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The response of turkeys to diets containing fat differing in degree of oxidation *

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ABSTRACT

A 16-week experiment was conducted on 224 three-day-old BUT-9 turkey chickens randomly assigned to 4 groups, each with 4 replicates; each group comprised 7 toms and 7 hens. In successive 4-week periods the basic ration was supplemented with 2 to 5% of a mixture of rape seed oil and poultry fat (66:34) differing in peroxide value in groups I-IV <5, 50, 100 and 150 mEq O_2/kg, respectively.

The addition of oxidized fat had a negative effect on the growth rate of turkeys, causing significant ($P<0.01$) differences in the body weight of the birds at ages 12 and 16 weeks. At end of the experiment the birds in the control group (I) were an average 1.07 kg heavier than those in groups II-IV; these differences were considerably greater in tom turkeys and averaged 1.7 kg. The lower weight gain in the experimental birds was caused by the approximately 10% smaller consumption of feed than in the control group. Increasing the peroxide value of added fat from 50 mEq O_2/kg (group II) to 100 or 150 mEq O_2/kg (groups III and IV) did not further reduce body weight. The degree of fat oxidation did not distinctly affect mortality, feed consumption, or slaughter value of the turkeys. The addition of oxidized fat significantly lowered serum and hepatic vitamin E levels and, to a smaller extent, also the vitamin A content in the liver.

KEY WORDS: oxidized fat, turkeys, performance, slaughter value

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INTRODUCTION

In recent years supplementation of feed mixtures with fat has become the subject of controversy since fat oxidation may lower the nutritional value of diets and lead to the formation of toxic products (Cabel et al., 1988). In many earlier studies (Lipstein et al., 1965; L'Estrange et al., 1966; Lea et al., 1966) it was reported that diets containing both oxidized fat and appropriate amounts of antioxidants (vitamin A and selenium) were not harmful to the health of birds and did not lower chicken or turkey performance. Similarly, Matyka (1981) found that adding highly oxidized fat to chicken diets only slightly lowered feed consumption, nutrient digestibility, and body weight gain, but did cause subclinical changes in their bodies. More recent experiments show that the oxidation products of fat in feeds can decrease the growth rate of birds (Cabel et al., 1988), cause many unfavourable changes in their bodies (Dibner et al., 1996), and even lower the shelf-life of the meat from them (Asghar et al., 1989). It is possible that broilers from new, fast-growing lines are less tolerant to high levels of fat in the diet and are more susceptible to metabolic disorders (Scheele et al., 1993). For this reason the renewed interest in the influence of the products of thermooxidative changes of fat, on the growth and health of birds is justified.

The objective of this study was to determine the reaction of meat turkeys to the presence of oxidized fat in the diet. The effect of the degree of fat oxidation on the growth of turkeys, feed utilisation, slaughter value, and vitamin E and A contents in the serum and liver was studied.

MATERIAL AND METHODS

The experiment was conducted at the State Turkey Evaluation Station of the Warmia and Masuria University on 224 three-day-old BUT-9 turkey chickens randomly allocated to four groups, each with four replicates (7 toms and 7 hens in each). The environmental and lighting conditions were according to Faruga and Jankowski (1996). The birds were fed *ad libitum* with mash diets. The ration composition was changed every four weeks according to the requirements of the birds, successively increasing the fat content in diet from 2 to 5% (Table 1). The diets differed in the peroxide value of the added fat, which equaled from: < 5, 50, 100 and 150 mEq O_2/kg. The degree of oxidation and fat content were chosen so that the highest lipid peroxide content per kg of feed approached 7 mEq O_2 (Table 2), i.e., the amount lowering body weight gains of chickens in the experiments of Cabel et al. (1988). Fat (a mixture of rape seed oil and poultry fat at a proportion of 66:34) was oxidized under controlled conditions as described by Zduńczyk et al. (2000). Every week a new lot of diets was supplemented with fat in order to prevent further oxidation during storage.

TABLE 1

Chemical composition and nutritive value of diets

Component, %	Feeding period, weeks			
	0-4	5-8	9-12	13-16
Wheat	49.22	53.18	47.46	46.34
Triticale	-	-	15.00	15.00
Barley	-	-	-	10.00
Soyabean meal (46% CP)	37.00	34.00	25.00	17.00
Meat meal (55% CP)	8.00	6.00	5.00	3.00
Fat[1]	2.00	3.00	4.00	5.00
Remaining[2]	3.78	3.82	3.54	3.66
Calculated, in 1 kg of diet				
crude protein, g	272.1	251.9	216.5	178.2
EM, MJ/kg	12.05	12.41	12.94	13.37
crude fat, g	42.6	50.8	59.8	68.4
Lys, g	16.8	15.9	13.6	10.8
Met + Cys, g	10.5	9.9	8.3	7.3
Ca, g	12.7	11.4	10.0	8.9
P available, g	7.2	6.2	5.0	4.5
Na, g	1.55	1.55	1.51	1.57
Se, mg	0.3	0.3	0.3	0.3
vitamin A, IU	15000	13000	12000	12000
vitamin E, mg	40	35	30	30

[1] mixture of rape seed oil and poultry fat in proportion 66:34

[2] limestone, monocalcium phosphate, NaCl, $NaHCO_3$, DL-methionine, L-lysine HCL, L-treonine, mineral-vitamin premix in amount adequate to requirement, feed enzyme and acidifier; and also from 1 to 12 weeks only Diclazuril (1 mg/kg) and Flawofosfolipol (5 mg/kg diet)

TABLE 2

Peroxide content (mEq O_2/kg) in added fat and in diets

Feeding period weeks	Added fat % of diet	Peroxide content in added fat			
		5	50	100	150
		peroxide content in diet			
		I	II	III	IV
0 - 4	2	0.1	1.0	2.0	3.0
5 - 8	3	0.1	1.5	3.0	4.5
9 -12	4	0.2	2.0	4.0	6.0
13 -16	5	0.25	2.5	5.0	7.5

After completion of the experiment, 6 toms and 6 hens with body weights close to the group average were taken from each group and were slaughtered after 12 h of fasting. Blood and liver samples were taken immediately for determination of vitamin A and E contents. Vitamins were assayed by HPLC according to Cuesta Sanz and Castro Santa-Cruz (1986). The carcasses were cooled for 24 h at +4°C, then slaughter performance was determined.

The results were subjected to statistical analysis using one and two-factorial analysis of variance using STAT-1 software.

RESULTS

The addition of fat characterized by varied degrees of oxidation to diets did not cause significant differences in the body weight of turkeys (LBW) at 4 and 8 weeks of age (Table 3). At 12 weeks of age the average LBW of turkeys in group I was

TABLE 3

Performance of turkey

Indices	Peroxide content in added fat, mEq O_2/kg (group)				SEM
	<5 (I)	50 (II)	100 (III)	150 (IV)	
Live body weight, kg					
at 4 weeks ♀ ♂	1.22	1.22	1.19	1.20	0.017
♂ n = 28	1.35	1.34	1.27	1.34	0.016
♀ n = 28	1.09	1.10	1.11	1.05	0.014
at 8 weeks ♀ ♂	4.18	3.92	3.91	3.87	0.065
♀ n = 22	4.86	4.52	4.26	4.46	0.061
♂ n = 22	3.49	3.31	3.55	3.28	0.044
at 12 weeks ♀ ♂	7. 84^{A}	7.26^{B}	7. 40^{B}	7.04^{B}	0.146
♀ n = 16	9.24^{A}	8.53^{B}	8.25^{B}	8.29^{B}	0.104
♂ n = 16	6.43^{a}	5.99^{b}	6.56^{b}	5.79^{b}	0.069
at 16 weeks ♀ ♂	11.00^{A}	10.05^{B}	9.85^{B}	9.88^{B}	0.237
♀ n = 10	13.44^{A}	12.11^{B}	11.58^{B}	11.94^{B}	0.167
♂ n = 10	8.56^{a}	8.00^{b}	8.13^{b}	7.81^{b}	0.104
Daily diet intake[1], g	233	213	209	213	0.524
Kg feed/kg LBW	2.37	2.37	2.38	2.42	0.006
Mortality, %[1]	3.33	1.67	-	5.00	

[1] average values for the whole period of experiment

^{a,b} $P<0.05$; ^{A,B} $P<0.01$

n – value of birds in group

significantly higher than in the remaining groups. LBW in group IV was 0.8 kg lower, i.e. 11.4% less than in group I. After 16 weeks the turkeys in group I continued to be significantly heavier (by 1.07 kg) than in the remaining groups. The dominance of group I over the other groups, both at 12 and 16 weeks, was visible primarily in tom turkeys (1.7 kg on average). The lack of significant differences in LBW among groups II, II, and IV shows that increasing level of oxidation to over 50 mEq O_2/kg did not cause any further deterioration of body weight gain.

Average consumption of diets containing oxidized fat (groups II-IV) was 212 g daily, which was about 10% lower than in the control group (233 g/day). Feed consumption was already lowered in the group receiving fat oxidized to 50 mEq O_2/kg and did not continue to decline when the peroxide value of the added fat increased to 100 and 150 mEq O_2/kg. Feed consumption per kg body weight (Table 3) did not differ significantly, but was the highest in group IV (150 mEq O_2/kg). Survival was good in all groups (from 95 to 100%); the highest mortality was in group IV (5%) but it can not be attributed to the studied factor, since the deaths occurred in the first four weeks of life, similarly as in the remaining groups.

The addition of oxidized fat to the diets caused serum and hepatic level of vitamin E to decline significantly (Table 4). Oxidizing fat also lowered the vitamin A content in the liver, although the differences among groups were not statistically confirmed.

The carcass dressing percentage (Table 5) was similar in all groups (about 81%). Among the evaluated internal organs only the relative weight of the stomach differed significantly, but this can not be attributed to the studied factor. Similarly significant differences in breast muscle content ($P<0.01$) and fat deposits ($P<0.05$) were not unequivocally dependent on the degree of fat oxidation in the feed. Turkeys from groups II and III (peroxide value of added fat 50 and 100 mEq O_2/kg, respectively) had larger stomachs and lower breast muscle contents, and their carcasses had more

TABLE 4

Vitamin A and E content in blood serum and liver of turkey[1]

Indices	Group				SEM
	I	II	III	IV	
Vitamin E					
serum, µg/100 cm³	168.65^{Aa}	135.58^{ABb}	134.01^{ABb}	118.54^{B}	5.87
liver, µg/100 g	180.47^{A}	114.35^{B}	95.10^{B}	92.06^{B}	9.20
Vitamin A					
serum, µg/100 cm³	190.42	178.46	185.13	185.02	3.45
liver, µg/100 g	19.80	17.63	17.61	15.34	0.81

^{a,b} – $P<0.05$; ^{A,B} – $P<0.01$

[1] means of 6 males and 6 females; SEM – pooled standard error of the mean

fat. In terms of the studied traits, turkeys from group IV (fat with a peroxide value of 150 mEq O_2/kg was added) did not differ from the control group.

Breast muscle pH measurements (Table 6), both 1 and 24 h after slaughter, were similar and equaled: 5.90 – 6.09 and 5.90 – 5.94, respectively. No effect of degree of oxidation of the fat on carcass pH was found.

TABLE 5

Indices of slaughter analysis, % of liveweight[1]

Indices	Peroxide content in added fat, mEq O_2/kg (group)				SEM
	<5 (I)	50 (II)	100 (III)	150 (IV)	
Carcass yield	81.40	80.70	81.20	81.50	0.193
Gizzard	0.91^{a}	1.00^{b}	1.02^{b}	0.91^{a}	0.015
Liver	0.97	1.00	1.01	1.01	0.013
Heart	0.29	0.36	0.30	0.30	0.006
Spleen	0.06	0.07	0.07	0.06	0.001
Breast muscles	24.70^{A}	23.40^{B}	23.00^{B}	24.20^{A}	0.171
Leg muscles	19.20	18.40	18.50	18.90	0.138
Abdominal fat	1.30^{a}	1.70^{b}	2.00^{c}	1.50^{a}	0.103

^{a,b} – $P<0.05$; ^{A,B} – $P<0.01$

[1] as in Table 4

TABLE 6

pH of breast muscle[1]

pH	Peroxide content in added fat, mEq O_2/kg				SEM
	<5 (I)	50 (II)	100 (III)	150 (IV)	
After 1 h	5.90	5.98	6.03	6.09	0.025
After 24 h	5.92	5.90	5.94	5.92	0.018

[1] as in Table 4

DISCUSSION

The performance of the turkeys in the control group was in agreement with the standards for this type of hybrid and with results obtained in earlier studies (Jankowski et al., 1996). Introducing fat with a peroxide value of 50 mEq O_2/kg reduced body weight gain. Increasing the degree of oxidation to 100 and 150 mEq O_2/kg did not cause any further decline in body weight gain. In our experiment body weight gains of turkeys declined when the peroxide content in feed equaled 1.0 in the first month and increased to 2.5 mEq O_2/kg by the fourth month of the experiment. The results of other authors in experiments carried out mainly on chick-

ens, are equivocal. In the experiment of Calabotta and Shermer (1985) lower body weight of chickens was found when the birds were fed a diet with a low content of peroxides, from 1 to 2 mEq O_2/kg. In the experiment of Cabel et al. (1988) the body weight of 49-day-old chickens was lower only in the group receiving the highest amount of peroxides (7 mE O_2/kg). In the study by Dibner et al. (1996) the body weight of 3-week old chickens fed diets containing 4 mEq O_2/kg, was not significantly lower than in the control group.

Oxidizing the fat added to the diets only slightly worsened feed utilisation by turkeys. Dibner et al. (1996) obtained similar results, while Calabotta and Shermer (1985) and Cabel et al. (1988) reported otherwise. The smaller differences in feed utilisation found in our experiment than in the final body weight of turkeys indicate that the main factor lowering gain of the birds was decreased consumption of feed containing oxidized fat. Similar conclusions were drawn from experiments on chickens reported by Matyka (1981). Similarly as Cabel et al. (1988), no effect was in the degree of fat oxidation on the survival of the birds was found. Reduced hepatic vitamin E reserves were in agreement with the results of Asghar et al. (1989), who found that oxidized dietary fat lowered the tocopherol content in cell membranes of broilers.

The results of the discussed studies do not give grounds for concluding that turkeys are more sensitive to dietary fat oxidation than chickens. In the case of turkeys, the slaughter value was similar to the standards set for this type of bird and with the results of other studies (Faruga and Jankowski, 1996; Jankowski et al., 1996; Mikulski et al., 1997). Also breast muscle pH values immediately after slaughter and after 24 h storage of carcasses were within standard limits (Meller et al., 1997).

REFERENCES

Asghar A., Lin C.F., Gray J.L, Buckley D.J, Booren A.M., Crackel R.L., Flegal C.J., 1989. Influence of oxidized dietary oil and antioxidant supplementation on membrane-bound lipid stability in broiler meat. Brit. Poultry Sci. 30, 815-823

Cabel M.C., Waldroup P.W., Shermer W.D., Calabotta D.F., 1988. Effect of ethoxyquin feed preservative and peroxide level on broiler performance. Poultry Sci. 67, 1725-1730

Calabotta D.F., Shermer W.D., 1985. Controlling feed oxidation can be rewarding. Feedstuffs 25 (11), 24

Cuesta Sanz D., Castro Santa-Cruz M., 1986. Simultaneous measurement of retinol and alphatocopherol in human serum by high performance liquid chromatography with ultraviolet detection. J. Chromatogr. 380, 140-144

Dibner J.J., Atwell C.A., Kitchell M.L., Shermer W.D., Ivey F.J., 1996. Feeding of oxidized fats to broilers and swine: effect on enterocyte turnover, hepatocyte proliferation and the gut associated lymphoid tissue. Anim. Feed Sci. Tech. 62, 1-13

Faruga A., Jankowski J., 1996. Turkeys Breeding and Management (in Polish). PWRiL, Warszawa (Poland)

Jankowski J., Faruga A., Puchajda H., Wężyk S., 1996. Performance of turkeys of different origin, kept under the same environmental conditions. Proceedings of 20th World Poultry Congress, New Delhi (India) 3, 461-465

Lipstein B., Budowski P., Bornstein S., 1965. Effect of autooxidation on the nutritive value of acidulated soybean soapstock in chick. Poultry Sci. 44, 1480-1484

L'Estrange J.L., Carpenter K.J., Parr L.J., 1966. Nutritional effect of autooxidized fats in animal diets. Beef fat in the diet of broiler chicken. Brit. J. Nutr. 20, 113-122

Lea C.H., Parr J., L'Estrange J.L., Carpenter K.J., 1966. Nutritional effect of autooxidized fats in animal diets. 3. The growth of turkeys on diets containing oxidized fish oil. Brit. J. Nutr. 20, 123-133

Matyka S., 1981. Feeding value of some highly rancid animal fats for broiler chickens (in Polish). Central Laboratory of Feed Industry, Lublin (Poland)

Meller Z., Filuś K., Jankowski J., 1997. Meat quality of young WAMA turkey. Acta Acad. Agr. Tech. Olst., Zoot. 46, 105-121

Mikulski D., Jankowski J., Faruga A., Mikulska M., 1997. The effect of enzyme supplementation of triticale-barley feeds on fattening performance of turkey. J. Anim. Feed Sci. 6, 391-399

Scheele C.W., 1993. Effect of nutritional factors on the occurrence of ascites and heart failure syndrome. Proceedings of 9th European Symposium on Poultry Nutrition, Jelenia Góra (Poland), pp. 215-230

Zduńczyk Z., Juśkiewicz J., Wróblewska M., Frejnagel S., Koncicki A., 2000. The response of rats on long-term feeding with diets containing oxidized fat. 1. Thermooxidative changes in fat, body weight gain, feed consumption and utilisation. J. Anim. Feed Sci. 9, 137-146

STRESZCZENIE

Reakcja indyków na żywienie mieszankami zawierającymi tłuszcz o różnym stopniu utlenienia

Szesnastotygodniowe doświadczenie przeprowadzono na 224 trzydniowych pisklętach indyczych BUT-9, podzielonych losowo na 4 grupy, składające się z czterech powtórzeń, po 7 samców i 7 samic w każdym. W kolejnych okresach 4-tygodniowych, do mieszanki podstawowej dodawano od 2 do 5% mieszaniny oleju rzepakowego i tłuszczu drobiowego (66:34). Liczba nadtlenkowa tłuszczu dodawanego do mieszanek w grupach I-IV wynosiła odpowiednio: <5, 50, 100 i 150 mEq O_2/kg.

Dodatek utlenionego tłuszczu ujemnie wpływał na tempo wzrostu indyków, powodując istotne ($P<0,01$) różnice w masie ciała ptaków w wieku 12 i 16 tygodni. Po zakończeniu doświadczenia indyki z grupy kontrolnej (I) były średnio o 1,07 kg cięższe niż z grup II - IV; u indorów różnica ta była znacznie większa i wynosiła aż 1,7 kg. Niższe przyrosty masy ciała ptaków w grupach doświadczalnych były następstwem zmniejszenia o około 10% spożycia mieszanek w porównaniu z grupą kontrolną. Zwiększenie liczby nadtlenkowej tłuszczu dodawanego do mieszanek z 50 mEq O_2/kg (grupa II) do 100 lub 150 mEq O_2/kg (grupa III i IV), nie powodowało dalszego obniżania masy ciała indyków. Stopień utlenienia tłuszczu nie wpłynął wyraźnie na przeżywalność, zużycie paszy i wartość rzeźną indyków. Dodatek utlenionego tłuszczu istotnie zmniejszał zawartość witaminy E w surowicy krwi i wątrobie, w mniejszym stopniu obniżał również zawartość witaminy A w wątrobie indyków.