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RESEARCH ARTICLE

Effect of Different Emulsifiers on Growth Performance, Intestinal Histology and Serum Biochemistry in Broilers Reared on Different Fat Sources

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A B S T R A C T

The main objective of this research study was to evaluate the efficacy of different emulsifiers on growth performance, intestinal histology and serum biochemistry in broilers reared on different fat sources. A 2 x 4 experiment using 2 oil sources (soybean oil (SO) and refined poultry oil (RPO)) and 4 emulsifiers (control, lysolecithin, lysophospholipid and bile acids) was undertaken using factorial arrangement under completely randomized design using Minitab 17. One thousand, three hundred and sixty (1360) day-old broiler birds (ROSS-308) were divided into eight treatments having five replicates (34 birds in each). Feed intake and body weight were recorded in order to calculate FCR. Two birds from each replicate were randomly selected and slaughtered to collect ilium samples. Use of soybean oil in broiler diet had improved (P<0.05) FCR than poultry oil; however, weight gain and feed intake was not affected (P>0.05) by oil sources. Weight gain, feed consumption and FCR were improved (P<0.05) in bile acid supplemented group. Low density lipoprotein and atherogenic index were lower (P<0.05) in birds fed diet containing bile acids. Bile acid in broiler diet had greater (P<0.05) villus height and villus surface area than other emulsifiers. It can be concluded that bile acids in broiler diet had improved growth performance and increased villus height as compared to lysolecithin and lysophospholipid.

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INTRODUCTION

Lipids (oils and fats) are energy-rich compounds and chemically these are triglycerides i.e., tri-esters of fatty acids and glycerol (Bauer *et al.*, 2005). They have an important role in protecting shocks, producing hormones, maintaining body temperature, muscular metabolism and normal functioning of the central nervous system in broiler birds (Khatun *et al.*, 2018). Birds cannot synthesize essential fatty acids; therefore, essential fatty acids are obtained from dietary fat and must be added to poultry feed. Further, fat addition in the broiler diet improves growth performance and also provides extra caloric effect to meet the requirements of fast-growing broilers in a short time. Also, addition of fat in broiler diet improved nutrient digestion and absorption. In the broiler diet, both vegetable and animal fat are used to increase the energy value (Kanakri *et al.*, 2018). The use of fat in broiler diet enhances the absorption of fat-soluble vitamins and enhanced the likeness of birds toward feed (Sahito *et al.*, 2012). Dietary addition of bile acids and emulsifiers enhanced emulsification, micelle development and fat digestion (Siyal *et al.*, 2017; Pantaya *et al.*, 2020) and the use of lecithin as an emulsifier improves production performance in growing chicks (Huang *et al.*, 2007; Liu *et al.*, 2020). The use of external emulsifiers solubilizes fats and enhances the absorption of fatty acids. Emulsifiers also improved FCR, feed consumption and performance of birds depending on fat type (Roy *et al.*, 2010). Lysophospholipids are much effective than lecithin in fat emulsifying characteristics. Lysophospholipids has greater hydrophilic-lipophilic balance than bile and lecithin and reduces critical micelle concentration (Van-Nieuwenhuyzen and Tomas, 2008). This also indicates that lysophospholipids has a greater ability to form micelles in broiler GIT tract and provide a large surface area for lipase action (Maingret *et al.*, 2000). Further, supplementation of exogenous desiccated bile in broiler's diet had better daily weight gain, fat digestibility and FCR during a period of 42 days (Alzawqari *et al.*, 2016). However, information regarding the comparison of different types of emulsifiers on different oil is limited. Therefore, this study is planned to examine the effect of different emulsifiers on growth performance and intestinal histology in broiler reared on different fat sources.

MATERIALS AND METHODS

The present study was conducted at R&D house at Sharif feed Mills, Okara, Punjab, Pakistan with prior approval from the animal care and use committee of the University of Agriculture, Faisalabad via letter no. 15497-500.

Housing and management: Birds were reared in environmentally controlled house maintaining all standard conditions like temperatures, relative humidity, and ventilation etc. Feed was offered to birds in round bottom feeder while water was available in nipple lines. House temperature was sustained at 95°F at first week of trial with following reduction of 5°F every week. Birds were vaccinated with ND+IB (day 1), IBD (day 8), IBD (day 18) and ND (day 25) vaccine.

Experimental birds and experimental diet: In this experiment, three types of emulsifiers (lysolecithin, lysophospholipid and bile acids) were supplemented in soybean and refined poultry oil-based diet. One thousand, three hundred and sixty (1360) day-old broiler birds (ROSS-308) were divided into eight treatments. Eight diets; A (SO + No emulsifier), B (SO + lysophospholipid at 0.05%), C (SO + lysolecithin at 0.05%), D (SO + bile acids at 0.05%), E (RPO + No emulsifier), F (RPO + lysophospholipid at 0.05%), G (RPO + lysolecithin at 0.05%) and H (RPO + bile acids at 0.05%) were formulated (Table 1).

Growth performance: Data on the following parameters were recorded on a weekly basis. Body weight of birds was measured at the end of each subsequent week. Feed intake was calculated by subtracting feed refusal from feed offered. Feed conversion ratio was calculated week-wise using the following relationship.

$$\mathrm{FCR} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

Blood sampling: Blood was collected from wing vein and were centrifuged at 3000 rpm for 10 min to extract serum, then stored for further analysis (Urea, Uric acid, Triglycerides, Cholesterol, HDL, LDL and atherogenic index (LDH/HDL) (Conkbayir *et al.*, 2015).

Intestinal Histology: Two birds were randomly slaughter at the last of experiment. Ilium specimens were collected and fixed in 10% neutral buffered formalin solution for 24 h, then embedded in paraffin and sectioned at 4 µm. By using an image analysis software (ToupView 3.7) the following parameters were measured: (i) villus height (VH), (ii) villus width (VW), (iii) depth of crypt (CD) (iv) ratios of VH/VW, (v) ratios of VH/CD, (vi) villus Surface Area (mm2) is calculated by multiplying 2π (VH) x (VW/2) (Sakamoto *et al.*, 2000).

Table 1: Ingredients composition of experimental diets

Ingredients	Starter Phase		Finisher Phase	
	Soybean oil (A-D)[1]	Poultry Oil (E-H)[2]	Soybean oil (A-D)[1]	Poultry Oil (E-H)[2]
Corn	52.50	52.41	55.69	55.54
Soybean Meal 45%	38.93	38.95	34.64	34.67
Soya oil	3.66	0	6.03	0
Poultry Oil	0	3.73	0	6.15
Calcium Carbonate	0.90	0.90	0.72	0.72
DCP	2.17	2.17	1.76	1.76
Sodium Chloride	0.39	0.39	0.39	0.39
Sodium Bicarbonate	0.30	0.30	0.12	0.12
L-Lysine Sulphate	0.35	0.35	0.08	0.08
DL-Methionine	0.37	0.37	0.26	0.26
L-Threonine	0.11	0.11	0	0
Vit. premix*	0.15	0.15	0.15	0.15
Min. premix**	0.15	0.15	0.15	0.15
Extra Phy	0.01	0.01	0.01	0.01
Total	100.0	100.0	100.0	100.0
Nutrients (calculated)				
ME (Kcal/kg)	3000	3000	3200	3200
CP	22	22	20	20
EE	5.87	5.94	8.29	8.41
CF	2.94	2.94	2.80	2.80
Ash	4.93	4.93	4.42	4.41
Ca	0.96	0.96	0.79	0.79
Av. P	0.48	0.48	0.40	0.40
Sodium	0.25	0.25	0.20	0.20
Potassium	0.88	0.88	0.81	0.81
Chlorine	0.30	0.30	0.30	0.30
DEB	250	250	210	210
Dig. Lysine	1.28	1.28	1.03	1.03
Dig. Methionine	0.67	0.67	0.54	0.54
Dig. Met + Cys	0.95	0.95	0.80	0.80
Dig. Threonine	0.86	0.86	0.69	0.69
Dig. Tryptophan	0.25	0.25	0.23	0.23
Dig. Arginine	1.41	1.41	1.28	1.28
Dig. Leucine	1.70	1.70	1.59	1.59
Dig. Isoleucine	0.86	0.86	0.79	0.79
Dig. Valine	0.92	0.92	0.85	0.85
Dig. Histidine	0.53	0.53	0.49	0.49
Nutrients (Analyzed)				
DM	88.82	89.42	90.38	90.69
CP	21.83	22.05	20.22	20.42
EE	5.45	5.48	7.26	7.80
AIA	1.24	1.41	1.42	1.56

*Vitamins premix provides 10000 IU Vitamin A, 5 mg Riboflavin, 12 mg Ca Pantothenate, 2.2 mg thiamin, 1.55 mg Folic acid, 44 mg nicotinic acid, 2.2 mg Vitamin B_6, 12.1 µg Vitamin B_{12}, 250 mg Choline chloride, 0.11 mg d-biotin, 1100 IU Vitamin D_3, 11.0 IU Vitamin E, 1.1 mg Vitamin K per kg of diet. **Mineral premix provides 30 mg Fe, 50 mg Zn, 5 mg Cu, 60 mg Mn, 0.1 mg Co, 0.3mg I and 1 mg Se per kg of diet. [1] A (SO + No emulsifier), B (SO + lysophospholipid at 0.05%), C (SO + lysolecithin at 0.05%), D (SO + bile acids at 0.05%). [2] E (RPO + No emulsifier), F (RPO + lysophospholipid at 0.05%), G (RPO + lysolecithin at 0.05%) and H (RPO + bile acids at 0.05%).

Statistical Analysis: The obtained data were subjected to statistical analysis using analysis of variance technique (ANOVA) with the completely randomized design under the factorial arrangement and treatment means were compared using Tukey's Test in Minitab 17 (Steel *et al.*, 1997).

RESULTS

Growth performance: Effects of different emulsifiers on growth performance in broiler reared on soya and poultry oil during the overall period (1-35 days) are shown in Table 2. Poultry oil and soybean oil in broiler diet had no effect (P>0.05) on weight gain and feed intake, while, FCR was improved (P<0.05) in a group fed diet containing soya oil than those receiving poultry oil. Feed intake was lower (P<0.05), whereas, weight gain and FCR were improved (P<0.05) in birds given bile acids than other emulsifiers. There was an interaction (P<0.05) between oil sources and emulsifier type on broiler growth performance. Weight gain, feed intake and FCR were improved (P<0.05) in birds receiving bile acid in both soybean oil and poultry oil than those receiving poultry oil without emulsifier based diet.

Table 2: Effect of different emulsifiers on growth performance in broiler reared on soya and poultry oil

	Feed Intake (g)	Weight gain (g)	FCR
Oil Sources			
Soya oil	3178.95	1980.86	1.607[b]
Poultry Oil	3199.34	1945.44	1.649[a]
SEM	20.2	12.4	0.011
P Value	0.481	0.51	0.013
Emulsifiers			
No Emulsifier	3146.50[bc]	1899.77[b]	1.664[a]
Lysophosholipid	3115.79[c]	1906.25[b]	1.636[ab]
Lysolecithin	3267.35[a]	2004.31[a]	1.630[ab]
Bile Acids	3226.92[ab]	2042.29[a]	1.580[b]
SEM	28.6	17.5	0.016
P Value	0.002	0.0001	0.008
Oil Sources x Emulsifiers			
SO + No Emulsifier	3326.89[a]	2086.10[a]	1.595[b]
SO + Lysophosholipid	2963.90[b]	1801.80[b]	1.647[ab]
SO + Lysolecithin	3202.05[a]	1981.53[a]	1.616[b]
SO + Bile Acids	3222.94[a]	2054.02[a]	1.569[b]
RPO + No Emulsifier	2966.11[b]	1713.43[b]	1.733[a]
RPO + Lysophosholipid	3267.68[a]	2010.69[a]	1.625[b]
RPO + Lysolecithin	3332.66[a]	2027.08[a]	1.645[ab]
RPO + Bile Acids	3230.90[a]	2030.56[a]	1.592[b]
SEM	40.5	21.7	0.022
P Value	0.0001	0.0001	0.010

SEM, standard error of the mean; P>0.05: Non-Significant, P<0.05: Significant.

Serum Biochemistry: Effect of different emulsifiers on serum biochemistry in broiler reared on soya and poultry oil shown in Table 3. Serum biochemistry parameters include urea, uric acid, triglycerides, cholesterol, HDL and LDL. Different oil sources had no effect (P>0.05) on serum biochemistry parameters. Low density lipoprotein and atherogenic index were lower (P<0.05) in birds given bile acids than other emulsifiers. There was interaction (P<0.05) between oil sources and emulsifiers type on atherogenic index, while all other serum biochemistry test remained unaffected (P>0.05) by dietary treatments.

Blood Hematology: Effect of different emulsifiers on blood hematology in broiler reared on soya and poultry oil shown in Table 4. Oil source and emulsifiers use in this experiment had no effect (P>0.05) on blood hematology parameters. No interaction was noted in oil source and emulsifier on blood hematology test.

Intestinal morphology: Effect of different emulsifiers on intestinal histology in broiler reared on soya and poultry oil shown in Table 5. Intestinal histology include villus height, villous width, crypt depth, VH:CD, VH:VW and villus surface area (mm^2). There was no effect (P>0.05) of oil sources (poultry vs soybean oil) on VH, VW, CD, VH:CD, VH:VW and villus surface area. Villus height and villus surface area were higher (P<0.05) in birds receiving bile acid than other emulsifiers, while, remaining parameters remain unaffected (P>0.05) by different fat emulsifiers, however, VW, CD, VH:CD, VH:VW remain unaffected (P>0.05) by different fat emulsifiers (Fig. 1).

DISCUSSION

Highest weight gain, lower feed intake and improved FCR were observed in the group having bile acids. This is due to that endogenous bile acids are insufficient to emulsify whole fat present in the diet. So, the addition of exogenous bile acid improved fat utilization and growth performance of birds. Results are in line with the Kamran *et al.* (2020) who concluded that use of polyglycerol polyricinoleate at 0.025, 0.035 and 0.045% in soy oil based diet had improved weight gain and FCR in broilers. Allahyari-Bake and Jahanian (2017) observed that addition of emulsifier in broilers diet containing soy-free fatty acids had higher (P<0.05) feed intake and improved (P<0.05) weight gain than control. Also, use of 0.1% emulsifier in broiler diet had improved FCR as compared to 0 and 0.05% inclusion of emulsifier, while, feed

Table 3: Effect of different emulsifiers on serum biochemistry in broiler reared on soya and poultry oil (mg/dL)

	Urea	Uric acid	Triglycerides	Cholesterol	HDL	LDL	Atherogenic index*
Oil Sources							
Soya oil	19.95[b]	3.92	51.10	139.80	99.17	30.41	0.31
Poultry Oil	27.30[a]	6.41	61.93	150.95	103.10	35.46	0.34
SEM	2.11	1.14	8.39	5.31	2.84	2.72	0.02
P Value	0.019	0.134	0.368	0.147	0.336	0.199	0.317
Emulsifiers							
No Emulsifier	24.50	4.01	51.70	141.40	98.90	32.16[ab]	0.32[ab]
Lysophosholipid	23.40	5.24	64.96	155.90	101.80	41.11[a]	0.40[a]
Lysolecithin	22.70	6.14	58.60	143.20	97.84	33.64[ab]	0.34[ab]
Bile Acids	23.90	5.26	50.80	141.00	106.00	24.84[b]	0.23[b]
SEM	2.98	1.61	11.9	7.51	4.02	3.85	0.03
P Value	0.978	0.830	0.817	0.457	0.490	0.045	0.010
Oil Sources x Emulsifiers							
SO + No Emulsifier	20.20	3.26	53.60	124.60	87.40	26.48	0.30[ab]
SO + Lysophosholipid	18.20	3.26	49.00	145.00	100.40	34.80	0.35[ab]
SO + Lysolecithin	19.80	5.24	50.00	142.60	98.68	33.92	0.34[ab]
SO + Bile Acids	21.60	3.92	51.80	147.00	110.20	26.44	0.24[b]
RPO + No Emulsifier	28.80	4.76	49.80	158.20	110.40	37.84	0.34[ab]
RPO + Lysophosholipid	28.60	7.22	80.92	166.80	103.20	47.42	0.45[a]
RPO + Lysolecithin	25.60	7.04	67.20	143.80	97.00	33.36	0.34[ab]
RPO + Bile Acids	26.20	6.60	49.80	135.00	101.80	23.24	0.23[b]
SEM	4.21	2.28	16.8	10.6	5.69	5.45	0.05[ab]
P Value	0.899	0.950	0.677	0.158	0.054	0.361	0.537

SEM, standard error of the mean; P>0.05: Non-Significant, P<0.05: Significant. *Atherogenic index (LDH/HDL).

Table 4: Effect of different emulsifiers on blood hematology in broiler reared on soya and poultry oil

	RBC 10^6 / ul	WBC 10^3/ul	HGB g/dl	MCV (+FL)	HCT (%)	MCHC (g/dl)	MCH (+pg)	PLT 10^3 /ul
Oil Sources								
Soya oil	2.04	24.42	11.03	137.10	31.58	33.28	49.53	16.54
Poultry Oil	2.03	23.51	10.97	148.80	28.92	32.18	46.92	17.03
SEM	0.06	0.53	0.89	8.59	2.27	0.72	1.04	1.58
P Value	0.901	0.233	0.958	0.350	0.419	0.297	0.096	0.828
Emulsifiers								
No Emulsifier	2.02	23.59	9.50	148.40	27.10	31.95	46.74	14.56
Lysophosholipid	2.05	23.40	10.58	147.90	29.72	33.40	48.90	16.97
Lysolecithin	2.04	24.17	13.43	144.52	33.70	32.45	46.78	18.20
Bile Acids	2.04	24.71	10.48	130.98	30.47	33.12	50.48	17.42
SEM	0.09	0.75	1.25	12.1	3.21	1.01	1.48	2.23
P Value	0.995	0.599	0.182	0.720	0.555	0.742	0.252	0.692
Oil Sources x Emulsifiers								
SO + No Emulsifier	1.97	22.78	8.83	145.43	27.97	32.20	47.23	13.70
SO + Lysophosholipid	2.06	25.20	10.37	149.57	25.00	33.83	50.33	15.82
SO + Lysolecithin	2.01	24.03	13.70	144.67	40.43	32.90	47.30	18.10
SO + Bile Acids	2.12	25.68	11.23	108.73	32.90	34.17	53.27	18.53
RPO + No Emulsifier	2.06	24.39	10.17	151.37	26.23	31.69	46.25	15.42
RPO + Lysophosholipid	2.03	21.59	10.80	146.23	34.43	32.97	47.47	18.11
RPO + Lysolecithin	2.06	24.31	13.17	144.37	26.97	32.00	46.27	18.30
RPO + Bile Acids	1.96	23.75	9.73	153.23	28.03	32.07	47.70	16.30
SEM	0.12	1.05	1.77	17.2	4.53	1.43	2.09	3.16
P Value	0.751	0.105	0.868	0.494	0.130	0.949	0.666	0.892

SEM, standard error of the mean; P>0.05: Non-Significant, P<0.05: Significant

Table 5: Effect of different emulsifiers on intestinal histology in broiler reared on soya and poultry oil

	VH (µm)	VW (µm)	CD (µm)	VH:CD	VH:VW	Villus Surface Area (mm^2)
Oil Sources						
Soya oil	1146.04	292.77	205.80	5.80	4.31	1.06
Poultry Oil	1171.55	315.53	216.04	5.79	4.30	1.16
SEM	14.5	15.2	8.99	0.24	0.29	0.06
P Value	0.218	0.293	0.424	0.969	0.981	0.228
Emulsifiers						
No Emulsifier	1022.76^{c}	268.51	193.61	5.49	4.10	0.88^{b}
Lysophosholipid	1163.26^{b}	330.88	213.45	5.65	3.99	1.20^{a}
Lysolecithin	1180.98^{b}	306.76	224.37	5.71	4.27	1.14^{ab}
Bile Acids	1268.19^{a}	310.44	212.25	6.33	4.85	1.23^{a}
SEM	20.5	21.5	12.7	0.34	0.41	0.08
P Value	0.0001	0.231	0.395	0.315	0.453	0.013
Oil Sources x Emulsifiers						
SO + No Emulsifier	1001.60^{d}	280.12	188.96	5.59	3.97^{ab}	0.89^{ab}
SO + Lysophosholipid	1187.97^{ab}	275.43	223.77	5.50	4.64^{ab}	1.03^{ab}
SO + Lysolecithin	1159.35^{bc}	264.35	207.02	5.84	5.05^{ab}	0.96^{ab}
SO + Bile Acids	1235.25^{ab}	351.18	203.45	6.26	3.57^{b}	1.37^{ab}
RPO + No Emulsifier	1043.92^{cd}	256.90	198.26	5.38	4.23^{ab}	0.86^{b}
RPO + Lysophosholipid	1138.56^{bc}	386.34	203.12	5.80	3.34^{b}	1.38^{a}
RPO + Lysolecithin	1202.60^{ab}	349.17	241.72	5.57	3.48^{b}	1.32^{ab}
RPO + Bile Acids	1301.12^{a}	269.71	221.05	6.40	6.12^{a}	1.10
SEM	29.0	30.4	18.0	0.48	0.58	0.12
P Value	0.209	0.007	0.483	0.919	0.002	0.020

SEM: standard error of the mean; P>0.05: Non-Significant, P<0.05: Significant. VH:CD is ratio of villus height and crypt depth (µm) while VH:VW is ratio of villus height and villus width, Villus Surface Area (mm^2) is calculated by multiplying 2π x VH x VW/2.

consumption and body weight were not affected (Zosangpuii *et al.*, 2015; Zhao and Kim, 2017). Liu *et al.* (2020) reported that weight gain and FCR were improved (P<0.05) in birds receiving 97% de-oiled lecithin in basal diet than control group. Abbas *et al.* (2016) reported that use of emulsifier (lecithin) at 0.035% in broiler diet had better (P < 0.05) FCR in birds fed different oil levels (1, 2 and 3%) during finisher phase than those who reared on lecithin free diet. Tan *et al.* (2016) showed that addition of emulsifier (0.05%) with rice bran oil in the broiler diet had higher (P<0.05) weight gain than the control group. Cho *et al.* (2012) noted that birds fed diet supplemented with 0.1% multi-enzyme + 0.05% emulsifier in low-density diet had greater (P<0.05) feed intake than high-density diet. Neto *et al.* (2011) showed that broiler birds reared on diet having soybean oil with emulsifier had higher (P<0.05) weight gain and better (P<0.05) FCR. Supplementation of ox-bile at 0.5% in broiler diet had increased weight gain and improved FCR than the control group (Alzawqari *et al.*, 2011).

Low density lipoprotein and atherogenic index were lower (P<0.05) in birds given bile acids than other emulsifiers. This might be due to that addition of emulsifiers in broiler diet increased the availability of HDL content to birds. Atherogenic index is the indication of cardiac attack. Lower the value mean lower the incidence of cardiac attack. According to Ge *et al.* (2018) supplementation of bile acids caused decrease (P<0.05) in triglycerides and LDL. Results are not in line with the findings of Hemati Matin *et al.* (2016) who reported that supplementation of bile acids did not have any effect (P>0.05) on total serum cholesterol, triglycerides and HDL.

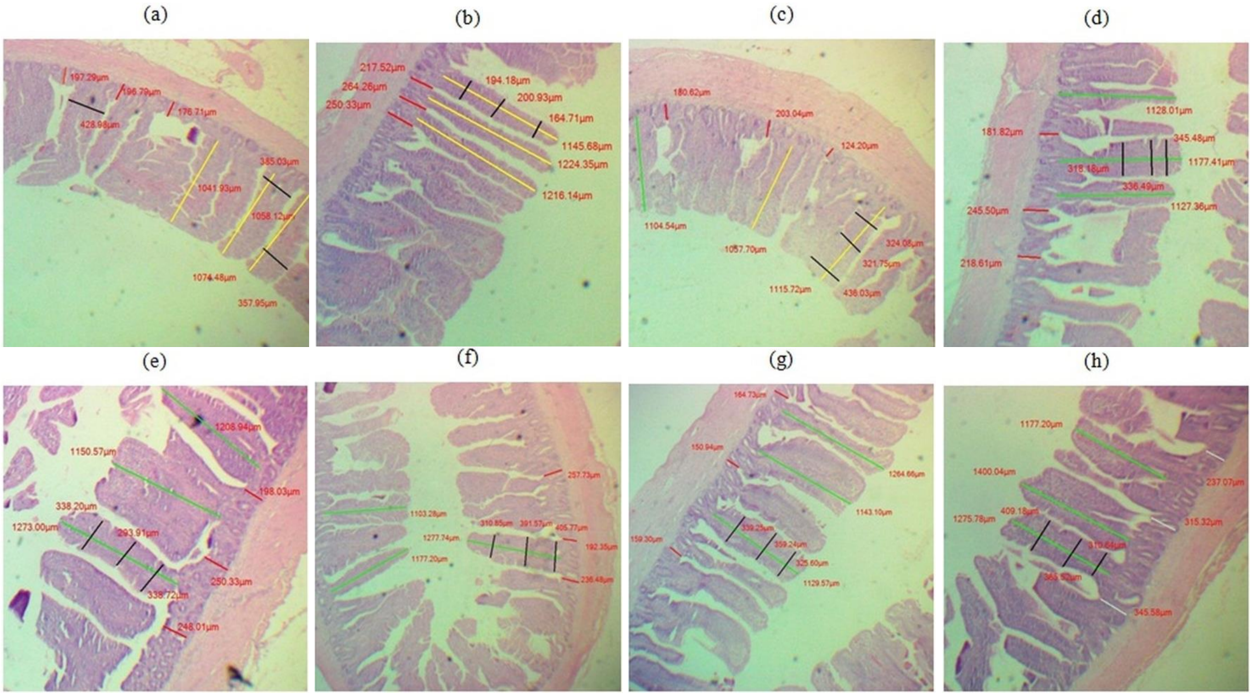

Fig. 1: Histology of ilium part of small intestine of different treatments (a) (SO + No emulsifier), (b) (SO + lysophospholipid), (c) (SO + lysolecithin), (d) (SO + bile acids), (e) (RPO + No emulsifier), (f) (RPO + lysophospholipid), (g) (RPO + lysolecithin) and (h) (RPO + bile acids) (40x).

Arshad *et al.* (2020) reported that lipase at 0.018% and bile acid at 0.03% addition in 100 kcal/kg low energy diets had no effect on HDL, LDL and triglyceride level in broiler. Lai *et al.* (2018) revealed that serum triglyceride, HDL and LDL concentrations were unaffected (P>0.05) by bile acids supplementation. Serum cholesterol, LDL and triglycerides concentrations were lower in birds fed diet containing emulsifier (lysophospholipids) (Zhao and Kim, 2017). Two levels of energy and supplementation of emulsifier had similar effect on cholesterol, triglycerides, LDL and HDL (Aguilar *et al.*, 2013). These results imply that the ability to transport cholesterol from peripheral tissues to the liver was unaffected by supplemental bile acids.

Birds fed diet having bile acid had greater (P<0.05) villus height and villus surface area, however, VW, CD, VH:CD, VH:VW remain unaffected by different fat emulsifiers. This might be due to that emulsifier reduce the destruction of intestinal villi results in increased surface area. These findings are in consistent with the outcome of Brautigan *et al.* (2017) who showed that addition of lyso-lecithin.in broiler diet increased villus height and width of jejunum of broiler. However, Zosangpuii *et al.* (2015) found no effect of emulsifier (glycerol polyethylene glycol ricinoleate: GPGR) at 0.04% on villi length of duodenum, jejunum and ilium because to low level of emulsifier used in broiler diet.

Conclusions: It can be concluded that soybean oil had improved growth performance than poultry oil. Further, bile acids in poultry diet have improved growth performance, increased villus height, reduced LDL and atherogenic index as compared to lysolecithin and lysophospholipid.

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Authors contribution: MS did experimental work and manuscript writing; SAB performed data analysis; HN designed the experiment; MSR prepared the manuscript.

REFERENCES

Abbas MT, Arif M, Saeed M, *et al.*, 2016. Emulsifier effect on fat utilization in broiler chicken. Asian J Anim Vet Adv 11:158-67.

Aguilar YM, Becerra JC, Bertot RR, *et al.*, 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. J Food Agri Environ 11:629-33.

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. Poult Sci 96:1149-58.

Alzawqari M, Moghaddam HN, Kermanshahi H, *et al.*, 2011. The effect of desiccated ox bile supplementation on performance, fat digestibility, gut morphology and blood chemistry of broiler chickens fed tallow diets. J Appl Anim Res 39:169-74.

Alzawqari MH, Al-Baadani HH, Alhidary IB, *et al.*, 2016. Effect of taurine and bile acid supplementation and their interaction on performance, serum components, ileal viscosity and carcass characteristics of broiler chickens. S Afr J Anim Sci 46:448-57.

Arshad MA, Bhatti SA, Hassan I, *et al.*, 2020. Effects of bile acids and lipase supplementation in low-energy diets on growth performance, fat digestibility and meat quality in broiler chickens. Braz J Poult Sci 22:1-8.

Bauer E, Jakob S and Mosenthin R, 2005. Principles of physiology of lipid digestion. Asian-Aust J Anim Sci 18:282-95.

Brautigan DL, Li R, Kubicka E, *et al.*, 2017. Lysolecithin as feed additive enhances collagen expression and villus length in the jejunum of broiler chickens. Poult Sci 96:2889-98.

Cho JH, Zhao P and Kim IH, 2012. Effects of emulsifier and multi-enzyme in different energy densitydiet on growth performance, blood profiles, and relative organ weight in broiler chickens. J Agri Sci 4:161-8.

Conkbayir C, Burak A and Ökçün EB, 2015. Lipid variables related to the extent and severity of coronary artery disease in non-diabetic Turkish Cypriots. Iran J Public Health 44:1196-203.

Ge XK, Wang AA, Ying ZX, *et al*., 2018. Effects of diets with different energy and bile acids levels on growth performance and lipid metabolism in broilers. Poult Sci 98:87-895.

Hemati Matin H, Shariatmadari F, Torshizi MK, *et al*., 2016. In vitro bile acid-binding capacity of dietary fibre sources and their effects with bile acid on broiler chicken performance and lipid digestibility. Br Poult Sci 57:348-57.

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-Aust J Anim Sci 20:1880-6.

Kamran J, Mehmood S, Mahmud A, *et al*., 2020. Effect of fat sources and emulsifier levels in broiler diets on performance, nutrient digestibility, and carcass parameters. Braz J Poult Sci 22:1-10.

Kanakri K, Carragher J, Hughes R, *et al*., 2018. The effect of different dietary fats on the fatty acid composition of several tissues in broiler chickens. Eur J Lipid Sci Tech. 120:1-13.

Khatun J, Loh TC, Akit H, *et al*., 2018. Influence of different sources of oil on performance, meat quality, gut morphology, ileal digestibility and serum lipid profile in broilers. J Appl Anim Res 46:479-85.

Lai W, Huang W, Dong B, *et al*., 2018. Effects of dietary supplemental bile acids on performance, carcass characteristics, serum lipid metabolites and intestinal enzyme activities of broiler chickens. Poult Sci 97:196-202.

Liu X, Yoon SB and Kim IH, 2020. Growth performance, nutrient digestibility, blood profiles, excreta microbial counts, meat quality and organ weight on broilers fed with de-oiled lecithin emulsifier. Animal 10:1-12.

Maingret F, Patel AJ, Lesage F, *et al*., 2000. Lysophospholipids open the two-pore domain mechanogated K (+) channels TREK-1 and TRAAK. J Biol Chem 275:10128-33.

Neto GAC, Pezzato AC, Sartori JR, *et al*., 2011. Emulsifier in broiler diets containing different fat sources. Braz J Poult Sci 13:119-25.

Pantaya D, Widayanti A, Jadmiko P, *et al*., 2020. Effect of bile acid supplementation in broiler feed on performance, carcass, cholesterol, triglycerides and blood glucose. Environ Earth Sci 411:1-7.

Roy A, Haldar S, Mondal S, *et al*., 2010. Effects of supplemental exogenous emulsifier on performance, nutrient metabolism and serum lipid profile in broiler chickens. Vet Med Int 2010:1-9.

Sahito HA, Soomro RN, Memon A, *et al*., 2012. Effect of fat supplementation on the growth, body temperature and blood cholesterol level of broiler. Glo Adv Res J Chem Mat Sci 1:23-34.

Sakamoto K, Hirose H, Onizuka A, *et al*., 2000. Quantitative study of changes in intestinal morphology and mucus gel on total parenteral nutrition in rats. J Surg Res 94:99-106.

Siyal FA, El-Hack MEA, Alagawany M, *et al*., 2017. Effect of soy lecithin on growth performance, nutrient digestibility and hepatic antioxidant parameters of broiler chickens. Int J Pharmacol 13:396-402.

Steel RGD, Torrie JH and Dickie DA, 1997. Principles and Procedures of Statistics. A Biometric Approach, 3rd edition, McGraw-Hill, Book Publishing Company, Toronto, Canada.

Tan HS, Zulkifli I, Farjam AS, *et al*., 2016. Effect of exogenous emulsifier on growth performance, fat digestibility, apparent metabolisable energy in broiler chickens. J Microbiol Biotechn 4:7-10.

Van-Nieuwenhuyzen W and Tomas MC, 2008. Update on vegetable lecithin and phospholipid technologies. Eur J Lipid Sci Tech. 110:472-86.

Zhao PY and Kim IH, 2017. Effect of diets with different energy and lipase levels on performance, digestibility and carcass trait in broilers. Poult Sci 96:1341-7.

Zosangpuii, Patra AK and Samanta G, 2015. Inclusion of an emulsifier to the diets containing different sources of fats on performances of Khaki Campbell ducks. Iran J Vet Res 16:156-60.