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Effect of fat source, energy level and enzyme supplementation and their interactions on broiler performance

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Abstract: This study was performed to evaluate the effects of replacing typical soybean oil (SBO) in broiler's diet with a less expensive commercial blend (Kofat) (KOF), using two levels of metabolizable energy (ME) and supplementing Tomoko (TOM) enzyme on broilers performance. Eight dietary treatments, 2 x 2 x 2 factorial arrangement in a randomized complete block design, were used in this experiment. A total of 200-(0) day (d) old male (Ross 308) chicks were distributed among 40 cages with 5 replicate cages per treatment. Cumulative feed intake (FI) was not influenced by fat source, energy level or TOM supplementation (P >0.05). For the period from 1 to 30 d of age, energy x enzyme interaction was significant for body weight gain (BWG) and feed conversion ratio (FCR) (P<0.01; P <0.001). TOM supplementation had a positive effect on the low energy diet while it had a negative effect on the normal energy diet with respect to BWG and FCR. Tom enzyme was able to restore the nutritional value in the low energy diet. Fat source (SBO vs. KOF) had no influence on performance of broilers during the experiment period. It is recommended to feed KOF as a source of fat, lower the ME of the diet in the starter and finisher periods by 100 kcal/kg and to supplement the diet with TOM enzyme at a rate of 0.05%.
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Keywords: Soybean oil, Kofat, energy level, Tomoko, broilers, performance.

1. Introduction

Fats and vegetable oils are frequently included in broiler diets to increase the energy density of the diet, improve efficiency and increase digestibility in broilers (Baião and Lara, 2005; Fascina *et al*., 2009; Monfaredi *et al*., 2011). Soybean oil (SBO) is the most commonly included oil in broiler feeds, but other oils can also be used as energy source, such as corn oil, palm oil, rapeseed oil, sunflower oil, cottonseed oil or coconut oil, depending on the cost and location where these oils are available (Baião and Lara, 2005; Barbour *et al*., 2006). The value of the various fats and oils depends on price, ME contents, digestibility and absorption (Waldroup *et al*., 1995). The high cost of supplemental energy necessitates the optimization of fat inclusion in broilers' diets especially during the finisher period where the feed consumption is the greatest. So, the demand is great toward feeding low-price, plant fat sources.

Bioavailability of nutrients from corn and soybean meal (corn-SBM) is not ideal and recent data indicate that there is room for improvement. Marquardt (1997) reported that corn and SBM are incompletely digested by poultry due to the presence of non-starch polysaccharides (NSPs) which is considered as anti-nutritional factor. Water soluble NSPs fed to young chicks interfere with the digestion and absorption of other nutrients by increasing the viscosity of digesta in the gut (Ward and Marquardt, 1983).

Several attempts have been made to increase the nutritional value of corn-SBM diets by adding protease and carbohydrases either before or after processing (Café *et al.*, 2002; Gracia *et al.,* 2003; Abudabos, 2012). One approach to incorporate enzymes into corn-SBM diets is by changing the nutrient density of the feed to reduce the cost per ton of feed and then, by adding enzymes, restoring the nutritional value of the feed. This results in better performance or at least similar to a normal feed density (Pack and Bedford, 1997). It was suggested that enzymes reduce the negative effects of NSPs and improve the digestion of nutrients in poultry diets.

The objective of the present study was to evaluate the effects of replacing a typical source of oil in broilers' diets (SBO) with a cheaper commercial fat blend Kofat (KOF), using two levels of metabolizable energy (ME) (normal and low) with and without Tomoko (TOM) enzyme supplementing on broilers performance from 1 to 30 d of age.

2. Materials and Methods

Two sources of fat (SBO and KOF), two levels of TOM enzyme (0.0% and 0.05%) and two levels of energy (a normal and subnormal or low level of ME, 100 kcal/kg difference) were applied in a factorial arrangement for a total of 8 dietary treatments. Diets were fed to 0-d old male broiler chicks (Ross 308) which were obtained from a commercial hatchery (Al-Wadi Poultry Farm Co., Riyadh, Saudi Arabia). Chicks were sexed, grouped by weight in such a way as to reduce variation in mean body weight then were allotted to 40 cages in a four-deck cage system inside an environmentally controlled chamber and received the experimental diets in electrically heated battery brooders with raised wire floors. Each treatment was assigned to 5 replicate pens with 5 chicks per cage (50 cm length, 60 cm width and 36 cm depth). The experimental treatments were as follow: T1 = low energy, SBO without TOM; T2 = T1 + 0.05% TOM; T3 = normal energy, SBO without TOM; T4 = T3 + TOM; T5 = low energy, KOF without TOM; T6 = T5 + 0.05% TOM; T7 = normal energy, KOF without TOM; T8 = T8 + TOM. A typical isocaloric and isonitrogenous, except for the low energy diets, starter (0-16 d) and finisher (17-30 d) diets based on corn-SBM diets were formulated in mashed form according to Table 1 which met or exceeded the recommendations in commercial practice in Saudi Arabia. The starter diet contained 2900 for the low and 3000 kcal of ME/kg for the normal diet, while the finisher contained 3000 and 3100 kcal/kg for the low and normal diets, respectively. The chicks had been vaccinated for Marek's disease, Newcastle and Infectious Bronchitis. Ambient temperature and relative humidity were concurrently and continuously recorded at 3 hours interval using two data loggers (HOBO Pro Series Data Logger, Model H08-032-08, Onset Co., USA) placed inside the chamber. The average temperature and relative humidity for the whole period were 24.35°C ± 0.24 (SD) and 25.52% ± 3.10 (SD), respectively. Body weight gain (BWG) and feed intake (FI) were recorded weekly by cage and feed conversion ratio (FCR) was computed at 16 and 30 d of age. The study was conducted under a protocol approved by King Saud University and complies with the current laws of Saudi Arabia.

Tomoko (Biogenkoji Research Institute, 876-15, Mizobe, Kagoshima, Japan) is a multi-enzyme preparation which is produced by fermentation using Koji-feed (*Aspergillus awamori*), the activity of enzyme was authenticated by the supplier to have minimum level of acidic protease (10,000 U/g), α-amylase (40 U/g), pectinase (30 U/g), phytase (10 U/g), glucoamylase (5 U/g), cellulase (4 U/g) and *Aspergillus awamori* cells (10 mg/g). Kofat (EcoOils Sdn Bhd, 81700 Pasir Gudang, Johr Darul Takzim, Malaysia) is formulated from mixture of various vegetable oils supplemented with anti-oxidant and lecithin. According to the manufacturers, the fatty acid composition profile of KOF is as follow: Myristic acid (C14:0) 6.0%, palmitic acid (C16:0) 30-35%, stearic acid (18:0) 4.0-5.0%, oleic acid (C18:1) 35.0-42.0% and linoleic acid (C18:2) 16-20%.

Statistical analysis

Analysis of variance was performed using General Linear Model procedure of the Statistical Analysis System (SAS, 2002-2003) for randomized complete block design with 2 x 2 x 2 factorial arrangements of treatments, in which each experimental diet was fed to 5 replicate pens. The data were tested for main effects (fat source, energy level and enzyme), two-ways and three-ways interactions. The experimental unit was the pen mean. Statistical significance was assessed at (P <0.05).

3. Results

Birds' performance for the starter period is shown in Table 2, FI was not affected by fat source, energy level or enzyme supplementation and their interaction (P>0.05). A two-way energy x enzyme was significant for BWG (P<0.005) such that TOM supplementation to the low energy level increased BWG by 20 g while TOM supplementation to the normal energy diet decreased BWG by 30 g. Energy level of the diet affected BWG significantly (P <0.01); chicks on the normal energy diet gained 20 g more than birds which had received the low energy diet. A two-way energy x enzyme was significant for FCR (P<0.001) such that enzyme supplementation to the low energy level improved FCR as compared to un-supplemented diet (1.379 vs. 1.322, respectively) while TOM supplementation to the normal energy diet increased FCR as compared to un-supplemented diet (1.260 vs. 1334, respectively). Energy level of the diet affected FCR (P<0.001); chicks on the normal energy diet had better FCR, with a 1.260 compared to 1.334 for chicks which had received the low energy diet.

Birds' performance for the finisher period is shown in Table 3, none of the three-way interactions were significant for FI, BWG and FCR. However, FI was influenced by the energy level of the diet (P<0.05), birds on the low energy diet consumed 42 g extra amount of feed as compared to those on the normal energy diet. BWG was not influenced by any treatment (P>0.05). On the other hand, energy x enzyme interaction was significant for FCR (P<0.001).

TOM supplementation to the low energy diet improved FCR by 12 points (1.584 vs. 1.704) while in the normal energy diet TOM supplementation caused a drop in FCR by 2 points (1.624 vs. 1.604). Two main effects, energy level and enzyme affected FCR significantly (P<0.04; P<0.001, respectively). Birds which had received the normal energy level had a better FCR as compared to the other group (1.614 vs. 1.643, respectively). On the other hand, TOM supplementation improved FCR by 5 points (1.604 vs. 1.653, respectively).

Birds' performance for the cumulative period from 0 to 30 d of age is shown in Table 4. Feed intake was not influenced by any treatment (P>0.05). Energy x enzyme interaction was significant for BWG and FCR (P<0.01; P<0.001). Tomoko supplementation to the low energy diet increased BWG by 45 g and improved FCR by 9.8 point as compared to un-supplemented diet. However, TOM supplementation to the normal energy diet decreased BWG by 41 g and caused a drop in FCR by 5 points. FCR was influenced by the energy level (P<0.001) and TOM supplementation (P<0.05) as a main effect factors. No three-way interactions were detected for all parameters measured for the cumulative period.

Table 1. Composition of experimental diets fed to broilers from 1 to 30 d

Ingredients (%)	Starter		Finisher	
	Low (T1, T5)[1]	Normal (T3, T7)[2]	Low (T1,T5)[1]	Normal (T3, T7)[2]
Corn	58.00	56.80	59.65	58.55
Soybean meal (48% CP)	36.10	36.10	34.00	34.00
Soybean oil or Kofat	1.80	3.00	2.90	4.00
Salt	0.30	0.30	0.30	0.30
Limestone	0.72	0.72	0.64	0.64
Di calcium phosphate	2.30	2.30	2.00	2.00
DL-methionine	0.23	0.23	0.16	0.16
L-Lysine	0.15	0.15	-	-
Vitamin-mineral premix[3]	0.30	0.30	0.30	0.30
Choline chloride premix, 60%	0.10	0.10	0.05	0.05
Calculated analysis				
ME (kcal/kg)	2900	3000	3000	3100
CP (%)	22.0	22.0	21.0	21.0
Methionine (%)	0.55	0.55	0.47	0.47
Methionine + Cystine (%)	0.82	0.82	0.73	0.73
Lysine	1.25	1.25	1.1	1.1
Calcium	1.00	1.00	0.90	0.90
Available phosphorus	0.45	0.45	0.40	0.40

[1]Diets 2 and 6 had 0.05% Tomoko enzyme added.
[2]Diets 4 and 8 had 0.05% Tomoko enzyme added.
[3]Vitamin-mineral mix is supplied in the following per kg of diet: Retinyl acetate, 3.41 mg; cholecalciferol, 0.07 mg; DL-α-tocopheryl acetate, 27.5 mg; menadione sodium bisulphate, 6 mg; riboflavin, 7.7 mg; niacin, 44 mg; pantothenic acid, 11 mg; cyanocobalamin, 0.02 mg; choline496 mg; folic acid, 1.32 mg; pyridoxine HCl, 4.82 mg; thiamine mononitrate, 2.16 mg; D-biotin, 0.11 mg; manganese, 67 mg; zinc, 54 mg; copper, 2 mg; iodine, 0.5 mg; iron, 75 mg; and selenium, 0.2 mg.

Table 2. Feed intake (FI), live weight (BWG) and feed conversion ratio (FCR) of broiler chickens given experimental diets at 16 d

Diet	Source	Energy kcal/kg	Enzyme (%)	FI (g)	BWG (g)	FCR (g:g)
1	Soy oil	2900	0	637	462	1.377
2	Soy oil	2900	0.05	646	485	1.330
3	Soy oil	3000	0	652	520	1.253
4	Soy oil	3000	0.05	631	486	1.300
5	Kofat	2900	0	660	477	1.381
6	Kofat	2900	0.05	649	494	1.315
7	Kofat	3000	0	647	510	1.268
8	Kofat	3000	0.05	661	484	1.368
SEM				17.6	10.8	0.024
P value				NS	NS	NS
Source						
Soy oil				642	489	1.315
Kofat				655	491	1.332
SEM				8.9	5.4	0.012
P value				NS	NS	NS
Energy						
Low				648	480	1.350
Normal				648	500	1.297
SEM				8.9	5.4	0.012
P value				NS	0.01	0.005
Enzyme						
Without				649	493	1.319
With				647	487	1.328
SEM				8.9	5.4	0.012
P value				NS	NS	NS
Source x Energy						
	Soy	2900		641	474	1.353
	Soy	3000		642	503	1.276
	Kofat	2900		654	485	1.348
	Kofat	3000		654	497	1.317
SEM				12.6	7.69	0.017
P value				NS	NS	NS
Source x Enzyme						
	Soy		0	645	491	1.315
	Soy		0.05	638	486	1.315
	Kofat		0	653	494	1.324
	Kofat		0.05	655	488	1.341
SEM				12.7	7.69	0.017
P value				NS	NS	NS
Energy x Enzyme						
		2900	0	648	470	1.379
		2900	0.05	647	490	1.322
		3000	0	646	515	1.260
		3000	0.05	646	485	1.334
SEM				12.6	7.7	0.017
P value				NS	0.005	0.001

Table 3. Feed intake (FI), live weight (BWG) and feed conversion ratio (FCR) of broiler chickens given experimental diets at 30 d

Diet	Source	Energy Kcal/kg	Enzyme (%)	FI (g)	BWG (g)	FCR (g:g)
1	Soy oil	3000	0	1434	846	1.697
2	Soy oil	3000	0.05	1394	881	1.583
3	Soy oil	3100	0	1381	854	1.617
4	Soy oil	3100	0.05	1416	883	1.605
5	Kofat	3000	0	1464	855	1.711
6	Kofat	3000	0.05	1380	871	1.585
7	Kofat	3100	0	1374	863	1.591
8	Kofat	3100	0.05	1336	814	1.643
SEM				26.9	18.3	0.02
P value				NS	NS	NS
Source						
Soy oil				1406	866	1.625
Kofat				1388	851	1.632
SEM				13.5	9.2	0.01
P value				NS	NS	NS
Energy						
Low				1418	863	1.643
Normal				1376	854	1.614
SEM				13.5	9.1	0.01
P value				0.03	NS	0.04
Enzyme						
Without				1413	845	1.653
With				1382	862	1.604
SEM				13.5	9.1	0.01
P value				NS	NS	0.001
Source x Energy						
	Soy	3000		1414	863	1.639
	Soy	3100		1398	868	1.611
	Kofat	3000		1422	863	1.648
	Kofat	3100		1354	838	1.616
SEM				19.0	12.9	0.01
P value				NS	NS	NS
Source x Enzyme						
	Soy		0	1407	850	1.656
	Soy		0.05	1405	882	1.594
	Kofat		0	1418	859	1.650
	Kofat		0.05	1358	842	1.614
SEM				19.0	12.9	0.01
P value				NS	NS	NS
Energy x Enzyme						
		3000	0	1449	850	1.704
		3000	0.05	1387	876	1.584
		3100	0	1377	858	1.604
		3100	0.05	1376	848	1.624
SEM				19.1	12.9	0.01
P value				NS	NS	0.001

Table 4. Cumulative feed intake (FI), live weight (BWG) and feed conversion ratio (FCR) of broiler chickens given experimental diets (1 to 30 d)

Diet	Source	Energy Kcal/kg	Enzyme (%)	FI (g)	BWG (g)	FCR (g:g)
1	Soy oil	low	0	2072	1308	1.584
2	Soy oil	low	0.05	2039	1366	1.492
3	Soy oil	normal	0	2033	1375	1.479
4	Soy oil	normal	0.05	2047	1368	1.493
5	Kofat	low	0	2124	1334	1.593
6	Kofat	low	0.05	2029	1365	1.487
7	Kofat	normal	0	2020	1373	1.471
8	Kofat	normal	0.05	1997	1298	1.540
SEM				32.5	23.5	0.01
P value				NS	NS	NS
Source						
Soy oil				2043	1355	1.513
Kofat				2048	1343	1.523
SEM				16.3	11.7	0.008
P value				NS	NS	NS
Energy						
Low				2066	1344	1.539
Normal				2025	1354	1.497
SEM				16.3	11.7	0.008
P value				NS	NS	0.001
Enzyme						
Without				2063	1348	1.532
With				2028	1350	1.504
SEM				16.3	11.7	0.008
P value				NS	NS	0.03
Source x Energy						
	Soy	low		2056	1337	1.538
	Soy	normal		2040	1372	1.488
	Kofat	low		2076	1349	1.540
	Kofat	normal		2009	1336	1.505
SEM				23.0	16.6	0.01
P value				NS	NS	NS
Source x Enzyme						
	Soy		0	2053	1342	1.495
	Soy		0.05	2044	1368	1.532
	Kofat		0	2073	1354	1.532
	Kofat		0.05	2013	1332	1.514
SEM				23.0	16.6	0.01
P value				NS	NS	NS
Energy x Enzyme						
		low	0	2098	1321	1.588
		low	0.05	2034	1366	1.490
		normal	0	2027	1374	1.475
		normal	0.05	2022	1333	1.518
SEM				23.0	16.6	0.01
P value				NS	0.01	0.001

4. Discussion

The results revealed a significant energy x enzyme interaction in BWG and FCR at 30 d of age which could be explained by a difference in magnitude or response, birds on the low energy level responded positively to TOM supplementation, while those which had the normal energy diet responded negatively to TOM. The beneficial effect of TOM in the diet was the best when the TOM was added to the low energy diet. The improvement in FCR could be explained in part by the improvement in BWG that occurred as a result of the TOM, BWG for the low energy group plus TOM was restored and was comparable to that of the normal energy diet without the TOM, suggesting that the improvement in nutrient utilization brought about by TOM supplementation completely compensated for the reduced energy content. This result offers potential to reduce diet cost commensurate with no losses in production.

The improvement in BWG of broilers which had received TOM supplemented diets could be ascribed by the increase in protein and energy retentions. It was reported that enzymes reduce the negative effects of NSPs and improve the digestion of nutrients in poultry diets. Hydrolysis of NSPs reduces the viscous properties of β-glucan and pentosans, release some available monosaccharides and in part, eliminate the nutrient encapsulating effect of the cell wall (Bedford, 1993). It has been reported that enzyme supplementation to corn-soy diets improved growth performance significantly in broilers (Gracia *et al.,* 2003; Saleh *et al.,* 2006; Abudabos, 2012).

The positive effect of fats on live performance of broilers is well documented (Griffiths *et al*., 1977). Growth stimulating property of fats is not just a result of their high energy value, chicks fed diets with SBO or corn oil consumed more ME than chicks fed comparable diets that had low fat content (Carew *et al*., 1963; Pesti *et al*., 2002). The value of the various fats and oils is entirely dependent on their ME contents, and the ME content of the fat dependents on their digestibility and absorption (Pesti *et al*., 2002). In this experiment, birds received the two sources of fat had similar live performance; this led to the conclusion that the two sources have similar digestibility. Similar response was obtained by Valencia *et al.* (1993) who reported that there were no effects of the sources of oil (refined palm oil, palm oil, corn oil and poultry fat) on BWG and FCR of broilers. The result is congruent with previous findings of Abudabos (2009) who reported that birds which had received KOF or SBO responded equally.

Due to the high cost of feed ingredient for poultry especially dietary energy, it is important to continually evaluate the source as well as the level of energy in the diets (Pesti *et al*., 2002). KOF is a cheaper source of fat compared to SBO or corn oil. It is worth mentioning that fat supplementation is considered to be more cost effective over the finisher period as compared to the starter period because of increased digestibility of fat, improved of dietary ME and increased feed intake of the birds during the finisher period (Wiseman and Salvodr., 1989).

5. Conclusions

The results of this study indicated that the replacement of SBO with KOF resulted in comparable performance in terms of BWG, FI and FCR but using KOF as the fat source could result in lowering the overall feed cost since it is cheaper commercial fat blend as compared to SBO. Tomoko enzyme at the rate recommended by the manufacture (0.05%) was able to restore the nutritional value in the low energy diet. Based on the results obtained from this experiment and in order to lower the feed cost, it is recommended to feed KOF as a fat source for broilers at the low energy level with TOM supplementation.

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