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EFFECT OF FRESH VERSUS OXIDIZED SOYBEAN OIL ON GROWTH PERFORMANCE, ORGANS WEIGHTS AND MEAT QUALITY OF BROILER CHICKS

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ABSTRACT

Over a period of six weeks, 90 day-old broiler chicks were randomly allotted into two experimental groups comprising forty five chicks on each treatment. Two experimental rations containing 2% fresh soybean oil (3 $mEqO_2$/kg and acid value 2.52 mg/g of oil) and 2% oxidized soybean oil (50 $mEqO_2$/kg and acid value 7.26 mg/g of oil) were formulated for both starter (0-4 week) and finisher (5-6 week) phases. At the end of feeding trial, six chicks per treatment were slaughtered and meat and liver tissues were ground and stored at 4°C for thiobarbituric acid numbers. Weight gain and feed conversion ratio were significantly improved in chicks fed on diet containing fresh soybean oil (FSO) compared to the chicks fed diet containing oxidized soybean oil (OSO). Feed intake was non-significantly different between the two groups. Dressing percentage and organs weights of birds were found to be non-significant for both treatments. However, liver weight increased ($P<0.05$) in OSO group compared to FSO group. Higher ($P<0.05$) thiobarbituric acid numbers were found of liver of chicks fed OSO containing diet compared to FSO group, however, no difference was found in meat thiobarbituric acid number of both groups. This study suggested that addition of oxidized oil had negative effect on weight gain, feed conversion ratio, liver weight and liver thiobarbituric acid numbers.

Key words: Broiler chicks, oxidized soybean oil, growth, carcass quality.

INTRODUCTION

Poultry feeding is one of the most important aspects of poultry production. Therefore, for profitable poultry rearing, provision of economical and balanced feed is must. Among the constituents of poultry feed, fats supply concentrated form of energy (2.25 times more energy than carbohydrates and proteins). However, their inclusion as true fat or oil in the ration is limited because of the high risk of rancidity on prolong exposure to air, heat, sunlight and poor storage conditions (Linfield *et al.,* 1985; Ali *et al.,* 2000). Therefore, the quality of fat used in feed is important, particularly with regard to the oxidative rancidity that has occurred in fat and high fat ingredients. Unsaturated fatty acids are particularly susceptible to oxidative processes which involve the generation of fatty acid free radicals, which may then react with molecular oxygen to produce peroxide free radicals and lipid peroxidation (Sherwin, 1978) and undesirable products with offensive odour and toxic properties (Cheeke, 1991). During oxidative process secondary products including ketones, malonaldehyde and acids are produced (Lin *et al*., 1989). The nutritive value of such rancid fats or feeds results in nutritional and economic losses (Cheeke, 1991). Dietary fat quality not only affects animal growth performance and health (Lin *et al*., 1989; Enberg *et al*., 1996) but also influences the quality of broiler meat and meat products (Lin *et al*., 1989; Asghar *et al*., 1989). Moreover, the influence of oxidized fat on animal performance depends on the degree of oxidation. Lewis and Wiseman (1977) reported a significant fall in digestibility while the free fatty acid reached 50%. Hussein and Kratzer (1982) reported that rancidity had no effect on the energy content. Godber *et al*. (1993) showed that rancidity deteriorated the palatability and feed intake. Chicks showed poor growth performance when dietary rice bran was rancid.

The present study was planned to determine whether the quality of fats had any effect on growth performance, slaughter data (dressing percentage, weights of liver, heart, bursa and gizzard) and quality of meat in terms of thiobarbituric acid value.

MATERIALS AND METHODS

Birds and management

Ninety day-old chicks of mixed sex (male and female) of 44 ± 1.7g average live body weight were obtained from commercial hatchery. These chicks were randomly divided into two groups and assigned to two treatments. One group was fed diet containing 2% fresh soybean oil (3 $mEqO_2$/kg and acid value 2.52 mg/g of oil) and second group was fed diet containing 2% oxidized soybean oil (50 $mEqO_2$/kg and acid value 7.26 mg/g of oil) in both starter and finisher rations for 0 to 4 and 5 to 6 weeks of age, respectively. There were 15 chicks per replicate and three replicates per treatment group. Initial live body weight was recorded and then at weekly intervals thereafter. Weighed quantity of feed was offered daily and refusal was recorded to determine the feed consumption. Feed conversion ratio (FCR) was calculated from the body weight gain and feed consumption at 4th and 6th week of age. Fresh water was offered for *ad libitum* consumption. All the chicks were vaccinated against Newcastle disease, Infectious Bursal disease and Hydropericardium Syndrome, as per recommended schedule.

Experimental rations

Soybean oil was oxidized for 10 days by keeping in an oven at 27°C (Cable and Waldroup, 1988), while the fresh oil was kept at 4°C to prevent it from oxidation. During adding oil in feed, peroxide value and acid value of the fresh and oxidized oil were determined using AOAC (1990) methods. Two isocaloric and isonitrogenious mash (rations starter and finisher) containing 2% fresh or 2% oxidized soybean oil were formulated (NRC, 1994). Ingredients and proximate (AOAC, 1990) composition of experimental rations are shown in Table 1. Fresh and oxidized soybean oil having peroxide value of 3 mEq/kg oil and 50 mEq/kg oil, while acid value was 2.52 and 7.26 mg/g of oil, respectively.

Slaughter data

At the end of experiment, two birds per replicate were slaughtered to collect data on carcass characteristics. Hot carcass weight of birds was obtained by removing the skin, head, feathers, lungs, toes with feet and gastrointestinal tract. Dressing percentage was calculated by the formula: hot carcass weight/ slaughter weight x 100. Internal organs i.e. liver, heart, bursa and gizzard were weighed immediately after slaughtering. Chicken meat from thigh and abdominal muscles and liver tissues were collected, ground and stored in loose plastic packing at 4°C for 2 weeks.

Thiobarbituric acid numbers determination

Thiobarbituric acid (TBA) numbers is used for determining the quality of fat containing products. The product that has a high TBA numbers would not be suitable for use because it would contain a high peroxide or aldehyde content. TBA numbers of chicken meat and liver tissues were determined, as described by Pearson (1976).

Statistical analysis

The data were analyzed statistically using t-test for means comparison (Steel and Torrie, 1982).

RESULTS

The oxidation process of soybean oil resulted in increase of peroxide and acid values. The average peroxide value (mEq/kg) and acid value (mg/g) of soybean oil from five analysis were found to be 50 and 7.52 for oxidized soybean oil (OSO) and 3 and 2.52 for fresh soybean oil (FSO), respectively. Ingredient and chemical composition of broiler starter and finisher rations are given in Table 1.

Growth performance of experimental chicks is presented in Table 2. Average live weight gain was found to be higher ($p< 0.05$) in FSO group than the group that received OSO during starter (0-4 week) and overall (0-6 week) growing periods, even though live weight gain during finisher (5-6week) period was found to be non-significant. Average feed consumption appeared to be numerically greater for the fresh than oxidized soybean oil fed group but difference was not significant. There was significant ($P<0.05$) effect of the dietary oil quality on feed conversion ratio for overall growing periods.

Changes in slaughter data that included dressing percentage and weights of internal organs (heart, bursa and gizzard) showed (Table 3) non-significant differences between the two treatments. However, weight of liver of chicks fed fresh vs. oxidized soybean oil differed significantly ($p<0.05$).

The average TBA numbers of chicken meat and liver tissues were found to be 1.31 and 1.85 mg/kg for oxidized soybean oil fed group, and 1.25 and 1.50 mg/kg for fresh soybean oil fed group, respectively (Table 4). Thiobarbituric acid numbers of broiler meat was non-significant, however, significant ($P<0.05$) difference was found in TBA numbers of liver tissues of two groups. The mortality was high (6%) in chicks fed oxidized soybean oil than those received fresh soybean oil throughout the experiment.

DISCUSSION

Highest weight gain was found in chicks fed FSO than those fed OSO. Feed consumption appeared to be numerically greater for the fresh than oxidized soybean oil fed group, however, the difference was not significant. Feed conversion ratio during overall growing period was found to be significant. Better FCR was noted in chicks of FSO group compared to OSO group, which indicates that feed containing oxidized soybean oil is of poor quality. These results are in line with the previous findings (Chrapa 1968; Bartov and Bornstein 1972; Award *et al*., 1983; Takigawa and Ohyama, 1983; Miyazawa and Knobb, 1986). Lower weight gain ($p<0.05$) of birds fed OSO was generally similarly to earlier reports (Cabel and Waldroup, 1988; Lin *et al*., 1989; Engberg *et al*, 1996; Wang *et al*, 1997). Chae *et al*. (2002) also reported lesser ($p<0.05$) weight gain in chicks fed rancid rice polish compared to the chicks fed fresh rice polish. This might be due to destruction of fat-soluble vitamins in rancid oil that leads to reduced availability of nutrients as well as immunity, and consequently depressed growth performance (Lin *et al*., 1989; Cheeke, 1991).

Table 1: Ingredient and chemical composition (%) of broiler rations

Ingredients	Starter (0-4 Week)		Finisher (5-6 Week)	
	FSO group	OSO group	FSO group	OSO group
Corn	29.00	29.00	29.40	29.40
Rice broken	18.00	18.00	21.00	21.00
Rice polishing	7.00	7.00	7.00	7.00
Cotton seed meal	8.00	8.00	8.00	8.00
Rape seed meal	1.00	1.00	3.70	3.70
Soybean meal	13.40	13.40	8.00	8.00
Corn gluten meal 60%	6.00	6.00	4.00	4.00
Corn gluten meal 30%	3.00	3.00	4.50	4.50
Fish meal	8.00	8.00	8.00	8.00
Soybean oil (Fresh)	2.00	-	2.00	-
Oxidized soybean oil	-	2.00	-	2.00
Molasses	2.00	2.00	2.00	2.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Limestone	1.00	1.00	0.80	0.80
Lysine	0.10	0.10	0.10	0.10
Vitamin Mineral Premix[1]	0.50	0.50	0.50	0.50
Chemical composition (%)				
ME (kcal/kg)**	3000.00	3000.00	3000.00	3000.00
Dry matter*	89.51	89.22	88.75	88.90
Crude protein*	21.51	21.45	19.85	19.50
Crude fibre*	3.21	3.18	3.11	3.15
Crude fat*	4.80	4.78	4.61	4.58
Ash*	4.91	4.95	4.55	4.85
Peroxide (mEq/kg)*	0.85	2.07	0.89	2.21
Calcium**	1.06	1.06	1.06	1.06
Phosphorus**	0.45	0.45	0.42	0.42
Lysine**	1.09	1.09	1.01	1.01
Methionine**	0.72	0.72	0.60	0.60
ME:Cp ratio**	139:1	140:1	151:1	153:1

[1] Vitamin Mineral Premix provided the following per kg diet: Vit. A 8800 IU, D_3 3300 IU, E 6.6 IU, K_3 1.5 mg, B_1 1.5 mg, B_2 6.5 mg, B_6 2.3 mg, B_{12} 13.5 μg, Pantothenic acid 12.2 mg, Biotin 50 μg, Niacin 35.5 mg, Choline choride 900 mg, Folic acid 0.6 mg, Cu 8 mg, Mn 64 mg, Zn 65 mg, Fe 50 mg, I 1.5 mg, Co 0.25 mg, Se 0.1 mg.

* Analysed values; **Calculated values

Diaz (1977) reported non-significant difference in feed intake among broiler chicks fed on ration having oxidized fat/oil with or without added antioxidant that supports the present findings. L'Estrange *et al*. (1966) reported no differences in feed efficiency in broilers fed oxidized beef tallow compared with control.

Hussein and Kratzer (1982) and Award *et al*. (1988), however, reported reduced feed intake ($p<0.05$) in birds fed rations having rancid feed with high peroxide value which are in contradiction to the present findings. This might be due to the use of oil of higher degree of rancidity compared to the oil used in our study. Chae *et al*. (2002) also reported that chicks fed diet containing fresh or oxidized soybean oil had no difference in feed intake.

During oxidation process of fats and high fat ingredients, thiobarbituric acid values increase (Waheed *et al*., 2004) which might have negative impact on chicks growth and effeciency. Engberg *et al*. (1996) and Chae *et al*. (2002) found lower retention of fat and energy in animals fed oxidized oil, which may be explained by the reduced capability of fat digestion. Sallmann *et al.,* (1988) noticed lower vitamin E concentration in plasma and in liver tissues by 40-60% in broilers fed oxidized fat. Similarly, Eschenbach and Hartfiel (1985) recorded significantly reduced vitamin A in liver of broilers consuming oxidized oil or fat.

Oxidized soybean oil had no significant effects on dressing percentage and weights of internal organs (heart, gizzard and bursa), however, higher weight of liver was found when compared with birds fed fresh soybean oil. Results of dressing percentage are quite comparable to those reported earlier (Diaz, 1977; Hussein and Kartzer, 1982). Liver weight of chicks of present study is in agreement with L'Estrange and Carpenter (1966), who observed significantly higher

Table 2: Growth performance (grams/bird) of broiler chicks fed fresh and oxidized Soybean oil

Parameters	Treatments	
	FSO group	OSO group
Starter (0-4week)		
Average weight gain (g/b)	1029 ± 13.89[a]	983 ± 14.33[b]
Average feed intake (g/b)	1717 ± 3.40	1687 ± 2.77
FCR (kg feed/kg gain)	1.67 ± 0.02	1.72 ± 0.01
Finisher (5-6 week)		
Average weight gain (g/b)	722 ± 7.75	695 ± 7.42
Average feed intake (g/b)	1859 ± 1.85	1838 ± 1.76
FCR (kg feed/kg gain)	2.57 ± 0.02	2.64 ± 0.00
Overall (0-6 week)		
Average weight gain (g/b)	1751 ± 22.28[a]	1678 ± 21.21[b]
Average feed intake (g/b)	3576 ± 33.92	3526 ± 35.93
FCR (kg feed/kg gain)	2.04 ± 0.00[a]	2.10 ± 0.1[b]
Mortality (%)	2.00	6.00

[ab]Values (means ± SEM) in rows with different superscripts differ significantly ($p<0.05$).

Table 3: Slaughter data of broiler chicks fed fresh and oxidized soybean oil

Parameters	Treatments*	
	FSO group	OSO group
Dressing percentage	58.22 ± 0.48	57.64 ± 0.47
Organs weights		
Liver (g/bird)	42.58 ± 0.66[b]	46.00 ± 0.50[a]
Heart (g/bird)	04.92 ± 0.08	4.97 ± 0.05
Gizzard (g/bird)	35.00 ± 1.44	35.33 ± 1.45
Bursa of fibricia (g/bird)	1.02 ± 0.01	1.11 ± 0.01
Liver weight/100g of live weight	2.06 ± .02[b]	2.92 ± 0.09[a]
Heart weight/100g of live weight	0.293 ± 0.01	0.314 ± 0.03
Gizzard weight /100g live weight	2.08 ± 0.04	2.24 ± 0.03
Bursa weight/100g live weight	0.06 ± 0.05	0.07 ± 0.07

[ab]Values (means ± SEM) in rows with different superscripts differ significantly ($p<0.05$).
*Values in each parameter are means of 3 observations.

Table 4: Thiobarbituric acid numbers of meat and liver of chicken fed fresh and oxidized soybean oil

Parameters	Treatments*	
	FSO group	OSO group
Chicken meat	1.25 ± 0.02	1.31 ± 0.05
Chicken liver	1.50 ± 0.05[b]	1.85 ± 0.07[a]

[ab]Values (means ±SEM) in rows with different superscripts differ significantly ($p<0.05$).
*Values in each parameter are means of 3 observations

liver weight in birds consuming oxidized fat compared to fresh fat. Increased weight of liver may be due to the accumulation of dietary oxidative products (Cherian *et al*., 1996). Oxidized oil raises the levels of aldehyde and other oxidized metabolites (Wang *et al.*, 1997), thiobarbituric acid and acid values (Waheed *et al*., 2004). Miyazawa *et al*. (1986) stated that oxidized oil stimulated the liver lipid peroxidation in guinea pigs.

Samples of meat and liver from the birds that consumed FSO and OSO diets were chemically analyzed for TBA numbers. Oxidized oil had little effects on meat TBA numbers however, significantly higher ($p<0.05$) TBA numbers were found in liver tissues. The increase in TBA numbers in liver of the birds that consumed oxidized oil may be due to oxidative deterioration of longer chain n-3 fatty acids (Cherian *et al*.,1996) and fat-soluble vitamins (Cheeke, 1991). Rates of lipid peroxidation in pig and broiler muscles were higher when these animals were fed oxidized oil (Asghar *et al*., 1989; Lin *et al*., 1989; Chae *et al*., 2002). Higher mortality (6%) was found in OSO group compared to FSO group. This is because of oxidation of oil that might have influenced immunity and caused high mortality by reducing fat-soluble vitamins (Cheeke, 1991). It can thus be concluded that use of oxidized soybean oil in broiler rations should be avoided.

REFERENCES

Ali, H., A. Haq, S. Rasool, T. H. Shah and M. I. Anjum, 2000. Effect of sodium bentonite as aflatoxin binder in broiler feeds containing fungal infected grains. Pakistan J. Agric. Sci., 37 (3-4): 163-165.

AOAC, 1990. Official Methods of Analysis. Association of Official Analytical Chemists 15th ed. Washington, DC, USA.

Asghar, A., C. F. Lin, J. I. Gray, D. J. Buckly, A. M. Booten and C. J. Flagal, 1989. Influence of oxidized dietary oil and antioxidant supplementation on membrane bound lipid stability in broilers meat. British Poult. Sci., 30: 815-823.

Award, Y. L., M. El-Baggouri and O. E. Mohamed, 1983. Deterioration of rancidity in practical poultry diets and related production problems. J. Egyptian Vet. Med. Assoc., 43: 401-404.

Bartov, I. and S. Bornstein. 1972. Comparision of BHT and ethoxyquin as antioxidants in the nutrition of broilers. Poult. Sci., 51: 859-868.

Cabel, M. C. and P. W. Waldroup, 1988. Effect of ethoxquin preservative and peroxide level on broiler performance. Poult. Sci., 67: 1725-1730.

Chae, B. J., K. H. Lee and S. K. Lee, 2002. Effects of feeding rancid rice bran on growth performance and chicken meat quality in broiler chicks. Asian-Aust. J. Anim. Sci., 15: 266-273.

Cheeke, P. R, 1991. Applied Animal Nutrition: Feeds and Feeding. MacMillan Publishing Company, New York, USA.

Cherian, G., F. W. Wolfe and J. S. Sim, 1996. Dietary oils with added tocopherols: Effects on egg or tissue tocopherols, fatty acids, and oxidative stability. Poult. Sci., 75: 423-431.

Charapa, V. P, 1968. Effect of antioxidant in feed for broiler. Nutr. Abst. Rev. 40: 1969.

Diaz, R. P. G, 1977. Effect of including rancid fats in rations for meat chickens. Nutr. Abst. Rev., 49: 2385.

Engberg, R. M., C. Lauridsen, S. K. Jensen and K. Jakobson, 1996. Inclusion of oxidized vegitable oil in broiler diets. Its influence on nutrient balance and on the antioxidant status of broiler. Poult. Sci., 75: 1003-1011.

Eschenbach R. and W. Hartfiel, 1985. The effect of oxidized oils/fats and addition of α-tocopherol and antioxidants on growth and vitamins E and A contents of tissues of fattening chickens. Poult. Abstr., 12: 23, 1986.

Godber, J. S., D. Martin, T. S. Shin, G. Setlhakq, C. Tricon and M. Gervais, 1993. Quality parameters important in rice bran for human consumption. Louisiana Agric., 36: 9.

Hussein, A. and F. H. Kratzer, 1982. Effect of rancidity on the feeding value of rice bran for chickens. Poult. Sci., 61: 2450-2455.

Lin, C. F., A. Asghar, J. I. Gray, D. J. Buckly, A. M. Boome, R. L. Crackel and C. J. Flegal, 1989. Effect of oxidized dietary oil and antioxidant supplementation on broiler growth and meat stability. British Poult. Sci., 30: 855-864.

Linfield, W. M., S. Serota and L. Sivieri, 1985. Lipid-lipase interaction, a new method for the assay of lipase activity. J. Amer. Oil Chem. Soc., 62: 1152-1154.

Lewis, D. and J. Wiseman, 1977. The use of added fats in rations for growing pigs. Intl. Symposium on animal fats in pig feeding. Dubrovnik. NRA. pp: 101-110.

L'Estrange, J. L., K. J. Carpenter, C. H. Lea and L. J. Parr, 1966. Nutritional effects of oxidized fats in animal diets. 2. Beef fat in diet of broiler chicken. British J. Nutr., 20: 113-122.

Miyzawa, T. and T. Knobb, 1986. Effect of dietary vitamin C and vitamin E on tissue lipid per oxidation of guinea pigs fed with oxidized oil. Agric. Biol. Chem., 50: 71-78.

NRC, 1994. Nutrient requirement of poultry. National Research Council. National Academy Press, Washington, USA.

Pearson, D., 1976. The Chemical Analysis of Foods. 7th ed. Churchill, Livingstone, Edinburgh, UK.

Steel, R.G.D. and J. H. Torrie, 1982. Principles and Procedures of Statistics, 2nd Ed., McGraw Hill Book Co., Inc. New York, USA.

Sallmann, R.E., V.I. Stevens and B.D. Ladbrooke, 1988. Full fat canola seed as a feedstuff for turkeys. Poult. Sci., 67: 1731-1742.

Sherwin, E. R., 1978. Oxidation and autoxidation in fat and oil processing. J. Amer. Oil Chem. Soc., 55: 809-814.

Takigawa, A. and Y. Ohyama, 1983. Effect of oxidized oil on development of encephlaomalacia, growth, digestion and organs in chicks. Japanese J. Zool. Sci., 54: 444-450.

Waheed, A., T. Ahmad, A. Yousaf and I. J. Zafer, 2004. Effect of various levels of fat and antioxidants on the quality of broiler rations stored at high temperature for different periods. Pakistan Vet. J., 24: 70-75.

Wang, S. Y., B. Walter, M. Philip, D. Julia and S. William, 1997.Effect of santoquin and oxidized fat on liver and intestinal glutathion in broilers. Poult. Sci., 76: 961-967.