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

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) digestibilities (p<0.05). In overall trial, interaction results of PGPR and fat sources showed that performance of birds and nutrient digestibilities 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 phosphatidylycholine, Tween 80, Tween 20, and soy lecithin (Roy et al., 2010; Upadhaya et al., 2016; Upadhaya...
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Zhao 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 (Hasenhut et al. and 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 rations. 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-Rodriguez, 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 3x4 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).
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Table 1. Composition of experimental basal diets.

|                   | Starter (day 1-10) | Grower (day 11-22) | Finisher (day 23-35) |
|-------------------|--------------------|---------------------|----------------------|
|                   | 'SO | 'PF | 'OO | 'SO | 'PF | 'OO | 'SO | 'PF | '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 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Poultry Fat       | 0.00 | 3.00 | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 3.00 | 0.00 |
| Oxidized 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              | 0.359| 0.355| 0.355| 0.293| 0.296| 0.296| 0.237| 0.238| 0.238|
| CaCO3             | 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 |
| *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 |
| Digestable Lys, % | 1.28 | 1.28 | 1.28 | 1.15 | 1.15 | 1.15 | 1.03 | 1.03 | 1.03 |
| Digestable Met, % | 0.65 | 0.65 | 0.65 | 0.602| 0.602| 0.602| 0.55 | 0.55 | 0.55 |
| Digestable 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, 2Poultry Fat, 3Oxidized Soy Oil
*Vitamin and Mineral Premix: Each kilogram contained: Vit. A, 7,000 I.U; Vit. D3, 2,500 I.U; Vit. E, 30 mg; of Vit. K, 1 mg; Vit. B1, 1.5 mg; Vit. B2, 4 mg; Vit. B6, 2 mg; Vit. B12, 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 Selenium, 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 digestibilities 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 depilming 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. |
|---------------------------------------------------------------|
| **Performance indicators**                                    |
| **0-21 days**                                                 |
| **F.I (g) | WG (g) | FCR** |
| Poultry fat | Soy oil | Oxidized oil |
| 1225 | 893 ab | 1.37 b |
| 1230 | 918 a | 1.34 c |
| 1202 | 857b | 1.40 c |
| **p value** | 0.5026 | 0.0479 | <0.0001 |
| **SE** | 25.364 | 18.63 | 0.0046 |
| **0-35 days**                                                 |
| **F.I (g) | WG (g) | FCR** |
| Poultry fat | Soy oil | Oxidized oil |
| 3495 ab | 2076 b | 1.68 b |
| 3546 a | 2157 a | 1.64 c |
| 3419 b | 1944 a | 1.76 a |
| **p value** | 0.0410 | <0.0001 | <0.0001 |
| **SE** | 48.95 | 27.57 | 0.0119 |
| **PGPR level**                                                |
| 0 | 1190 a | 853 a | 1.39 a |
| 250 | 1222 b | 889 b | 1.37 b |
| 350 | 1235 c | 909 c | 1.36 c |
| 450 | 1229 d | 905 d | 1.35 d |
| **p value** | 0.4265 | 0.0479 | <0.0001 |
| **SE** | 29.28 | 21.51 | 0.0053 |
| **Interactions**                                              |
| Oil Sources | PGPR level |
| Poultry fat | 0 | 1187 ab | 859 ab | 1.38 ab |
| 250 | 1216 a | 880 a | 1.38 ac |
| 350 | 1251 a | 921 a | 1.36 ad |
| 450 | 1248 a | 911 a | 1.36 ac |
| **p value** | 0.8382 | 0.8575 | 0.8549 |
| **SE** | 50.72 | 37.27 | 0.0092 |
| Soy oil | 0 | 1185 ab | 863 ab | 1.37 ab |
| 250 | 1263 a | 936 a | 1.35 ab |
| 350 | 1254 a | 949 a | 1.32 ac |
| 450 | 1219 a | 923 a | 1.32 a |
| **p value** | 0.9182 | 0.8621 | 0.9796 |
| **SE** | 50.72 | 37.27 | 0.0092 |
| Oxidized oil | 0 | 1199 ab | 837 ab | 1.43 ab |
| 250 | 1188 a | 851 a | 1.39 a |
| 350 | 1199 a | 859 a | 1.39 b |
| 450 | 1222 a | 880 a | 1.38 bc |
| **p value** | 0.8382 | 0.8575 | 0.0549 |
| **SE** | 50.72 | 37.27 | 0.0092 |
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 digestibilities ($p<0.05$). PGPR by fat source interactions showed that supplementation

| Nutrient Digestibility | Crude Fat | Nitrogen | Dry Matter |
|------------------------|-----------|----------|------------|
| **Fat Sources**        |           |          |            |
| 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 | Crude Fat | Nitrogen | Dry Matter |
|--------|-----------|----------|------------|
| 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 | PGPR Levels | Crude Fat | Nitrogen | Dry Matter |
|-------------|--------------|-----------|----------|------------|
| Fat Sources |              |           |          |            |
| Poultry fat | 0            | 78.14 a   | 71.71    | 70.78 b    |
|             | 250          | 79.68 cd  | 72.57    | 71.17 ab   |
|             | 350          | 80.26 bc  | 72.15    | 71.87 abcd |
|             | 450          | 80.15 bc  | 73.21    | 71.88 abcd |
| Soy oil     | 0            | 81.13 bc  | 72.17    | 70.03 bc   |
|             | 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 c    |
|             | 250          | 72.80 c   | 71.71    | 70.47 cde  |
|             | 350          | 73.08 a   | 71.70    | 70.55 cd   |
|             | 450          | 73.15 a   | 72.07    | 70.12 dc   |
| p value     | 0.5858       | 0.8065    | 0.5038    |
| SE          | 0.6149       | 0.9741    | 0.5090    |

1SE; standard error, 2 Polyglycerol polyricinoleate

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

| Oil Sources   | Chroma | HUe | Lightness | Redness | Yellowness | pH   |
|---------------|--------|-----|-----------|---------|------------|------|
| 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**

| p value       | 0.964  | 0.084| 0.283     | 0.945   | 0.559      | 0.207|
| SE            | 0.631  | 1.354| 0.866     | 0.347   | 0.646      | 0.032|

**Interaction**

| Oil Sources | PGPR Levels                                      |
|-------------|--------------------------------------------------|
| Poultry fat | Poultry fat, 0, 250, 350, 450 PGPR levels       |
|             | 27.46, 55.74, 51.41, 13.16, 23.07, 6.04         |
|             | 27.54, 56.77, 52.33, 13.16, 22.58, 6.04         |
|             | 27.77, 57.97, 53.06, 13.29, 23.00, 6.10         |
|             | 27.54, 59.11, 52.65, 13.08, 23.51, 6.06         |
| Soy oil     | Poultry fat, 0, 250, 350, 450 PGPR levels       |
|             | 27.40, 54.75, 51.00, 13.50, 22.76, 6.03         |
|             | 28.05, 57.99, 53.08, 13.48, 22.95, 6.08         |
|             | 27.37, 56.72, 52.54, 12.83, 21.93, 6.09         |
|             | 28.03, 58.00, 53.63, 12.74, 25.39, 6.07         |
| Oxidized oil| Poultry fat, 0, 250, 350, 450 PGPR levels       |
|             | 27.40, 55.51, 51.27, 12.97, 22.68, 6.01         |
|             | 28.06, 56.25, 52.43, 13.75, 22.78, 6.13         |
|             | 27.30, 60.41, 52.49, 13.30, 23.50, 6.04         |
| 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        |

**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 (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.
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

| Fat Sources | Breast % | Dressing% | Fat % | Liver % | Thigh % |
|-------------|----------|-----------|-------|---------|---------|
| 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    |

| PGPR Levels | Breast % | Dressing% | Fat % | Liver % | Thigh % |
|-------------|----------|-----------|-------|---------|---------|
| 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    |

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

Means with different superscripts in a column differ significantly (p<0.05)
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 & Decuyper 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 & Decuyper 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 digestibilities 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.

**REFERENCES**

Alzawqari M, Moghaddam HN, Kermanshahi H, Raji AR. 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 2011; 39(2):169-174.

Aziz ur Rahman M, Chuaqni X, Huwei S, Binghai C. Effects of hay grass level and its physical form (full length vs. chopped) on standing time, drinking time, and social behavior of calves. Journal of Veterinary Behavior: Clinical Applications and Research 2017; 21(Supplement C):7-12.

Anjum, A., U. Zafar, H. M. Awais and A. Shaqoor. 2019. Impact of Puddling on Water Productivity of Rice Under Raised Bed Technology. J. Glob. Innov. Agric. Soc. Sci.7(3):129-134.

Bastida-Rodriguez J. The Food Additive Polyglycerol Polyricinoleate (E-476): Structure, Applications, and Production Methods. Chem. Eng. 2013; 2013:21.

Blanch A, Barroeta A, Baucells M, Serrano X, Puchal F. Utilization of different fats and oils by adult chickens as a source of energy, lipid and fatty acids. Anim. Feed Sci. Technol. 1996, 61(1-4):335-342.

Chung H, Guenter W, Rotter R, Crow G, Stanger N. Effects of dietary fat source on sudden death syndrome and cardiac sarcoplasmatic reticular calcium transport in broiler chickens. Poult. Sci. 1993; 72(2):310-316.

Dânicic S, Simon O, Jeroch H, Bedford M. Interactions between dietary fat type and xylanase supplementation when rye-based diets are fed to broiler chickens 2. Performance, nutrient digestibility and the fat-soluble vitamin status of livers. Br Poult Sci 1997; 38(5):546-556.

Dierick N, Decuyper J. Influence of lipase and/or emulsifier addition on the ileal and faecal nutrient digestibility in growing pigs fed diets containing 4% animal fat. J. Sci. Food Agric. 2004; 84(12):1443-1450.

Emmett JL, Garrow JL, Baker DH. Development of an experimental diet for determining bioavailable choline concentration and its application in studies with soybean lecithin. J. Anim. Sci. 1996; 74(11):2738-2744.

Engberg RM, Lauridsen C, Jensen SK, Jakobsen K. Inclusion of oxidized vegetable oil in broiler diets. Its influence on nutrient balance and on the antioxidative status of broilers. Poult. Sci. 1996; 75(8):1003-1011.

Hasenhuettl GL, Hartel RW. Food emulsifiers and their applications. 2008 Springer,

Huang J, Yang D, Wang T. 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 2007; 20(12):1880.
Hussain MA, Mahmud A, Jussain J, Qaisrani S, Mehmoood S, Rehman A. Subsequent Effect of Dietary Lipone Regimens Fed in the Starter Phase on the Growth Performance, Carcass Traits and Meat Chemical Composition of Aseel Chicken in the Grower Phase. Brazilian Journal of Poultry Science 2018 (a); 20:455-462.

Hussain MA, Mahmud A, Hussain J, Qaisrani SN, Mehmoood S, Ahmad S, Rehman AU. Effect of dietary amino acid regimens on growth performance and body conformation and immune responses in Aseel chicken. Indian J Anim Res 2018 (b).

Hussain S., A.A. Khan, A. Shakoor, A. Goheer, T. Qadir, M.M. Khan and Z. Hussain. 2018. Effect of cold and heat stress on different stages of wheat: a review. J. Glob. Innov. Agric. Soc. Sci. 6(4):123-128.

Keles, R., H. Bayrak and G. Imriz. 2019. Determination of Grain Yield and Leaf Chlorophyll Content of Some Dry Bean (Phaseolus vulgaris L.) Varieties. J. Glob. Innov. Agric. Soc. Sci. 7(2):53-57.

Leeson S, Atteh J. Utilization of fats and fatty acids by turkey pouls. Poult. Sci. 1995; 74(12):2003-2010.

Maisonnier S, Gomez J, Bree A, Berri C, Baeza E, Carre B. Effects of microflora status, dietary bile salts and guar gum on lipid digestibility, intestinal bile salts, and histomorphology in broiler chickens. Poult. Sci. 2003; 82(5):805-814.

Muhammad AU, Xia CQ, Cao BH. Dietary forage concentration and particle size affect sorting, feeding behaviour, intake and growth of Chinese holstein male calves. J Anim Physiol Anim Nutr (Berl) 2016; 100(2):217-223.

Noy Y, Sklan D. Metabolic responses to early nutrition. J. Appl. Poult. Res. 1998; 7(4):437-451.

Rahman MA, Qi XC, Bingham C. Nutrient intake, feeding patterns and abnormal behavior of growing bulls fed different concentrate levels and a single fiber source (corn stover silage). Journal of Veterinary Behavior 2019; https://doi.org/10.1016/j.jveb.2019.03.003

Roy A, Haldar S, Mondal S, Ghosh TK. Effects of supplemental exogenous emulsifier on performance, nutrient metabolism, and serum lipid profile in broiler chickens. Vet Med Int 2010; 2010:262064.

Roy A, Haldar S, Mondal S, Ghosh TK. Effects of supplemental exogenous emulsifier on performance, nutrient metabolism, and serum lipid profile in broiler chickens. Veterinary medicine international 2010; 2010

Sharif M, Shoaib M, Rahman MAU, Ahmad F, Rehman SU. Effect of distillery yeast sludge on growth performance, nutrient digestibility and slaughter parameters in Japanese quails. Scientific Reports 2018; 8(1):8418.

Smits CH, Moughan PJ, Beynen AC. The inhibitory effect of a highly viscous carboxymethylcellulose on dietary fat digestibility in the growing chicken is dependent on the type of fat. J. Anim. Physiol. Anim. Nutr. 2000; 83(4-5):231-238.

Tancharoenrat P, Ravindran V, Zaefarian F, Ravindran G. Influence of age on the apparent metabolizable energy and total tract apparent fat digestibility of different fat sources for broiler chickens. Anim. Feed Sci. Technol. 2013; 186(3-4):186-192.

Tavarez MA, Bolier DD, Bess KN, Zhao J, Yan F, Diliger AC, McKeith FK, Killefer J. Effect of antioxidation inclusion and oil quality on broiler performance, meat quality, and lipid oxidation. Poult. Sci. 2011; 90(4):922-930.

Tiwana, U., S. Hafeez, H. M. Ahmad and Habib ur Rehman. 2019. Diet composition of a wildlife species in agri-ecosystems of Faisalabad, Punjab, Pakistan. J. Glob. Innov. Agric. Soc. Sci. 7(2):73-78.

Upadhyaya S, Park J, Yun H, Kim I. 283 Role of emulsifier as fat replacer in low density diet for growing and finishing pigs. J. Anim. Sci. 2016; 94(suppl.2):133-133.

Upadhyaya SD, Lee JS, Jung KJ, Kim IH. Influence of emulsifier blends having different hydrophilic-lipophilic balance value on growth performance, nutrient digestibility, serum lipid profiles, and meat quality of broilers. Poult. Sci. 2017; 97(1):255-261.

Wiseman J, Salvador F, Craigon J. Prediction of the apparent metabolizable energy content of fats fed to broiler chickens. Poult. Sci. 1991; 70(7):1527-1533.

Xia C, Liang Y, Bai S, He Y, Muhammad AUR, Su H, Cao B. Effects of harvest time and added molasses on nutritional content, ensiling characteristics and in vitro degradation of whole crop wheat. Asian-Australas. J. Anim. Sci. 2018; 31(3):354-362.

Zaefarian F, Romero LF, Ravindran V. Influence of high dose of phytase and an emulsifier on performance, apparent metabolizable energy and nitrogen retention in broilers fed on diets containing soy oil or tallow. Br Poult Sci 2015; 56(5):590-597.

Zhang B, Haitao L, Zhao D, Guo Y, Barry A. Effect of fat type and lysophosphatidylcholine addition to broiler diets on performance, apparent digestibility of fatty acids, and apparent metabolizable energy content. Anim. Feed Sci. Technol. 2011; 163(2-4):177-184.

Zhang B, Haitao L, Zhao D, Guo Y, Barry A. Effect of fat type and lysophosphatidylcholine addition to broiler diets on performance, apparent digestibility of fatty acids, and apparent metabolizable energy content. Anim. Feed Sci. Technol. 2011; 163(2-4):177-184.

Zhao P, Li H, Hossain M, Kim I. Effect of emulsifier (lysophospholipids) on growth performance, nutrient digestibility and blood profile in weanling pigs. Anim. Feed Sci. Technol. 2015; 207:190-195.

Zollitsch W, Knaus W, Aichinger F, Lettner F. Effects of different dietary fat sources on performance and carcass characteristics of broilers. Anim. Feed Sci. Technol. 1997; 68(1-4):63-73.
