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Effect of dietary fat level and source on performance and immune system response of turkeys

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ABSTRACT. An experiment was conducted to determine effects of different levels and sources of fats in diets on growth performance, carcass characteristics and immune response of turkeys during four periods (0-21, 22 to 42, 43 to 63 and 64 to 70 days of age). A completely randomized design with five treatments, six replicates and eight B.U.T.6 turkey chickens per replicate was used. Treatments included: Control diet, diet containing 2.5% of soybean oil, diet containing 2.5% fat supplement, diet containing 5% soybean oil, diet containing 5% fat supplement. The results showed that using 5% of soybean oil increased average daily gain of turkeys (89.04 g) throughout the experimental period (0-70 days) compared with the control group (81.11 g; $p < 0.05$). Treatments containing 2.5 and 5% soybean oil improved feed conversion ratio compared to control group ($p < 0.05$). Soybean oil at the levels of 2.5 and 5% was led to higher spleen and bursa percentages compared to other treatments, respectively ($p < 0.05$). The level and source of dietary fat had not significant effect on antibody titer against Newcastle virus vaccine on 42 and 70 days of age ($p > 0.05$). It can be concluded that supplementing diet with 5% soybean oil improved the performance of turkeys.

Keywords: average daily gain; carcass quality; fat supplement; feed intake; immunity.

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Introduction

In recent years, interest in the use of feed components or feed additives with immunomodulatory properties has increased significantly, especially in conditions of intensive poultry and pig production, where many stressful factors have an adverse effect on animal metabolic status and health (Darabighane & Nahashon, 2014; El Enshasy & Hatti-Kaul, 2013). The recommendations of the National Research Council (NRC, 1994) and the breeding companies of turkey strains (Aviagen turkeys, Nicholas BUT 6 Strain, Large White, 2013) indicate that the turkey diet should be very rich in energy and protein, and practically balancing such diets is not possible without the help of protein sources and high quality energy. It has become common practice to add fat and oil to commercial turkey diets in order to meet the high energy requirements of the birds.

The addition of fat sources increases dietary energy levels. Other benefits involve improved feed efficiency, increased growth rates of birds, decreased dustiness of feeds, lower heat increment during heat stress and feed palatability. On the other hand, excess fat in the young animal's diet leads to improper digestion, lower feed intake (FI) and lower body weight gains (BWG) resulting in economic losses and posing a threat to the birds' life (Abbas et al., 2016). Fat sources used in the poultry diet are derived from animal and plant sources and are considered as components with high energy content (Mossab, Hallouis, & Lessire, 2000). Fat is mainly composed of triglycerides and, although fats are not water-soluble, its digestion takes place in an aqueous environment of the gastrointestinal tract, where it is hydrolyzed by lipase into fatty acids and mono- and diglycerides (Zaefarian, Romero, & Ravindran, 2015). For about 37 years, effects of lipids, and in particular fatty acids, have been shown to be safe. By increasing fat sources to broiler diet, the amount of feed intake decreased and feed efficiency was improved (Firman, Leigh, & Kamyab, 2010).

In general, vegetable fat has a better absorption and higher metabolizable energy due to the high content of unsaturated fatty acids than animal fats and therefore, are utilized more efficiently by birds (Tancharoenrat, Ravindran, Molan, & Ravindran, 2014). Fat is able to affect the immune system through the production of cytokines and molecules involved in immunity. A recent study by Koppenol, Delezie,

Parmentier, Buyse, and Everaert (2015) evaluated the trans generational modulating effect of supplementing maternal diets with n-3 PUFAs, i.e., eicosapentaenoic acid (EPA, C20:6 n-3) and docosahexaenoic acid (DHA, C22:5 n-3) on the immune response of chickens. Other studies have also indicated that serum white blood cell count and IL-2 concentration were increased at 7 days following IBD challenge in birds fed diets with 5.5% fish oil (Maroufyan et al., 2013). Dietary supplementation with rich sources of n-3 PUFAs, especially with fish oil, can have a beneficial, modulating influence on the immune system; specifically they appear to decrease acute and chronic inflammatory immune reactions and simultaneously to improve indices of specific immune response (Swiatkiewicz, Arczewska-Wlosek, & Jozefiak, 2015).

The mechanism of lipid effects on the immune system and inflammatory response are widespread and complex at the same time (Cherian & Sim, 1991). According to the available information, studies on the effect of using different levels of fat sources on the immune response of turkeys are scarce. Therefore, the aim was to determine effects of different levels and sources of fat in the diet on growth performance, carcass characteristics and immune response of turkeys.

Material and methods

In order to carry out this research, 240 day old male turkeys from BUT6 strain were used. This experiment was conducted in a completely randomized design with five treatments, six replicates and eight turkey chicks per replicate. The diets in each individual treatment were balanced and the chicks were fed with diets from one to 70 days of old. Treatments included: Control diet (no fat supplement), diet containing 2.5% of soybean oil, diet containing 2.5% fat supplement, diet containing 5% soybean oil, diet containing 5% fat supplement. The diets were formulated with similar energy and nitrogen concentrations; according to the nutrient requirements of poultry (NRC, 1994). The ingredients and chemical composition of the control diets, which correspond to the standard dietary requirements for turkeys BUT6 strain, during four periods (0-21, 22 to 42, 43 to 63 and 64 to 70 days of age) are shown in Tables 1 and 2, respectively.

The weights of birds and feed intake were determined on 21, 42 and 63 days of age to measure body weight gain, feed intake and feed conversion ratio. At the end of the experimental period, two turkeys from each replicate, which were almost near the average weight of that experimental unit, were selected and after live weight recording, the turkeys were slaughtered and immediately plucked, and corresponding values were measured. The weights of carcass parts included carcass, breast, thigh, ventricular fat, liver, bursa, wing, back, gizzard, pancreas, heart and spleen, were measured using digital scales with accuracy of 0.1 gram. Blood samples were taken at 42 and 70 days of age (seven days after each Newcastle vaccine) and serum was isolated to conduct HI test for determining antibody target against Newcastle virus.

The statistical analysis was conducted using a completely randomized design and the results of the experiment were analyzed with the GLM procedure of SAS software. The comparison of treatment means was performed using Tukey test ($p < 0.05$).

Table 1. Ingredients of turkey control diet within each productive phase.

Ingredients	Days			
	0-21	22-42	43-63	64-70
Corn	45.2	53.56	58.36	64.85
Soybean meal 45%	44.8	39.2	33.52	28.19
Soybean oil	0	0	0	0
Fat powder	0	0	0	0
Fish meal	4.87	2	2.62	2.67
Carbonate	1.44	1.33	1.18	1.06
Calcium phosphate	2.26	2.44	2.04	1.18
Common salt	0.15	0.12	0.1	0.1
Sodium bicarbonate	0.2	0.2	0.2	0.2
DL- Methionine	0.29	0.28	0.21	0.16
L- lysine	0.26	0.34	0.14	0.17
Mineral premix[1]	0.25	0.25	0.3	0.3
Vitamin premix[2]	0.25	0.25	0.3	0.3
Filler[3]	0	0	1	0.79
Diclazuril	0.03	0.03	0.03	0.03

[1]Every 2.5 kilograms of vitamin-rich turkey supplement contain: vit A: 12500000IU, vit D3: 4000000IU, vit E: 200000 mg, vit K3: 4000 mg, vit B1: 3000 mg, vit B2: 7000 mg, vit B3: 20000 mg, vit B5: 60000 mg, vit B6: 6000 mg, vit B9: 2000 mg, vit B12: 40 mg, vit H2: 300 mg. [2]Every 2.5 kilograms of mineral turkey supplement contain: Fe:52000mg, Cu20000 mg, Mn:120000 mg, Zn:100000 mg, I:2100 mg, Se:200, Choline Chloride:34000 mg. [3] Sand was used as filler.

Table 2. Calculated chemical composition of turkey diets within each productive phase.

Treatments	0-21 days	22-42 days	43-63 days	64-70 days
ME (kcal kg^{-1})	2790	2800	2830	2900
Crude protein (%)	26.77	22.4	22.64	20
Total lysine (%)	1.73	1.53	1.35	1.19
Total methionine (%)	0.72	0.55	0.5	0.45
Total Met+ Cys (%)	1.12	1.01	0.9	0.81
Total threonine (%)	1.02	0.9	0.81	0.72
Total arginine (%)	1.76	1.57	1.39	1.23
Calcium	1.38	1.26	1.14	1.03
Available P (%)	0.7	0.63	0.57	0.52
Sodium (%)	0.16	0.15	0.15	0.14

Results

The results of feed intake were presented in Table 3. In the 0-21 days period, supplementation of 5% soybean oil had significantly greater feed intake than 2.5 and 5% supplemented fat powder ($p < 0.05$), while other treatments did not differ significantly ($p > 0.05$). In the period of 22-42 days of age, control treatment significantly increased feed intake compared to 5% supplemented soybean oil ($p < 0.05$), although other experimental treatments did not show any significant difference ($p > 0.05$). In the period of 43-63 days of age, the treatment containing 5% supplemented fat powder significantly increased feed intake compared to 2.5% supplemented soybean oil ($p < 0.05$), and other experimental treatments showed a non-significant difference.

The results of daily weight gain are presented in Table 4. In 0-29 days of age, 5% supplemented soybean oil significantly increased weight gain compared to 2.5 and 5% supplemented fat powder and 2.5% supplemented soybean oil ($p < 0.05$). In the period of 22-42 days of age, the treatment containing 5% soybean oil had the highest daily weight gain and the treatment containing 2.5% soybean oil had the least weight gain ($p < 0.05$). In the period of 43-63 days, the treatments containing 5% soybean oil and 5% fat powder did not differ significantly ($p > 0.05$), but both of these treatments significantly increased the weight gain compared with other treatments ($p < 0.05$). In the whole period, 5% soybean oil treatment had significantly higher weight gain than other treatments ($p < 0.05$).

Table 3. Effect of dietary fat level and sources on the average daily feed intake of turkeys (g $chick^{-1}$ day^{-1}).

Treatments	Days			
	0-21	22-42	43-63	0-70
0% fat	27.03^{ab}	121.07^{a}	286.35^{ab}	164.8
2.5% soybean oil	26.16^{ab}	111.83^{ab}	277.18^{b}	158.37
2.5% fat powder	25.85^{b}	110.72^{ab}	289.83^{ab}	164.27
5% soybean oil	28.84^{a}	110.31^{b}	292.13^{ab}	165.74
5% fat powder	25.08^{b}	111.2^{ab}	293.56^{a}	165.32
SEM	0.365	1.297	1.882	1.111
P-Value	0.006	0.030	0.033	0.202

^{ab}Means within a column with different superscripts are significantly different ($p < 0.05$).

Table 4. Effect of dietary fat level and sources on the average daily weight gain in turkeys (g $chick^{-1}$ day^{-1}).

Treatments	Days			
	0-21	22-42	43-63	0-70
0% fat	19.29^{ab}	70.33^{a}	132.29^{c}	81.11^{b}
2.5% soybean oil	18.46^{b}	65.92^{c}	138.34^{b}	81.71^{b}
2.5% fat powder	18.34^{b}	68.56^{bc}	132.93^{c}	82.46^{b}
5% soybean oil	21.12^{a}	75.23^{a}	148.03^{a}	89.04^{a}
5% fat powder	18.1^{b}	68.64^{bc}	145.65^{a}	83.49^{b}
SEM	0.313	0.662	1.311	0.588
P-Value	0.006	0.001	0.001	0.001

$^{a-c}$Means within a column with different superscripts are significantly different ($p < 0.05$).

Feed conversion ratio results are presented in Table 5. Feed conversion ratio was not influenced by experimental treatments in 0-29 days ($p > 0.05$). In the period of 42-23 days, 5% soybean oil group had significantly lower feed conversion ratio than other treatments ($p < 0.05$). In the period of 43-63 days,

control group and treatment containing 2.5% fat powder had significantly higher feed conversion ratio than other treatments ($p < 0.05$), whereas there was no significant difference between these two treatments ($p > 0.05$). In the whole period, treatment containing 5% soybean oil had the lowest feed conversion ratio and control treatment had the greatest ratio ($p < 0.05$). The results of this experiment showed that 5% supplemented soybean oil improved the feed conversion ratio significantly in comparison with other treatments.

Table 5. Effect of dietary fat level and sources on the feed conversion ratio in turkeys.

Treatments	Days			
	0-21	22-42	43-63	0-70
0% fat	1.41	1.72^{a}	2.16^{a}	2.03^{a}
2.5% soybean oil	1.41	1.69^{a}	2^{b}	1.93^{bc}
2.5% fat powder	1.4	1.61^{a}	2.18^{a}	1.99^{ab}
5% soybean oil	1.36	1.46^{b}	1.97^{b}	1.86^{c}
5% fat powder	1.38	1.62^{a}	2.01^{b}	1.97^{ab}
SEM	0.01	0.021	0.019	0.013
P-Value	0.561	0.001	0.001	0.001

$^{a-c}$Means within a column with different superscripts are significantly different ($p < 0.05$).

The results of carcass traits are presented in Table 6. The results showed that percentage of breast, thigh and back weight was not affected by experimental treatments ($p > 0.05$). As the results of the present experiment are indicated (Table 7), carcass weight was not affected by different treatments ($p > 0.05$). Treatment containing 5% soybean oil had significantly higher spleen weights than 0% fat ($p < 0.05$). Treatment containing 5% soybean oil supplements had significantly higher bursa weights than other treatments ($p < 0.05$). Treatment containing 2.5% supplemented soybean oil had significantly higher spleen weight than other treatments ($p < 0.05$). Treatment containing 2.5% fat powder and control treatment had significantly higher liver weight than other treatments ($p < 0.05$), while these two treatments did not differ significantly ($p > 0.05$). Treatment containing 5% fat powder had the highest pancreas weight ($p < 0.05$). The highest heart rate was obtained by experimental treatments containing 5% supplemental fat and control group ($p < 0.05$). However, there was no significant difference between these two groups ($p > 0.05$). Treatment containing 2.5% fat supplement had significantly greater gizzard weight than other treatments ($p < 0.05$). Treatment containing 5% fat had the highest amount of abdominal fat and 5% soybean oil group had the least amount ($p < 0.05$). As the results of the present study are indicated (Table 8), the effect of level and source of dietary fat on antibody titer against Newcastle disease vaccine was not significant on days 42 and 70 ($p > 0.05$).

Table 6. Effect of dietary fat level and sources on the carcass traits of turkey (Percentage of carcass weight).

Treatments	Breast	Thigh	Back
0% fat	30.57	31.6	25.08
2.5% soybean oil	31.96	31.07	24.39
2.5% fat powder	31.35	31.72	24.49
5% soybean oil	31.6	31.14	25.09
5% fat powder	31.7	31.46	24.17
SEM	0.165	0.175	0.148
P-Value	0.09	0.41	0.27

Table 7. Effect of dietary fat level and sources on the weight of internal organs in turkeys (as percentage of live weight).

Treatments	Carcass	Spleen	Pancreas	Heart	Gizzard	Abdominal fat	Bursa
0% fat	66.86	0.086^{c}	0.15^{bc}	0.409^{a}	1.65^{b}	0.234^{b}	0.094^{c}
2.5% soybean oil	66.51	0.108^{a}	0.142^{c}	0.382^{b}	1.67^{b}	0.177^{d}	0.112^{ab}
2.5% fat powder	66.48	0.099^{b}	0.161^{b}	0.40^{ab}	1.8^{a}	0.2^{c}	0.103^{bc}
5% soybean oil	66.56	0.103^{ab}	0.145^{c}	0.379^{b}	1.74^{ab}	0.145^{e}	0.115^{a}
5% fat powder	66.33	0.095^{b}	0.172^{a}	0.413^{a}	1.71^{b}	0.268^{a}	0.096^{c}
SEM	0.214	0.001	0.002	0.003	0.012	0.005	0.001
P-Value	0.967	0.001	0.001	0.001	0.005	0.001	0.001

$^{a-e}$Means within a column with different superscripts are significantly different ($p < 0.05$).

Table 8. Effect of dietary fat level and sources on the antibody titer against the Newcastle Virus in turkey in 42 and 70 days

Treatments	Days	
	42	70
0% fat	5.75	6.83
2.5% soybean oil	5.91	6.66
2.5% fat powder	6.5	7.08
5% soybean oil	7	7
5% fat powder	6.08	6.66
SEM	0.206	0.103
P-Value	0.289	0.731

Discussion

Other studies reported that the use of lipid-based fats increased feed intake (Tabeidian & Sadeghi, 2006). In the experiment of Sanz, Flores, and Lopez-Bote (2000), effect of different sources of fat (sunflower oil and cow's suet) on the performance of broiler chickens was investigated and reported that different sources of fat had no effect on feed intake. However, in the study of Altop, Erener, Duru, and Isik (2018) in broilers, liquidambar essential oils increased feed intake (FI) compared to the control group. Increased feed intake resulted from the use of fat powder can be due to increased gluten-free diets mixed with fatty powder or because of the reduction in the energy content of calcium bonded fatty acids (Tabeidian & Sadeghi, 2006).

The favorable results of 5% soybean oil treatment on growth performance of birds could be explained by the positive impact of this fat sources combination on the reduced passage rate of the digesta through the gastrointestinal tract, allowing for better nutrient absorption and utilization (Latshaw, 2008), resulting in a more efficient use of nutrients from diet. From 1 to 42 d, the liquidambar essential oils treatment had higher live weight gain (LWG) compared to the control group (Altop et al., 2018). According to Wang, Zhang, Yan, and Kim (2016), the inclusion of emulsifier in low-energy diets can increase the BWG of broiler chickens to the level determined in birds fed high-energy diets. Leeson and Atteh (1995) found that unsaturated fatty acids (found in large amounts in soybean oil) were better utilized by turkeys than saturated fatty acids. Kaczmarek, Bochenek, and Rutkowski (2015) demonstrated that glycerol polyethylene glycol ricinoleate had a positive effect on the digestion of animal fat/rapeseed oil blends. The analysis of data confirmed the results from a previous experiment with broiler chickens (Lalev et al., 2016), showing statistically significant difference between live weights of groups at 35 and 49 days of age and higher values in birds fed rations with Rümanol ML.

It is reported that in broilers fed 8% beef tallow in the diet, a significant depression of feed efficiency was observed compared to birds fed sunflower or fish oil. Furthermore, adding 3% of canola oil in broiler diet resulted in a significant improvement in body weight and feed conversion ratio when compared to birds fed animal fat (Newman et al., 2002). In turkeys at the age of 6 weeks, dietary supplementation with vegetable oils (soybean oil, maize and canola) was more effective than control diet or animal fats (Leeson & Atteh, 1995). Diets with a non-saturated fatty acid profile such as soybean oil-based rations improved the feed conversion ratio; this is because digestibility of fats increases with increasing unsaturation degree of fat (Poorghasemi, Seidavi, Qotbi, Laudadio, & Tufarelli, 2013). These findings indicate that the effect of the type of fat source on the nutritional conversion factor can be through the fatty acid profile. Mala, Slezáčková, Strakova, Suchý, and Večerek (2004) showed that replacement of fat powder with vegetable oils would reduce the performance of broiler chickens.

The tissue fat content of broiler chickens is more affected by vegetable sources containing high amounts of unsaturated fatty acids compared with animal fats (NRC, 1994). However, Ayed, Attia, and Ennouri (2015) reported higher abdominal fat percentages in broiler chickens fed rations with palm oil, which was rich in saturated fatty acids. Has-Schön, Škrtić, and Kralik (2008) concluded that the most favorable effects on the lipid status of turkey pectoral muscle were observed with the Pronova preparation. The results of Sanz, Flores, Perez de Ayala, and Lopez-bote (1999) showed lower amounts of stored fat in the abdomen of broiler chickens fed with sunflower oil compared to those fed oatmeal or fats. Crespo and Esteve-Garcia (2002) suggested that reduction of abdominal fat in broilers fed a diet supplemented with oil seems to be a consequence of higher lipid oxidation despite the higher synthesis of endogenous fatty acids. In other studies, researchers found that the accumulation of energy and fat in chicken recipient lard was higher than

those fed with sunflower oil (Sanz et al., 2000). In broiler chickens, Abdulla et al. (2017) did not observe any effect of tested dietary energy sources on slaughter yield, breast and leg percentages from grill weight. In contrast to the results of this research, Poorghasemi et al. (2013) showed no significant effect of dietary lipid source on relative weights of the liver, heart and gizzard in broiler chickens. However, they confirmed the positive influence of mixing dietary saturated and unsaturated fats not only on breast muscles, but on leg as well.

The effects of dietary fatty acids on immune responses to common food-borne bacterial infections in chickens have been reviewed (Harrison, Balan, & Babu, 2013). In contrast with our results, in broilers fed diets with soybean oil, it was observed an increased heterophil:lymphocyte ratio, reduced weights of the bursa of Fabricius and spleen, and reduced antibody titers against ND and IBD viruses (Sadeghi, Mirmohseni, Shawrang, & Aminafshar, 2013). In most researches which direct fat sources were used, there are different results in the immune responses. Different types of dietary fatty acids, short-chain or medium-chain polyunsaturated, had variable effects on bacterial clearance and disease outcome through suppression or activation of immune responses (Harrison et al., 2013). Perhaps these different responses are the product of variation in the experimental models, but the widespread differences in the composition of the fatty acids used in these studies can also be attributed to this condition. Exposed dogs inflammatory challenges (for example, the challenge posed by lipopolysaccharide injections) are associated with lower weight gain and lower feed intake. When feeding these chicks with fish oil, some of its protective effects were observed against the harmful effects of inflammation.

Conclusion

From our experiment it seems that the supplementation of 5% soybean oil in the diet could produce better performance. However, it was not demonstrated differences due to fat sources on carcasses weights, nor on antibody titer against the Newcastle virus.

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