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Replacing Soybean Oil in the Finisher Phase with Different Levels of Dry Protected Plant Fat and Two Forms of Feed and their Effect on Performance, Carcass Quality and Blood Parameters of Broilers

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Abstract: An experiment was conducted to evaluate the effect of different levels of dry fat (dried palm oil) as an energy source and two feed forms (mash and pelleted)used in the finisher stage on growth performance, carcass traits, meat quality and blood serum metabolites of broiler chickens. A total of 450 straight-run Lohmann broiler chicks reared in an open-sided house and fed corn-soybean meal based diet with SBM oil as a source of energy from 1-28d of age. On d 28 birds were randomly assigned to 6 dietary treatments of 3 different levels of dry fat (2, 4 and 6%) and 2 forms of feed in 3 x 2 factorial arrangements. Each treatment has 3 replicates with 25 birds each (75/treatment). Experiment lasted for 42d. Processing yields and cut-ups were determined on d 42 in addition to meat quality traits and serum lipid levels. The different% of dietary fat did not improve growth performance with the interaction of fat level and feed form. But it was highly significant (P<0.05) with pelleted feed. Also significant higher difference (P<0.05) was shown in heart% with 2% fat and gizzard% between mash and pelleted feed (1.44 vs. 1.19) and with 2% fat mash feed. Breast% had a higher significant result (P<0.05) in mash feed. Abdominal fat% at 4% fat was significantly lower than 2 and 6%. Different significance were shown in meat analysis such as DM, fat and ash% with the different levels of fat and forms of feed. No significant differences were shown in blood parameters such as LDL, HDL, Cholesterol and Triglycerides.

Key words: Dry fat, feed form, broiler performance, blood parameters

INTRODUCTION

The addition of fat to broiler diets is mainly to increase the energy density, since it is a concentrated source of energy, besides it improves the absorption of fat-soluble vitamins, diminishes the pulverulence and dustiness of feed reduces dust loss, increases the palatability of rations, a source of linoleic acid and lubricant for equipment in feed mills. The main objective of the poultry industry is to improve body weight and feed efficiency of the birds, therefore feed intake is an important factor in formulating the diet. Regulating dietary energy by supplementing fat is believed to be one of the most effective ways to adjust feed intake of broiler chicks, resulting in an improvement in feed efficiency (Pinchasov and Nir, 1992), by increasing the efficiency of the consumed energy (lower caloric increment) and decreasing feed intake. Studies (Harms *et al*., 2000; Bryant *et al*., 2005) showed that increasing dietary energy or fat supplementation decreased feed intake and improved Feed Conversion Ratio (FCR) of broiler chicks; this can decrease age at market. Furthermore, it reduces the passage rate of the digesta in the gastrointestinal tract which allows a better absorption of all nutrients present in the diet. The effects of fats and vegetable oils need to be examined not only for production characteristics but also for meat quality and blood parameters relative to human health (Ozdogan *et al*., 2003). A number of different fat sources are available for poultry from the vegetable sources. Soybean oil is the preferred fat source as it is perceived as the highest quality fat available. Other vegetable oils are sunflower oil, or palm oil. However, when different fat sources were fed as a portion of a complete ration, most experiments indicated no difference in performance parameters (Young, 1961; Fuller and Rendon, 1979; Quart *et al*., 1992; Pesti *et al*., 2002).

According to Smink *et al*. (2010), palm oil or mixtures of palm oil, fatty acids distilled from the palm and calcic soap are sources of vegetal oils with a fatty acid profile that might replace animal fats without any kind of negative impact on carcass quality.

Different types of feed forms have been evolved in broiler production at the present time. The physical form of feed (mash, pellet and crumble) is a crucial factor in meat yield of broilers (Jahan *et al*., 2006). The economic importance of poultry feeding becomes apparent when it is realized that 60-70% of the total production cost of poultry is feed cost, therefore the efficient use of feed is extremely important in broiler production.

Mash is a form of a complete feed that is finely ground and mixed so that birds cannot easily separate out ingredients; each mouthful provides a well balanced diet (Agah *et al*., 2008). Mash diet gives greater unification of growth, less death loss and it is more economical.

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However, ground feed is not so palatable and does not retain their nutritive value as well as ungrounded feed (Jahan *et al.*, 2006). Pellet system of feeding is really a modification of the mash system. It consists of mechanically pressing the mash into hard dry pellets or "artificial grains". Pelleted feeds are fed nearly exclusively to broilers and turkeys (Behnke, 1998). The benefits of pelleting include enhanced handling characteristics of feeds and improved bird performance. Pelleting increases bulk density and flowability and decreases spillage and wind loss. Improved weight gain: feed ratios from feeding pellets as compared with mash have been documented (Calet, 1965; Choi *et al.*, 1986; Nir *et al.*, 1994). Reasons for the enhanced performance may be due to increased digestibility, decreased ingredient segregation, reduction of energy during prehension and increased palatability (Behnke, 1998). The greatest advantage in using pellets is that there is little waste in feeding. Feeding of each form of feed has its advantages and disadvantages. The effectiveness, digestibility and conversion efficiency of different forms of feed are also different. But limited research work has been performed to investigate the effect of feeding different forms of feed (mash and pellets) on the productive performance of broilers in Jordan. In this situation the present study has been undertaken to investigate the effect of feeding mash and pellet feeds combined with different levels of dry fat and their interaction in the finisher stage on growth rate, feed efficiency and other productive characteristics of broiler chicks.

MATERIALS AND METHODS

Experimental birds: A total of 450 straight-run one-day-old broiler chicks of Lohmann strain were raised from day 1 to 28 as one group in an open-sided house. On day 28, birds were randomly selected and assigned to 6 experimental dietary treatments (75 birds each), with 3 replicates (pens) of 25 birds/pen. A (23L: 1D) lighting regimen was provided with all management practices for birds (including vaccination) which were in accordance with the recommended standard commercial guide program for the strain used.

Experimental diets: Birds were fed commercial pelleted starter and grower diets (two weeks each). All diets were corn-soybean based diet. Feed and water were provided *ad-libitum* throughout the experimental period. On day 28, they were given three fat levels (2, 4 and 6%) of plant dry fat (Polyfat) to give three dietary energy levels (3030,30130and3230Kcal/Kg) and two feed forms; mash and pellets, with six different isonitrogenous dietary treatments. The experimental treatments were formulated to meet NRC (1994) recommendations for all nutrients. The ingredient composition and analysis of diet are shown in Table 1. Plant dry fat (Polyfat) is manufactured by Norel-Misr, Egypt, made from dried palm oil. It was used in the finisher diets to replace soybean oil that has been used in the starter and grower diets.

Parameters measured: Feed intake, body weight, weight gain were recorded every week and Feed Conversion Ratio (FCR) was calculated. Mortality was recorded daily and birds that died were weighed for adjustment of feed conversion (Table 2). On day 42 of the experiment, two birds from each replicate were randomly selected (6/treatment), weighed, fasted overnight, slaughtered, scalded, feathers mechanically plucked in a rotary drum picker and eviscerated to determine carcass yields and dressing%. Giblets (liver, heart and gizzard) were removed, weighed and expressed as a percentage of live body weight (Table 3). Then, carcasses were tagged, chilled in ice-water for 30 minutes, individually packed in polyethylene bags and kept in refrigerator for 12 hours, after which they were weighed to obtain cold carcass weight. Abdominal fat pad was removed from parts around the viscera and gizzard, weighed to the nearest gram and expressed as a percentage of cold carcass weight. Carcasses were dissected into different parts (wings, breast and legs), weighed and then were put in polyethylene bags and stored in freezer for further analysis (Table 4). Chemical analyses of the breast representative samples of the experimental carcass meat were carried out to determine% of Dry Matter (DM), Crude Protein (CP), ether extract and ash according to the method of AOAC (2002) (Table 5). Randomized samples of the diets were also collected and ground by POLYMIX grinder (PX-MFC 90 D, KINEMATICA AG, Switzerland) through 1mm screen, dried in a forced air oven for six hours at 105°C to determine dry matter content, then samples were analyzed for crude protein, crude fiber, ether extract and ash contents. Blood samples were obtained from each bird by jugular vein puncture and drawn into vacuumed capillary tubes in order to determine the blood cholesterol, triglyceride, High-density Lipoprotein (HDL) and Low-density Lipoprotein (LDL) levels (Table 6). After coagulation, blood samples were centrifuged at 3000 RPM for 15 minutes to obtain serum and then serum was collected and centrifuged, then stored at -20°C, to be analyzed using (Vitros 250, France) with specialized kits (Ortho-Clinical Diagnostics).

Statistical analysis: The experimental design was Completely Randomized (CRD). Analysis of variance of the data was conducted by using pen means and including the main effects of differences among three

Table 1: Ingredients and chemical composition of the experimental diets.

	Starter (0-14 d)	Grower (15-27 d)	Finisher (28-42 d)		
	(%)				
Ingredients			2% fat	4% fat	6% fat
Corn	58.48	62.21	68.3	66.8	65.2
Soyabean Meal (48%CP)	35.65	31	26	26	26
Soya Oil	1.7	2.61	0	0	0
Plant Dry Fat	0	0	2	4	6
Limestone (ground)	1.4	1.4	1	0.5	0.1
DCP	1.4	1.4	1.4	1.4	1.4
NaCl	0.41	0.41	0.42	0.42	0.42
DL-Methionine	0.2	0.2	0.2	0.2	0.2
L-Lysine	0.16	0.17	0.18	0.18	0.18
Coccidiostat	0.1	0.1	0	0	0
Vitamin Premix[1]	0.1	0.1	0.1	0.1	0.1
Mineral Premix[2]	0.1	0.1	0.1	0.1	0.1
Choline Chloride	0.1	0.1	0.1	0.1	0.1
Antioxidant	0.1	0.1	0.1	0.1	0.1
Anti-Fungal	0.1	0.1	0.1	0.1	0.1
Nutrient composition					
Analyzed					
CP[3]%	22.1	20.2	18.3	18.2	18.0
EE[3]%	4.6	5.2	4.9	6.6	8.2
Calculated					
ME (kcal/kg)	2990	3080	3030	3130	3230
Ca%	0.9	0.9	0.9	0.9	0.9
NPP[3]%	0.4	0.4	0.4	0.4	0.4
Na%	0.2	0.2	0.2	0.2	0.2
Methionine%	0.5	0.5	0.5	0.5	0.5
TSAA%	0.9	0.9	0.8	0.8	0.8
Lysine%	1.3	1.2	1.1	1.1	1.1
Tryptophan%	0.3	0.3	0.2	0.2	0.2
Threonine%	0.8	0.8	0.7	0.7	0.7

[1]Vitamin premix provided per kilogram of diet: vitamin A, 14000 IU; vitamin D_3, 5000 IU; vitamin E 50 mg; vitamin B_1, 3 mg; vitamin B_2, 8 mg; vitamin B_6, 4 mg; vitamin B_{12}, 16 mg; biotine, 0.15 mg; niacine, 70 mg; folic acid, 2 mg; DL Ca. pantothenate, 20 mg.

[2]Trace mineral premix provided per kilogram of diet: Iron, 80mg; Zinc, 80 mg; Copper, 8 mg; Iodine, 1 mg; Selenium, 0.15 mg.

[3]CP (crude protein), EE (Ether extract), NPP (nonphytate phosphorus)

Table 2: Production Parameters of bird as affected by dietary fat levels and feed form

	Age (28-42d)				
	Final body weight g	Weight gain (wk5+6)	Total feed intake (wk5+6) g	FCR g:g	Mortality%
Fat levels					
2%	2220.00	746.34	1856.27	2.51	4.33
4%	2226.67	750.67	1861.56	2.53	5.04
6%	2214.17	711.50	1830.09	2.61	6.29
SEM	±21.76	±38.54	±93.65	±0.04	±0.54
Feed type					
Mash	2153.33^b	675.78^a	1714.26^b	2.57	4.79
Pelleted	2287.22^a	796.56^b	1985.66^a	2.53	5.65
SEM	±17.76	±31.47	±76.47	±0.04	±0.44
Fat level x Feed type					
2% Fat x Mash	2146.67	678.00	1694.52	2.52	4.00
2% Fat x Pelleted	2293.33	814.67	2018.02	2.51	4.67
4% Fat x Mash	2133.33	677.33	1729.92	2.61	4.67
4% Fatx Pelleted	2320.00	824.00	1997.10	2.46	5.40
6% Fat x Mash	2180.00	672.00	1718.33	2.60	5.70
6% Fat x Pelleted	2248.33	751.00	1941.85	2.63	6.88
SEM	±30.77	±54.50	±132.45	±0.06	±0.77

$^{a-b}$ Means in the same column with no superscripts are significantly different (P<0.05)

dietary fat levels and the two feed forms using GLM procedure of SAS (2004). Significant differences among means were separated using Fisher protected LSD. Significance was determined at (P<0.05) to test for interaction and main effects (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

Different growth performance parameters including body weight, weight gain, feed intake, feed conversion ratio and mortality rates are presented in Table 2. The different dietary fat percentages did not improve final body weight; while pelleted feed gave significant higher (P<0.05) final body weight, weight gain and total feed intake, this is in accordance to Choi *et al.* (1986), who stated that pelleting the finisher diet significantly improved weight gain and feed intake. Skinner-Noble *et al.* (2005), also reported that body weight improved with feed pelleting due to the reduction in the energy and time required for eating pelleted diet and increasing the time spent resting. While McNaughton and Reece (1984) found that pelleting increased body weight by 2.2% but weight gain was significantly (P<0.05) higher in mash (424.78g) compared to pelleted feed (340.56g), McAllister *et al.* (2000) stated that there were no significant differences in live weight gain between birds fed on mash diet and those given complete pelleted diets. No significant effect was shown in the interaction of fat% and feed form. In agreement to our results, many authors (Hulan *et al.*, 1984; Leeson *et al.*, 1991; Pinchasov and Nir, 1992; Quart *et al.*, 1992; Lopez-Ferrer *et al.*, 1999a, 2001b, Pesti *et al.*, 2002) found no difference in performance among broilers fed different types of fat with different degrees of saturation which caused lower feed consumption and body weights and poorer feed conversion efficiency than feeding the control diet and were unaffected by the level of energy in diet of broiler chicks. In contrast to our results, Abreu *et al.* (1996) and Nahashon *et al.* (2005) concluded that during the finishing period, broilers fed diets with 3200Kcal/Kg had the best FI value. Some studies with different fat sources have shown that the performance of broilers may be influenced by the type of supplementary fat in the diet (Danicke *et al.*, 2000; Lopez-Ferrer *et al.*, 2001a). Several reasons may be postulated why the differences seen in energy values do not translate into differences of actual performance. An explanation to our results might be the relatively small differences in ME content of the ration used due to the small fat inclusion levels which usually gives extra caloric effects. These levels were not wide enough to cause a wide calorie/protein ratio which will lead to improvement of bird's performance. Results for FCR showed no significant effect when increased the dietary fat percentage or feed form or their interaction on the overall feed conversion ratio. Leeson *et al.* (1996) showed that FCR significantly improved with increasing energy level during the finisher period. Mendes *et al.* (1995) showed that birds fed mash diets had a better feed conversion efficiency than those given the pellet. Leeson *et al.* (1999) and Jafarnejad *et al.* (2010) reported that feed

Table 3: Hot carcass yields of birds (expressed as a percentage of live body weight) as affected by dietary fat levels and feed.

	Dressing%	Liver%	Heart%	Gizzard%
Fat levels				
2%	76.68	2.10	0.56[a]	1.40
4%	75.73	2.02	0.45[b]	1.31
6%	74.88	2.10	0.46[b]	1.24
SEM	±0.51	±0.06	±0.03	±0.04
Feed type				
Mash	75.81	2.05	0.51	1.44[a]
Pelleted	75.72	2.11	0.47	1.19[b]
SEM	±0.42	±0.05	±0.02	±0.04
Fat level x Feed type				
2% Fat x Mash	76.44	2.12	0.59	1.65[a]
2% Fat x Pelleted	76.92	2.09	0.53	1.15[cd]
4% Fat x Mash	75.93	1.92	0.46	1.39[b]
4% Fat x Pelleted	75.54	2.13	0.44	1.23[bc]
6% Fat x Mash	75.05	2.10	0.48	1.29[bc]
6% Fat x Pelleted	74.71	2.10	0.45	1.18[cd]
SEM	±0.73	±0.09	±0.04	±0.06

[a-d]Means in the same column with no common superscript are significantly different (P<0.05)

Table 4: Cold carcass yield of birds (expressed as a percentage of cold carcass weight) as affected by dietary fat levels and feed form

	Wings %	Breast %	Leg %	Abdominal fat %
Fat levels				
2%	4.99	32.57	13.80	2.24[a]
4%	5.03	33.79	13.69	1.74[b]
6%	4.99	33.36	13.82	2.08[a]
SEM	±0.07	±0.41	±0.13	±0.08
Feed type				
Mash	5.07	33.87[a]	13.72	1.88[b]
Pelleted	4.94	32.61[b]	13.82	2.16[a]
SEM	±0.06	±0.33	±0.11	±0.06
Fat level x Feed type				
2% fat x Mash	5.08	32.95	13.83	2.17[a]
2% fat x Pelleted	4.90	32.19	13.78	2.31[a]
4% fat x Mash	5.05	34.27	13.68	1.78[b]
4% fat x Pelleted	5.01	33.31	13.69	1.70[b]
6% fat x Mash	5.08	34.38	13.64	1.71[b]
6% fat x Pelleted	4.90	32.35	114.00	2.46[a]
SEM	±0.10	±0.58	±0.19	±0.11

[a-b] Means in the same column with no common superscripts are significantly different (P<0.05)

conversion ratio improved with pelleted feed which also was not observed in this study. In agreement to our results concerning pelleting is work done by Bolukbasi *et al.* (2005) who determined that feed type (pellet and mash) had no effect on FCR. On contrary, Enberg *et al.* (2002); Greenwood *et al.* (2004) and Skinner-Noble *et al.* (2005), found that pelleted rations improved feed efficiency over mash rations. Possible reasons for the reduced effect of pelleting on feed efficiency may be due to the fact of pelleting temperature, usually if temperature is low then it would not have caused major effects on dietary constituents that might have improved digestibility. Feeding pelleted rations is not enough to ensure enhanced performance of poultry. The quality of pellets must be taken into account (Jafarnejad *et al.*, 2010).

Table 5: Breast meat chemical composition of birds (on fresh weight basis) as affected by dietary fat levels and feed form

	Dry matter %	Protein%	Fat%	Ash%
Fat levels				
2%	24.54[c]	21.31	0.73[b]	1.24
4%	24.61[b]	21.72	0.90[a]	1.22
6%	24.78[a]	21.79	0.68[c]	1.26
SEM	±0.01	±0.16	±0.01	±0.01
Feed type				
Mash	24.66[a]	21.56	0.74[b]	1.24
Pelleted	24.62[b]	21.65	0.80[b]	1.24
SEM	±0.01	±0.13	±0.01	±0.01
Fat level x Feed type				
2% fat x Mash	24.83[a]	21.26	0.73[c]	1.26[a]
2% fat x Pelleted	24.25[e]	21.36	0.73[c]	1.20[bc]
4% fat x Mash	24.44[d]	21.92	0. 80[b]	1.15[b]
4% fat x Pelleted	25.78[b]	21.52	1.00[a]	1.28[a]
6% fat x Mash	24.72[c]	21.49	0.69[d]	1.29[a]
6% fat x Pelleted	24.83[a]	22.08	0.68[d]	1.23[a]
SEM	±0.02	±0.23	±0.02	±0.02

[a-c]Means in the same column with no common superscripts are significantly different (P<0.05)

The dietary treatments had no effect on mortality rate. Fat percentage and feed form did not affect cumulative mortality. This agrees with Quentin *et al.* (2004) who reported that mortality rate of broilers was not affected by pelleting feed. Hussein *et al.* (1996) found that mortality was not affected by different energy levels used during the final weeks of age. Contrasts to our results are findings reported by Proudfoot and Hulan (1982) who observed that the incidence of Sudden Death Syndrome (SDS) was significantly higher for broilers fed on crumble-pellet or ground crumble-pellet form diet than for birds fed on mash. Leeson *et al.* (1999) reported that mortality increased with pellet feed compared to mash. No significant differences were detected among dietary treatments for the dressing% and the carcass yields which are presented in (Table 3). This agrees with Agah *et al.* (2008) who stated that carcass yields and the percentage weight of other organs were unaffected by feeding, mash and pelleted diet. The significant (P<0.05) effect was in the gizzard% with mash feed where it was higher than pelleted feed and the 2% fat mash feed compared to pelleted feed and the 4% fat. This might be explained by decreasing the passage rate of food and gradually increasing gizzard function and finally gizzards muscular mass (Tabiedian *et al.*, 2005). Our findings are in agreement with findings of Lopez-Ferrer *et al.* (2001).

The breast% as cold carcass yield (Table 4) was significantly affected by feed type where mash feed gave higher breast% when compared to pelleted diet (33.87 vs. 32.61%). No significant differences were shown with the interaction of the different fat levels and feed form. Habib *et al.* (2011), reported no significant differences with different fat sources. Abdominal fat% was significantly higher with the 2 and 6% fat and the pelleted compared to mash feed. The interaction gave significant higher difference (P<0.05) of the 2% fat mash feed

Table 6: Blood parameters of birds as affected by dietary fat levels and feed form

	Low density lipoprotein mg/dl	High density lipoprotein mg/dl	Cholesterol mg/dl	Triglycerides mg/dl
Fat levels				
2%	21.85	95.79	123.25	25.67
4%	20.76	93.04	119.46	20.92
6%	17.67	95.32	118.13	25.42
SEM	±1.79	±3.17	±3.87	±1.85
Feed type				
Mash	20.93	96.43	122.69	22.61
Pelleted	19.26	93.01	117.86	25.39
SEM	±1.46	±2.59	±3.16	±1.51
Fat level x Feed type				
2% fat x Mash	21.47	97.00	123.17	21.42
2% fat x Pelleted	22.24	94.58	123.33	29.92
4% fat x Mash	20.78	94.75	118.00	22.67
4% fat x Pelleted	20.75	97.67	120.92	19.17
6% fat x Mash	20.54	100.93	126.92	23.75
6% fat x Pelleted	14.80	89.37	109.33	27.08
SEM	±2.53	±4.49	±5.48	±2.01

compared to 4 and 6% and with the 4% pelleted feed. Normally with increasing dietary fat more energy will be available for chicks; this energy is stored in adipose tissues as abdominal fat (Pinchasov and Nir, 1992), this will increase the dietary energy: protein ratio which increases carcass fat deposition (Salmon *et al*., 1983). But the interaction of feed type and fat% did not follow this explanation. However, fat inclusion in broiler diets must take into account the effect on carcass fat quality, because dietary fatty acids are incorporated with little change into body fat (Scaife *et al*., 1994).

Breast meat compositions are shown in Table 5, dry matter% showed significant differences ($P<0.05$) with the different fat% and feed type, it increased with increasing the level of fat% and with the mash feed compared to the pelleted. These results are in agreement with Ozdogan *et al*. (2003), who stated that as dry matter increase fat content appeared to increase and this will give an idea about carcass fattening. The interaction showed higher significant difference ($P<0.05$) with the different fat% and mash feed where it decreased with increasing the level of fat while it was the opposite with the pelleted feed. Fat% of breast meat was highly significant ($P<0.05$) with the different fat% but 4% pelleted feed showed the highest value. 4% fat with either mash or pelleted feed gave the highest significant ($P<0.05$) fat%. The effect of dietary fat on metabolic efficiency of energy utilization varies with the amount and composition of the fat used (Fuller, 1979). Ash% showed significant results ($P<0.05$) between mash and pelleted feed at 2 and 4% fat but not at 6%. Ash% usually measures the amount of minerals found in the carcass especially Ca and P.

Blood parameters levels did not show any significant effect from using two forms of feed or different fat levels, numerically lowest LDL results were shown with the 6% fat pellet diet compared to the other fat% and feed form (Table 6). No significant differences were shown without the interaction contrast to Ozdogan *et al*. (2003), who reported significant differences in blood serum of broilers fed different fat sources which gives different energy levels. The 4% fat pellet feed gave numerically the lowest triglycerides level compared to the other fat% and feed type. According to Siegel *et al*. (1995) blood values are changed by the diet ingredients but this was not seen clearly in our study.

In conclusion the differences of results obtained in this study may be related to deficiencies, excesses or imbalance of nutrients other than energy from different fat sources. The 4% fat either with mash or pelleted feed gave better results for the abdominal fat% than the other two levels used. The interaction of feed type and fat levels was not clearly demonstrated in this study. Results obtained can be related to the quality of the consumed pellet which might be related to the type and percentage of fat used.

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