental groups showed non-significant difference among all treated groups (Table 3).

No significant change in haematological parameters indicated that emulsifiers didn't exert any harmful effects on broiler chicken. Results of haematological parameters are in agreement with the result of Cho *et al.* (2012). There was no significant difference in the biochemical parameters, viz. serum glucose, total protein, albumin, globulin cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL), low-density lipoprotein (LDL), alanine

aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), glutathione peroxidase (GSH), superoxide dismutase (SOD) and catalase (CAT) level due to supplementation of exogenous emulsifiers among different treatment groups. In corroboration of the result of the present study, Wickramasuriya *et al.* (2020) reported that emulsifier supplementation did not affect the blood metabolites of broiler chickens. However, Roy *et al.* (2010) observed that supplemental emulsifier had variable effects on serum metabolites.

All relative carcass characteristics (Table 4) except abdominal fat per cent were not influenced by the dietary treatments. There was significant difference in abdominal fat percent among different dietary treatments. Birds fed diet having optimum energy (T0) had highest abdominal fat percent; whereas birds fed energy restricted diet (T1) had lowest percent. These results are in agreement with the findings of Cho *et al.* (2012). Similarly, Aguilar *et al.* (2013) recorded that the feeding of exogenous emulsifier to the broiler feed did not influence the carcass traits. Abbas *et al.* (2016) found that fat emulsifier supplementation did not affect ($p>0.05$) liver, spleen and gizzard weight. In the current study, no differences ($p>0.05$) were found in the weight of the spleen and other organs among different treatments indicating that none of the emulsifiers had an immunosuppressive effect on broilers. Dietary treatments didn't affect appearance, flavor, tenderness, juiciness and overall acceptability (Table 4) of meat of broiler chicken fed diets supplemented with synthetic or herbal exogenous emulsifier.

Villi height (Table 4) was highest in positive control and lowest in negative control, decreased villi height ($p < 0.05$)

Table 4. Effect of synthetic and herbal feed emulsifiers on carcass characteristics and intestinal morphology of broiler chicken

Parameter	T0	T1	T2	T3	SEm	p-value
<i>Carcass characteristics</i>						
Dressing (%)	70.41±0.50	68.40±0.44	69.04±1.13	70.42±0.43	0.37	0.131
Eviscerated yield (%)	65.56±0.61	63.38±0.54	63.53±1.22	65.11±0.63	0.42	0.166
Giblets (%)	5.35±0.09	5.25±0.08	5.20±0.14	5.28±0.03	0.04	0.775
Abdominal Fat (%)	1.62 ^c ±0.017	1.34 ^a ±0.053	1.53 ^{bc} ±0.017	1.48 ^b ±0.015	0.025	0.001
Heart (%)	0.68±0.013	0.63±0.011	0.64±0.027	0.66±0.008	0.008	0.190
Liver (%)	2.35±0.042	2.19±0.051	2.20±0.075	2.28±0.024	0.027	0.146
Gizzard (%)	2.24±0.030	2.22±0.020	2.22±0.047	2.28±0.009	0.015	0.479
Spleen (%)	0.090±0.005	0.095±0.007	0.093±0.007	0.106±0.004	0.03	0.161
<i>Sensory attributes</i>						
Appearance	6.58±0.13	6.33±0.063	6.33±0.067	6.50±0.057	0.049	0.08
Flavour	6.43±0.23	6.00±0.05	6.19±0.03	6.22±0.06	0.071	0.206
Juiciness	6.33±0.063	6.11±0.060	6.52±0.21	6.51±0.20	0.083	0.126
Tenderness	6.19±0.03	6.08±0.05	6.45±0.22	6.50±0.057	0.245	0.245
Overall Acceptability	6.20±0.10	6.07±0.065	6.10±0.05	6.16±0.05	0.063	0.063
<i>Intestinal morphology</i>						
Villi Height (µm)	1136.66 ^c ±5.20	961.26 ^a ±7.22	1025.29 ^b ±4.93	1028.90 ^b ±5.19	19.07	0.01
Crypt Depth (µm)	94.28 ^b ±2.29	106.60 ^c ±3.21	78.46 ^a ±3.45	76.63 ^a ±4.40	3.97	0.01
Villi Width (µm)	91.92 ^a ±1.39	93.55 ^a ±2.74	97.45 ^a ±2.24	95.41 ^a ±2.38	1.14	0.382
V:C Ratio	12.05 ^b ±0.23	9.02 ^a ±0.20	13.10 ^b ±0.51	13.51 ^b ±0.74	0.56	0.01

^{a,b,c}

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

with lower V:C ratio ($p < 0.05$) were observed in the broiler chickens fed low energy diet (T2) compared to the birds fed high energy diets (T1) on day 35. Villi width didn't show any significant in all treatment groups. Increased villus height indicates a greater capacity for absorption of energy from fat, as the jejunum is the site of up to 82% of total fatty acid absorption (Rodriguez-Sanchez *et al.* 2019). Our results showed that emulsifier supplementation resulted in longer villus height and reduced crypt depth in the jejunum. These results support several other studies that report changes in intestinal morphology following lysolecithin supplementation. Boontiam *et al.* (2017) and Chen *et al.* (2019) showed that lysophospholipids supplementation of low-energy and low nitrogenous diets caused an increased jejunal villus height and a diminished crypt depth in the duodenum. Hu *et al.* (2018) reported an increased jejunum villi height along with an increased V:C ratio on day 28, in broiler chickens fed a low-energy, tallow-incorporated diet, supplemented with heat resistant lipase. In contrast, Boontiam *et al.* (2017) did not observe a significant difference in jejunum villi height and crypt depth in broiler chickens fed a lysophospholipid-supplemented diet containing soybean oil. Chen *et al.* (2014) reported that supplemental lipase in weanling pigs' diets containing 3% soybean oil increased VH, VH: CD ratio, and decreased CD in duodenum and jejunum.

It was concluded that decrease in 3% metabolizable energy of broiler chicken diet depressed growth performance, ether extract utilization and economics of broiler chicken whereas, dietary supplementation of exogenous herbal and synthetic emulsifier @ 250 g/tonne of energy restricted based broiler feed improved the growth performance, ether extract utilization and economics without affecting haemato-biochemical profile, carcass quality and sensory attributes of broiler chickens. Overall, the results indicate that herbal emulsifier is an efficacious feed emulsifier for use in broiler chicken feed and can be considered as substitute to synthetic emulsifier.

REFERENCES

- Abbas M T, Arif M, Saeed M, Reyad-ul-Ferdous M, Hassan M A, Arain M A and Rehman A. 2016. Emulsifier effect on fat utilization in broiler chicken. *Asian Journal of Animal and Veterinary Advances* **11**(3): 158–67.
- Aguilar Y M, Becerra J C, Bertot R R, Peláez J C, Liu G and Hurtado C B. 2013. Growth performance, carcass traits and lipid profile of broiler chicks fed with an exogenous emulsifier and increasing levels of energy provided by palm oil. *Journal of Food, Agriculture and Environment* **11**(1): 629–33.
- Allahyari-Bake S and Jahanian R. 2017. Effects of dietary fat source and supplemental lysophosphatidylcholine on performance, immune responses, and ileal nutrient digestibility in broilers fed corn/soybean meal-or corn/wheat/soybean meal-based diets. *Poultry Science* **96**(5): 1149–58.
- AOAC. 2007. *Official Methods of Analysis of the Association of Official's Analytical Chemists*. 17th Edn, Association of Official Analytical Chemists, Arlington, Virginia
- BIS. 2007. *Indian Standard: Poultry Feeds- Specification*, IS-374. Bureau of Indian Standards, 9, Bahadur Sah Zafar Marg, Manak Bhawan, New Delhi, India.
- Blanch A, Barroeta A C, Baucells M D, Serrano X and Puchal F. 1996. Utilization of different fats and oils by adult chickens as a source of energy, lipid and fatty acids. *Animal Feed Science and Technology* **61**(1-4): 335–42.
- Bontempo V, Comi M, Jiang X R, Rebucci R, Caprarulo V, Giromini C, Gottardo D, Fusi E, Stella S, Tirloni E and Cattaneo D. 2018. Evaluation of a synthetic emulsifier product supplementation on broiler chicks. *Animal Feed Science and Technology* **240**: 157–64.
- Boontiam W, Jung B and Kim Y Y. 2017. Effects of lysophospholipid supplementation to lower nutrient diets on growth performance, intestinal morphology, and blood metabolites in broiler chickens. *Poultry Science* **96**(3): 593–601.
- Chen S Y, Liu Z X, He Y D, Chu C and Wang M Q. 2014. Effect of coated lipase supplementation on growth, digestion and intestinal morphology in weaning piglets. *Journal of Animal and Veterinary Advances* **13**: 1013–17.
- Chen C, Jung B and Kim W K. 2019. Effects of lysophospholipid on growth performance, carcass yield, intestinal development, and bone quality in broilers. *Poultry Science* **98**: 3902–13.
- Cho J H, Zhao P and Kim I H. 2012. Effects of emulsifier and multi-enzyme in different energy density diet on growth performance, blood profiles, and relative organ weight in broiler chickens. *Journal of Agricultural Science* **4**(10): 161–68.
- Cohen G, Dembiec D and Marcus J. 1970. Measurement of catalase activity in tissue extracts. *Analytical Biochemistry* **34**(1): 30–38.
- Gole M, Manwar S, Khose K, Rathod P, Kumar D and Ganguly R K. 2022. Efficacy evaluation of a poultry feed emulsifier in broiler chicken. *The Pharma Innovation Journal* **11**(1): 11–19.
- Hu, X Q, Wang W B, Liu L, Wang C, Feng W, Luo Q P, Han R and Wang X D. 2019. Effects of fat type and emulsifier in feed on growth performance, slaughter traits, and lipid metabolism of Cherry Valley ducks. *Poultry Science* **98**(11): 5759–66.
- Hu Y D, Lan D, Zhu Y, Pang H Z, Mu X P and Hu X F. 2018. Effect of diets with different energy and lipase levels on performance, digestibility and carcass trait in broilers. *Asian-Australasian Journal of Animal Sciences* **31**(8): 1275–84.
- Huang J, Yang D and Wang T. 2007. Effects of replacing soy-oil with soy-lecithin on growth performance, nutrient utilization and serum parameters of broilers fed corn-based diets. *Asian-Australasian Journal of Animal Sciences* **20**(12): 1880–86.
- Johnson A M, Rohifs E M and Silverman L M. 1999. Protein. *The Textbook of Clinical Chemistry*. W.B. Saunders Philadelphia.
- Kaczmarek S A, Bochenek M, Samuelsson A C and Rutkowski A. 2015. Effects of glyceryl polyethylene glycol ricinoleate on nutrient utilisation and performance of broiler chickens. *Archives of Animal Nutrition* **69**(4): 285–96.
- Keeton J T, Foegeding E A and Patana-Anake C. 1984. A comparison of nonmeat proteins, sodium tripolyphosphate and processing temperature effects on physical and sensory properties of frankfurters. *Journal of Food Science* **49**(6): 1462–65.
- Kim W T, Shinde P and Chae B J. 2008. Effect of lecithin with or without chito oligosaccharide on the growth performance, nutrient digestibility, blood metabolites and pork quality of finishing pigs. *Canadian Journal of Animal Science* **88**(2): 283–92.

- Kramer C Y. 1957. Extension of multiple range tests to group correlated adjusted means. *Biometrics* **13**(1): 13–18.
- Kussaibati R, Guillaume J and Leclercq B. 1982. The effects of age, dietary fat and bile salts, and feeding rate on apparent and true metabolisable energy values in chickens. *British Poultry Science* **23**(5): 393–403.
- Lin H M, Dillard C J and Tappel A L. 1988. Plasma SH and GSH measurements. *Methods Enzymology* **233**: 380–82.
- Madesh M and Balasubramanian K A. 1998. Microtiter plate assay for superoxide dismutase using MTT reduction by superoxide. *Indian Journal of Biochemistry and Biophysics* **35**(3): 184–88.
- Meng X, Slominski B A and Guenter W. 2004. The effect of fat type, carbohydrase, and lipase addition on growth performance and nutrient utilization of young broilers fed wheat-based diets. *Poultry Science* **83**(10): 1718–27.
- Polin D and Hussein T H. 1982. The effect of bile acid on lipid and nitrogen retention, carcass composition, and dietary metabolizable energy in very young chicks. *Poultry Science* **61**(8): 1697–1707.
- Reitman S and Frankel S. 1957. Glutamic–pyruvate transaminase assay by colorimetric method. *American Journal of Clinical Pathology* **28**(1): 56–63.
- Rodriguez-Sanchez R, Tres A, Sala R, Guardiola F and Barroeta A C. 2019. Evolution of lipid classes and fatty acid digestibility along the gastrointestinal tract of broiler chickens fed different fat sources at different ages. *Poultry Science* **98**: 1341–53.
- Roy A, Haldar S, Mondal S and Ghosh T K. 2010. Effects of supplemental exogenous emulsifier on performance, nutrient metabolism, and serum lipid profile in broiler chickens. *Veterinary Medicine International*. Doi: <https://doi.org/10.4061/2010/262604> (Accessed on 11th July 2022).
- Schaible P J. 1970. *Poultry: Feeds and Nutrition*. 2nd Edn., The AVI Publishing Co. USA
- Siyal F A, Babazadeh D, Wang C, Arain M A, Saeed M, Ayasan T, Zhang L and Wang T. 2017. Emulsifiers in poultry industry- A review. *World Poultry Science Journal* **73**: 1–6.
- Snedecor G W and Cochran W G. 1994. *Statistical Methods*. 8th Edn. IOWA State University Press. Ames, Iowa, USA.
- Suleiman S A, Ali M E, Zaki Z M S, El-Malik E M A and Nasr M A. 1996. Lipid peroxidation and human sperm motility: Protective role of vitamin E. *Journal of Andrology* **17**(5): 530–37.
- Talapatra S K, Ray S C and Sen K C. 1940. The analysis of mineral constituents in biological materials. 1. Estimation of phosphorus, chlorine, calcium, magnesium, sodium and potassium in food-stuffs. *Indian Journal of Veterinary Science* **10**: 243–58.
- Tikare V, Matham V K, Patil V, Chandra S, Kumar D, Kotagiri R and Ganguly B. 2021. Efficacy evaluation of poultry feed emulsifier on performance and nutrient metabolism in Broiler Chicken. *Current Journal of Applied Science and Technology* **40**(48): 38–43.
- Weiss D J and Wardrop K J. 2011. *Schalm's Veterinary Hematology*. John Wiley & Sons.
- Wickramasuriya S S, Cho H M, Macelline S P, Kim E, Shin T K, Yi Y J, Park S H, Lee K B and Heo J M. 2020. Effect of calcium stearyl-2 lactylate and lipase supplementation on growth performance, gut health, and nutrient digestibility of broiler chickens. *Asian-Australasian Journal of Animal Sciences* **33**(6): 981–91.
- Xu Z R, Hu C H, Xia M S, Zhan X A and Wang M Q. 2003. Effects of dietary fructooligosaccharide on digestive enzyme activities, intestinal microflora and morphology of male broilers. *Poultry Science* **82**(6): 1030–36.
- Zampiga M, Meluzzi A and Sirri F. 2016. Effect of dietary supplementation of lysophospholipids on productive performance, nutrient digestibility and carcass quality traits of broiler chickens. *Italian Journal of Animal Science* **15**(3): 521–28.
- Zhang B, Haitao L, Zhao D, Guoand Y and Barri A. 2011. Effect of fat type and lysophosphatidylcholine addition to broiler diets on performance, apparent digestibility of fatty acids and apparent metabolisable energy content. *Feed Science and Technology* **163**: 177–84.
- Zhao P Y and Kim I H. 2017. Effect of diets with different energy and lysophospholipids levels on performance, nutrient metabolism, and body composition in broilers. *Poultry Science* **96**(5): 1341–47.