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Original Article

Effect of Fat Sources and Emulsifier Levels in Broiler Diets on Performance, Nutrient Digestibility, and Carcass Parameters

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Keywords

Polyglycerol polyricinoleate; digestibility; performance; broilers.

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ABSTRACT

The objective of the current study was to check the effect of fat types and polyglycerol polyricinoleate (PGPR) levels in broiler diets on broilers performance. For this purpose, three sources of fat {soy oil (SO), poultry oil (PO), and oxidized oil (OO) (oxidized soy oil)} and four levels of PGPR were used in a 3×4 factorial arrangement. The trial had 12 different dietary treatments: (T1) basal ration (BR) containing SO without PGPR supplementation, (T2) BR containing PO without PGPR supplementation, (T3) BR containing OO without PGPR supplementation, (T4) BR containing SO with PGPR supplementation (0.025%), (T5) BR containing PO with PGPR supplementation (0.025%), (T6) BR containing OO with PGPR supplementation (0.025%), (T7) BR containing SO with PGPR supplementation (0.035%), (T8) BR containing PO with PGPR supplementation (0.035%), (T9) BR containing OO with PGPR supplementation (0.035%), (T10) BR containing SO with PGPR supplementation (0.045%), (T11) BR containing PO with PGPR supplementation (0.045%), (T12) BR containing OO with PGPR supplementation (0.045%). Results revealed that interaction was present for fat sources and PGPR levels in the current experiment ($p<0.05$) for feed conversion ratio, body weight, dry matter (DM) and crude fat (CF) digestiblities ($p<0.05$). In overall trial, interaction results of PGPR and fat sources showed that performance of birds and nutrient digestiblities of DM and CF was increased in birds received diet contained SO and PGPR @ 0.35%. It is concluded that PGPR @ 0.035% could be successfully used in broiler ration contained soy oil to improve the performance.

INTRODUCTION

In commercial broiler diets, vegetable oils and animal fats are being used to improve the growth rate and feed efficiency (Blanch *et al.*, 1996; Tavárez *et al.*, 2011; Zhang *et al.*, 2011). However, the lower potential to synthesis and secrete bile salts in young broilers results in lower digestibility of fats and poor performance of growing broiler (Noy & Sklan 1998; Upadhaya *et al.*, 2017). Several researchers reported that addition of external emulsifiers in the diet of broilers improves fat digestibility and growth rate of broiler (Emmert *et al.*, 1996; Huang *et al.*, 2007; Zaefarian *et al.*, 2015; Zhang *et al.*, 2011; Zhao *et al.*, 2015). Different types of emulsifiers are being used in the diet of poultry to enhance fat digestibility, growth rate, feed efficiency and meat quality (Emmert *et al.*, 1996; Huang *et al.*, 2007; Zaefarian *et al.*, 2015; Zhang *et al.*, 2011; Zhao *et al.*, 2015). Examples of commercially available emulsifier for poultry are sodium stearoyl-2-lactylate (SSL), 1, 3- Diacyl glycerol, lyso phospholipids, lyso phosphatidylcholine, Tween 80, Tween 20, and soy lecithin (Roy *et al.*, 2010; Upadhaya *et al.*, 2016; Upadhaya *et al.*, 2017; Zaefarian *et al.*, 2015; Zhang *et al.*, 2011; Zhao *et al.*, 2015). The selection of external emulsifier is critical and depends upon the fat sources used in the broiler diet. Generally, emulsifier hydrophilic-lipophilic balance (HLB) is considered a good criterion to select a suitable external emulsifier for poultry diet (Hasenhuettl & Hartel 2008). For example, in the study of Upadhaya *et al.* (2017) 'sodium stearoyl-2-lactylate' HLB value of 20 have been used in broiler ration. Similarly, Upadhaya *et al.* (2017) also used 'Tween 20' with an HLB value of 12 in the ration of broilers.

Polyglycerol polyricinoleate (PGPR) is a commercially available emulsifier made from glycerol and fatty acids with an HLB value of 16. Polyglycerol polyricinoleate is well known emulsifier for food industry (Bastida-Rodríguez, 2013). However, there is no available study, that evaluated the effects of PGPR on intake, growth, nutrient digestibility and meat quality of broilers. Therefore, the purpose of the current research was to introduce a new emulsifier in the broiler industry. However, some researchers reported that the inclusion of emulsifier in broilers diets had no effects on performance of broiler (Roy *et al.*, 2010; Upadhaya *et al.*, 2016; Upadhaya *et al.*, 2017; Zhang *et al.*, 2011; Zhao *et al.*, 2015). Furthermore, researchers also reported that inclusion of external emulsifier in the diet of broiler performed differently on different fat sources (Roy *et al.*, 2010; Upadhaya *et al.*, 2016; Upadhaya *et al.*, 2017; Zhang *et al.*, 2011; Zhao *et al.*, 2015). Therefore, current experiment was planned to evaluate the effects of three fat sources (Soy oil, poultry oil, and oxidized oil (soy oil)) with different levels of PGPR supplementation on feed intake (FI), body weight (BW), feed conversion ratio (FCR), nutrient digestibility, meat quality, and carcass percentage. It was hypothesized that PGPR inclusion in the diet of broilers would improve the growth of broiler by enhancing the nutrient digestibility and this effect might be influenced by fat type.

MATERIAL AND METHODS

Experimental design, animal husbandry and experimental diets

The current study was carried out in completely randomized experimental design (CRD). Three fat sources and four levels of PGPR were used in a 3×4 factorial arrangement. Fat sources were soy oil, poultry oil, and oxidized oil (soy oil)), while levels of PGPR were 0, 0.025%, 0.035% and 0.045%. The trial had 12 different dietary treatments. Treatments were, (T1) basal ration (BR) contained soy oil without PGPR inclusion, (T2) BR contained poultry oil without PGPR inclusion, (T3) BR contained oxidized oil without PGPR inclusion, (T4) BR contained soy oil with PGPR inclusion @ 0.025%, (T5) BR contained poultry oil with PGPR inclusion @ 0.025%, (T6) BR contained oxidized oil with PGPR inclusion @ 0.025%, (T7) BR contained soy oil with PGPR inclusion @ 0.035%, (T8) BR contained poultry oil with PGPR inclusion @ 0.035%, (T9) BR contained oxidized oil with PGPR inclusion @ 0.035%, (T10) BR contained soy oil with PGPR inclusion @ 0.045%, (T11) BR contained poultry oil with PGPR inclusion @ 0.045%, (T12) BR contained oxidized oil with PGPR inclusion @ 0.045%.

A total of 720, day-old male broiler chicks were procured from a local hatchery. Chicks were divided into 12 treatments in such a way that each treatment had six replicates and each replicate had ten chicks. The duration of experimental period was 35 days. Flushing was done with the help of sugar solution (1kg sugar/5L water) on first day of experiment. Brooding temperature was set at 95 °F for first week. Temperature was decreased by 5° F every week until it reached at 75 °F. During the experimental period it was ensured that all birds received feed and water ad libitum. All vaccination schedule was practiced according to the suggestion of a veterinarian. The diets were corn-soybean based and formulated to meet or exceed the nutrient requirement of growing broiler as recommended by NRC 2004. All the ingredients used in the formulation of the experimental diets were supplied by commercial feed mill (Five Star Feeds Pvt. Ltd. Gujranwala, Pakistan). The ingredient data used in the diet formulation were taken from Brazilian tables for Poultry and Swine. All diets were formulated on digestible amino acids (AA) basis keeping lysine as reference AA. Experiment was divided into three dietary phases that were starter phase, grower phase and finisher phase as shown in table 1. The starter dietary phase was consisted of 0–8 days. The grower dietary phase was consisted of 9-21 days while finisher dietary phase was consisted of 22–35 days. The experimental protocol was approved by synopsis committee University of Veterinary and Animal Sciences, Lahore. Experimental procedures were followed by the guidelines and code of practice of University of Veterinary and Animal Sciences, Lahore. Permission of all experiment procedures were granted by ethical approval committee of University of Veterinary and Animal Sciences, Lahore. Birds were ensured free from hunger and thirst as described in previous research of animals (Aziz ur Rahman *et al.*, 2017; Rahman *et al.*, 2019).

Table – 1 Composition of experimental basal diets.

	Starter (day 1- 10)			Grower (day 11- 22)			Finisher (day 23- 35)		
	[1]SO	[2]PF	[3]OO	[1]SO	[2]PF	[3]OO	[1]SO	[2]PF	[3]OO
Corn	54.60	54.71	54.71	60.03	60.75	60.75	64.09	64.72	64.72
Soybean Meal	29.72	29.70	29.70	27.06	27.11	27.11	20.77	20.88	20.88
Rice Polish	4.00	4.00	4.00	3.74	2.96	2.96	2.435	1.788	1.788
Canola Meal	4.00	4.00	4.00	0.00	0.00	0.00	1.91	1.81	1.81
Fish Meal	0.00	0.00	0.00	3.00	3.00	3.00	5.50	5.50	5.50
Soy Oil	3.00	0.00	0.00	3.00	0.00	0.00	3.00	0.00	0.00
Poultry Fat	0.00	3.00	0.00	0.00	3.00	0.00	0.00	3.00	0.00
Oxidised Oil	0.00	0.00	3.00	0.00	0.00	3.00	0.00	0.00	3.00
L-Lysine SO4	0.609	0.610	0.610	0.461	0.462	0.462	0.374	0.375	0.375
dL-Methionine	0.377	0.376	0.376	0.321	0.321	0.321	0.260	0.260	0.260
L-Threonine	0.209	0.209	0.209	0.15	0.15	0.15	0.102	0.103	0.103
Salt	0.539	0.535	0.535	0.293	0.296	0.296	0.237	0.238	0.238
$CaCO_3$	1.277	1.286	1.286	1.140	1.133	1.133	0.931	0.930	0.930
Arginine	0.115	0.115	0.115	0.055	0.058	0.058	0.04	0.041	0.041
Monocalcium Phosphate	1.394	1.299	1.299	0.59	0.600	0.600	0.191	0.195	0.195
Phytase (10,000 FTU)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
[4]Vitamin/Min Premix/*Emulsifier	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100	100	100	100	100
Ether Extract%	5.89	5.9	5.9	6.3	6.2	6.2	6.45	6.37	6.37
Crude Protein%	21	21	21	20	20	20	19	19	19
ME (kcal/kg)	3,000	3,000	3,000	3,100	3,100	3,100	3,150	3,150	3,150
Calcium, %	0.96	0.96	0.96	0.87	0.87	0.87	0.8	0.8	0.8
Available P, %	0.48	0.48	0.48	0.43	0.43	0.43	0.4	0.4	0.4
Sodium, %	0.23	0.23	0.23	0.16	0.16	0.16	0.16	0.16	0.16
Digestible Lys, %	1.28	1.28	1.28	1.15	1.15	1.15	1.03	1.03	1.03
Digestible Met, %	0.65	0.65	0.65	0.602	0.602	0.602	0.55	0.55	0.55
Digestible Met + cys, %	0.95	0.95	0.95	0.87	0.87	0.87	0.8	0.8	0.8
Digestible Thr, %	0.86	0.86	0.86	0.77	0.77	0.77	0.69	0.69	0.69
Digestible Arg, %	1.37	1.37	1.37	1.23	1.23	1.23	1.1	1.1	1.1

[1] Soy Oil, [2]Poultry Fat, [3]Oxidized Soy Oil

[4]Vitamin and Mineral Premix: Each kilogram contained: Vit. A, 7 000 I.U; Vit. D_3, 2 500 I.U; Vit. E, 30 mg; of Vit. K_3 1 mg; Vit. B_1, 1.5 mg; Vit. B_2, 4 mg; Vit. B_6, 2 mg; Vit. B_{12}, 0.02 mg; niacin, 30 mg; folic acid, 0.55 mg; pantothenic acid, 10 mg; biotin, 0.16 mg; choline chloride, 400 mg; Copper, 20 mg; Iron, 70 mg; Manganese, 100 mg; Zinc, 70 mg; Iodine, 0.4 mg and Selinium, 0.5 mg

*Level of polyglycerol polyricinoleate was 0, 0.025, 0.035 and 0.045% in Soy Oil, Poultry Fat, Oxidized Soy Oil based diet for each phase, respectively. Polyglycerol polyricinoleate was mixed in premix

Performance parameters

To measure the FI, growth rate and performance parameters standard procedures were adopted as described in recent study (Sharif *et al.*, 2018). In brief, chicks and offered feed were weighed by pen at day 1, 21 and 35 of experiment. Feed intake was calculated, BWG and FCR were measured for the overall period.

Fecal samples

From days 35 to 37, fecal samples were collected from each pen by total collection method as described in the literature (Wang *et al.*, 2008). In brief, a plastic sheet was spread in each pen before the start of digestibility trial. After every 24h, total feces were collected from each pen carefully. Contaminants such as scales, feathers, down, straws, and other fine dust particle were removed. Collected samples were packed in sealed plastic bags. Sealed plastic bags were stored at -30 °C in refrigerator until further analysis. Furthermore, collected samples were grounded in grinder having 0.5-mm sieve. Grounded samples were further analyzed for chemical analysis as described in recent studies (Hussain *et al.*, 2018a; Hussain *et al.*, 2018b; Muhammad *et al.*, 2016; Xia *et al.*, 2018).

Nutrient digestibilities determination

For determination of digestibilities of nutrients, collected feed and excreta samples were analyzed for dry matter (DM) and crude fat determination. Dry matter and crude fat were determined using the protocol of AOAC (1995). The resulting values were used to calculate the DM and crude fat digestiblities as described in the recent studies (Anjum *et al.*, 2019;

Hussain *et al.*, 2018; Keles *et al.*, 2019; Sharif *et al.*, 2018; Tiwana *et al.*, 2019;).

Carcass and meat quality parameters determination

For determination of carcass and meat quality parameters standard procedures were followed as described in literature. In brief, two broilers were arbitrarily selected from each replicate within a treatment to measure live BW at day 35 of the trial. After slaughtering and depluming of feathers, head, viscera, and shanks were separated. Then portioning of the carcass was done to obtain the weight of breast, legs, live weight, carcass weight, thigh meat yield, and breast meat yield. Similarly, meat obtained was used for meat quality parameters determination.

Statistical analysis

Collected data were analyzed to check the significance of the treatments by using standard statistical procedure. In brief, data were subjected to ANOVA using the GLM procedure of SPSS. The models included main effects of fat sources (soy oil, poultry oil, and oxidized oil) and PGPR inclusion (0, 0.025%, 0.035% and 0.045%), and their interactions. Each pen was considered an experimental unit.

RESULTS

Growth performance

Results for growth performance are shown in table 2. Results revealed that fat source has effect on BWG and FCR in both starter and grower periods. Body weight gain was higher ($p<0.05$) for birds which were on a basal diet containing vegetable oil as compared to other diets both in starter and overall trial. Similarly, birds showed better FCR ($p<0.05$) which were on basal diet containing vegetable oil as compared to other fat sources both in starter and overall trial. Results also

Table 2 – Effect of fat type and polyglycerol polyricinoleate addition levels to broiler diets on performance of broiler.

		0-21 days			0-35 days		
		Performance indicators			Performance indicators		
		F.I (g)	WG (g)	FCR	F.I (g)	WG (g)	FCR
Oil Sources							
Poultry fat		1225	893 ab	1.37 b	3495 ab	2076 b	1.68 b
Soy oil		1230	918 a	1.34 c	3546 a	2157 a	1.64 c
Oxidized oil		1202	857b	1.40a	3419 b	1944c	1.76 a
p value		0.5026	0.0479	<0.0001	0.0410	<0.0001	<0.0001
[1]SE		25.364	18.63	0.0046	48.95	27.57	0.0119
[2]PGPR level							
0		1190	853	1.39 a	3529	2030 a	1.74 a
250		1222	889	1.37 b	3444	2035 a	1.69 b
350		1235	909	1.36 c	3516	2106 a	1.67 b
450		1229	905	1.35 c	3458	2064 a	1.67 b
p value		*0.4265*	*0.0479*	*<0.0001*	*0.3516*	*0.0783*	*<0.0001*
SE		29.28	21.51	0.0053	56.531	31.836	0.0137
Interactions							
Oil Sources	PGPR level						
Poultry fat	0	1187	859	1.38bc	3508 a	2024 abc	1.73 abc
	250	1216	880	1.38 bcd	3431 a	2050 abc	1.67 cd
	350	1251	921	1.36 cd	3584 a	2161 a	1.65 cd
	450	1248	911	1.36 bcd	3457 a	2068 abc	1.67 cd
Soy oil	0	1185	863	1.37 bcd	3593 a	2140 ab	1.67bcd
	250	1263	936	1.35 de	3539 a	2145 a	1.65 d
	350	1254	949	1.32 e	3529 a	2172 a	1.62 d
	450	1219	923	1.32 e	3523 a	2170 a	1.62 d
Oxidized oil	0	1199	837	1.43 a	3487 a	1928 c	1.81 a
	250	1188	851	1.39 b	3361 a	1911 c	1.76 ab
	350	1199	859	1.39 b	3434 a	1986 abc	1.73 abc
	450	1222	880	1.38 bc	3394 a	1953 bc	1.74 abc
p value		*0.8382*	*0.8575*	*0.0549*	*0.9182*	*0.8621*	*0.9796*
SE		50.72	37.27	0.0092	97.915	55.141	0.0237

[1]SE; standard error, [2] Polyglycerol polyricinoleate

Means with different superscripts in a column differ significantly ($p<0.05$)

showed main effects for PGPR level on FCR in both starter and overall periods. Birds showed poorest FCR ($p<0.05$) at PGPR inclusion level of 0. There were PGPR by fat source interactions during the starter phase for FCR ($p<0.05$). PGPR by fat source interactions showed that supplementation of PGPR improved the FCR ($p<0.05$) irrespective of fat sources during 0-21 days of experimental period. However, supplementation of PGPR in basal diet contained vegetable fat source had better FCR ($p<0.05$) than other fat sources. Interaction results of PGPR and diet contained vegetable fat showed better FCR when PGPR was supplemented @ 0.035%. In the overall trial, interactions were present for PGPR by fat source for both BWG and FCR ($p<0.05$). Findings of interaction revealed that inclusion of PGPR in fat sources improved the BWG and FCR ($p<0.05$) irrespective to fat sources in the overall trial. In the interaction of PGPR by fat source, it was revealed that BWG was improved in birds which received a diet contained vegetable fat source and supplemented with PGPR @ 0.035%**.** Similarly, in the case of FCR, birds showed better performance which received diet contained vegetable fat source and supplemented with PGPR @ 0.035%.

Nutrient digestibility

Results of nutrient digestibility are presented in table 3. Results revealed main effects for fat source on crude fat and DM digestibility. The birds showed better digestibility ($p<0.05$) for both crude fat and DM which were on a basal diet containing vegetable oil as compared to other diets. Results also showed main effects for PGPR level on DM and crude fat digestibility. Birds showed poorest DM and crude fat digestibility ($p<0.05$) at PGPR inclusion level of 0. There were PGPR by fat source significant interactions observed on crude fat and DM digestiblities ($p<0.05$). PGPR by fat source interactions showed that supplementation

Table 3 – Effect of fat type and polyglycerol polyricinoleate addition levels to broiler diets on nutrient digestibility.

		Nutrient Digestibility		
Fat Sources		Crude Fat	Nitrogen	Dry Matter
Poultry fat		79.56 [b]	72.41	71.42 [b]
Soy oil		82.72 [a]	72.97	72.27 [a]
Oxidized oil		72.37 [c]	71.75	70.07 [c]
p value		*<0.0001*	*0.0621*	*<0.0001*
SE		0.3074	0.4871	0.2545
Levels				
0		76.58 [b]	71.80	70.66 [b]
250		78.21 [a]	72.37	71.16 [ab]
350		79.01 [a]	72.59	71.75 [a]
450		79.07 [a]	72.74	71.46 [ab]
p value		<0.0001	0.3796	0.0082
SE		0.3550	0.5624	0.2939
Interaction				
Fat Sources	PGPR Levels			
Poultry fat	0	78.14 [d]	71.71	70.78 [bcde]
	250	79.68 [cd]	72.57	71.17 [abcd]
	350	80.26 [bcd]	72.15	71.87 [abcd]
	450	80.15 [bcd]	73.21	71.88 [abcd]
Soy oil	0	81.13 [bc]	72.17	72.03 [abc]
	250	82.14 [ab]	72.85	71.83 [abcd]
	350	83.70 [a]	73.92	72.84 [a]
	450	83.92 [a]	72.94	72.40 [ab]
Oxidized Oil	0	70.48 [f]	71.52	69.17 [e]
	250	72.80 [e]	71.71	70.47 [cde]
	350	73.08 [e]	71.70	70.55 [cde]
	450	73.15 [e]	72.07	70.12 [de]
p value		*0.5858*	*0.8065*	*0.5038*
SE		0.6149	0.9741	0.5090

[1]SE; standard error, [2] Polyglycerol polyricinoleate

Means with different superscripts in a column differ significantly ($p<0.05$)

of PGPR in fat sources increased the DM and crude fat digestibility ($p<0.05$) irrespective of fat sources. However, supplementation of PGPR in basal diet contained vegetable fat source had better crude fat and DM digestibility ($p<0.05$) as compared to other fat sources. Interaction results of PGPR and diet contained vegetable fat showed higher DM and crude fat digestiblities when PGPR was supplemented at a higher level.

Meat quality parameters

Results of meat quality parameters are showed in table 4. Results showed no main effects of fat sources and PGPR levels on the quality parameters of meat

Table 4 – Effect of fat type and polyglycerol polyricinoleate addition levels to broiler diets on meat quality of broilers.

		Meat quality indicators					
		Chroma	HUe	Lightness	Redness	Yellowness	pH
Oil Sources							
Poultry fat		27.71	56.87	52.56	13.14	23.26	6.07
Soy oil		27.55	57.60	52.30	13.18	22.78	6.05
Oxidized oil		27.47	57.72	52.22	13.20	23.08	6.07
p value		*0.904*	*0.731*	*0.892*	*0.978*	*0.691*	*0.71*
SE		0.547	1.172	0.750	0.301	0.559	0.028
PGPR Levels							
0		27.46	55.74	51.41	13.16	23.07	6.04
250		27.54	56.77	52.33	13.16	22.58	6.04
350		27.77	57.97	53.06	13.29	23.00	6.10
450		27.54	59.11	52.65	13.08	23.51	6.06
p value		*0.964*	*0.084*	*0.283*	*0.945*	*0.559*	*0.207*
[1]SE		0.631	1.354	0.866	0.347	0.646	0.032
Interaction							
Oil Sources				[2]PGPR Levels			
Poultry fat	0	27.40	54.75	51.00	13.50	22.76	6.03
	250	28.05	57.99	53.08	13.48	22.95	6.08
	350	27.37	56.72	52.54	12.83	21.93	6.09
	450	28.03	58.00	53.63	12.74	25.39	6.07
Soy oil	0	27.40	55.51	51.27	12.97	22.68	6.01
	250	27.44	58.25	52.70	12.71	22.16	6.03
	350	28.06	56.25	52.43	13.75	22.78	6.13
	450	27.30	60.41	52.49	13.30	23.50	6.04
Oxidized oil	0	27.57	56.97	51.96	13.02	23.77	6.10
	250	27.15	54.06	51.22	13.27	22.62	6.02
	350	27.89	60.93	54.19	13.29	24.29	6.10
	450	27.28	58.93	51.27	13.21	21.63	6.08
p value		*0.9518*	*0.1386*	*0.5318*	*0.4398*	*0.0190*	*0.6435*
SE		1.094	2.345	1.500	0.602	1.119	0.056

[1]SE; standard error, [2] Polyglycerol polyricinoleate

Means with different superscripts in a column differ significantly ($p<0.05$)

($p>0.05$). Similarly, there was no interaction for fat sources and PGPR levels on the quality parameters of meat ($p>0.05$) table 5.

DISCUSSION

The purpose of this experiment was to check the effects of PGPR inclusion in the diet of broiler on the FI, BWG, nutrient digestibility, carcass parameters, and meat quality. The other objective of current study was to optimize the level of PGPR on different fat sources in the diet of broilers. The results in the current study supported the hypothesis that fat sources in the diet of broiler influence the performance of broilers. The results in this study also supported the hypothesis that PGPR supplementation would enhance the performance of broiler chickens by increasing the nutrient digestibility.

In the overall trial, it was observed that fat sources changed the performance of the birds in term of BW and FCR. Birds gained more BW and had a better FCR when fed a diet contained soy oil. Perforamnce results of current study were similar with the findings of Zhang *et al.* (2011). Zhang *et al.* (2011) reported that broiler fed vegetable oil sources diet perform better as compare

Table 5 – Effect of fat type and polyglycerol polyricinoleate addition levels to broiler diets on carcass parameters.

		Carcass parameters				
		Breast %	Dressing%	Fat %	Liver %	Thigh %
Fat Sources						
Poultry fat		34.35	64.56	2.48	2.88	5.43
Soy oil		34.93	65.49	2.35	2.86	5.53
Oxidized oil		33.95	63.89	2.42	2.81	5.27
p value		*0.1461*	*0.0694*	*0.8450*	*0.8160*	*0.3168*
SE		0.4926	0.6821	0.2266	0.0991	0.1697
PGPR Levels						
0		33.86	64.00	2.65	2.82	5.25
250		34.52	64.46	2.38	2.85	5.37
350		34.75	65.24	2.29	2.87	5.52
450		34.51	64.89	2.37	2.86	5.49
p value		0.4447	0.4350	0.5547	0.9649	0.5086
[1]SE		0.5688	0.7876	0.2617	0.1144	0.1960
Interactions						
Fat Sources	[2]PGPR Levels					
Poultry fat	0	33.47	63.77	2.78	2.83	5.23
	250	34.86	64.49	2.26	2.89	5.36
	350	34.70	64.88	2.31	2.89	5.55
	450	34.37	65.11	2.59	2.90	5.56
Soy oil	0	34.59	65.19	2.45	2.84	5.43
	250	34.79	65.27	2.40	2.84	5.48
	350	35.49	66.44	2.44	2.89	5.75
	450	34.85	65.06	2.13	2.86	5.48
Oxidized oil	0	33.53	63.05	2.70	2.78	5.10
	250	33.92	63.62	2.49	2.82	5.29
	350	34.06	64.39	2.12	2.83	5.29
	450	34.30	64.49	2.39	2.83	5.42
p value		*0.9731*	*0.9770*	*0.9107*	*1.0000*	*0.9870*
SE		0.9852	1.3641	0.4532	0.1981	0.3395

[1]SE; standard error, [2] Polyglycerol polyricinoleate

Means with different superscripts in a column differ significantly ($p<0.05$)

to broiler on a diet contained animal sources fat. Other researchers also reported similar findings (Chung *et al.*, 1993; Dänicke *et al.*, 1997; Tancharoenrat *et al.*, 2013; Zollitsch *et al.*, 1997). In broiler production, it is generally considered that broilers perform better on diet contained vegetable oil sources (Chung *et al.*, 1993; Dänicke *et al.*, 1997; Tancharoenrat *et al.*, 2013; Zollitsch *et al.*, 1997). Chung *et al.* (1993) reported that broilers received a diet contained vegetable oil gained more weight in starter phase as compared to broilers received a diet contained animals fat sources. Chung *et al.* (1993) also reported that broilers had better FCR on a diet contained sunflower oil as compared to those broilers received a diet contained tallow. Dänicke *et al.* (1997) also observed better BW and FCR in broilers fed soy oil diets than in those broilers that were fed feed contained tallow as the energy source. However, in the current study lowest BW and FCR was observed in the birds contained oxidized oils which was expected due to presence of aldehydes, ketones, esters, and polymerized oils in oxidized oils that reduce fat retention and energy value of the diet (Engberg *et al.*, 1996). Our findings are also supported by the results of Tavárez *et al.* (2011) who observed that oxidized oil in the feed of broiler reduce BW.

Current study results revealed that increasing the level of PGPR in diet contained soy oil as fat source improved the FCR in starter phase. Furthermore, increasing the level of PGPR in diet contained soy oil as fat source improved both FCR and BW in the overall trial. Our findings are similar with the findings of Upadhaya *et al.* (2017) who observed a strong positive correlation between external emulsifier contents in the feed of broilers and BW gain of broilers. Furthermore, Upadhaya *et al.* (2017) also reported a strong negative correlation between external emulsifier contents in the feed of broiler and FCR. The improvement in gain in BW and better feed efficiency observed during the starter as well as the overall period of current experiment was due to the inclusion of external emulsifier in the feed of broilers. Emulsifier is known to improve performance by digestion of fats and support birds to overcome the inefficiency of lipase before 40 days of age in broilers (Tancharoenrat *et al.*, 2013).

Lower potential to synthesis and secretes bile salts in young broilers results in lower digestibility of fats and poor performance of growing broiler (Noy & Sklan 1998; Upadhaya *et al.*, 2017). Broiler at an early age had less fat digestion capacity as compared to mature birds (Tancharoenrat *et al.*, 2013). However, the inclusion of external emulsifier or synthetic emulsifier in the feed of broiler improve fat digestion and absorption in young chickens (Alzawqari *et al.*, 2011; Dierick & Decuypere 2004; Maisonnier *et al.*, 2003; Roy *et al.*, 2010; Upadhaya *et al.*, 2017; Zaefarian *et al.*, 2015; Zhao *et al.*, 2015). It has also been reported that inclusion of external emulsifier or synthetic emulsifier in the feed of broiler improve production performance in broilers (Alzawqari *et al.*, 2011; Dierick & Decuypere 2004; Maisonnier *et al.*, 2003; Roy *et al.*, 2010; Upadhaya *et al.*, 2017; Zaefarian *et al.*, 2015; Zhao *et al.*, 2015). Thus, in the current study, the inclusion of different levels of external emulsifier (PGPR) in the feed of broilers was expected to enhance the digestibility of dietary fat irrespective of fat sources. In the current study, the digestibility of DM and crude fat was improved with the increase in the inclusion levels of external emulsifier which is in agreement with a study of Upadhaya *et al.* (2017) who stated that increasing the level of emulsifier enhance the DM and crude fat digestibility of the diet. Similarly, Roy *et al.* (2010) also observed improved DM and fat digestibility in broilers fed diet had external emulsifier (glycerol polyethylene glycol ricinoleate) @ of 1% and 2% of added fat. Upadhaya *et al.* (2017) observed a positive correlation between external emulsifier contents in the feed of broiler and DM and fat digestibilities. Other researchers also reported that different external or synthetic emulsifiers such as lysophospholipid and 1, 3 diacylglycerol improve fat digestibility when a basal ratio of broilers and weaning pigs was supplemented with graded levels of emulsifier (Upadhaya *et al.*, 2016; Upadhaya *et al.*, 2017; Zhao *et al.*, 2015). In the recent study of Upadhaya *et al.* (2017), it was observed that DM digestibility was strongly correlated with fat digestibility. Current study result of DM digestibility and fat digestibility proved the findings Upadhaya *et al.* (2017) that DM digestibility and fat digestibility had strong correlation. In our study, higher digestiblities of DM and fat was the reason of improved growth performance of broilers. However, in the current study, fat sources and emulsifier did not influence the carcass and meat parameters of broilers. Our findings of carcass and meat parameters are similar with the results of previous researchers (Upadhaya *et al.*, 2016; Upadhaya *et al.*, 2017; Zhao *et al.*, 2015).

CONCLUSION

Based on the results, it is concluded that PGPR supplementation in fat sources improved the body weight, feed conversion ratio, digestibility of crude fat and dry matter in broilers. However, supplementation of PGPR @ 0.035% in basal diet contained soy oil showed comparatively higher performance than other fat sources in growing broilers.

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