PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 3 (4): 213-221, 2004

The Effect of Oxidized Fat Added to Feed Mixture on Selected Quality Attributes of Turkey Meat

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Abstract: The effects of the oxidation degree of fat added to feed mixtures for turkey females as well as the addition of an antioxidant on the quality of raw meat and meat after heat treatment were investigated. The manner of feeding had no significant effect on the contents of major compounds in the analyzed breast muscles. The addition of fat with a higher peroxide value to diets was found to decrease the contents of polyenic and saturated acids and to increase the concentration of monoenoic acids. The muscle fat of turkey females receiving oxidized fat and the Hadox-dry preparation simultaneously was characterized by a slightly higher concentration of unsaturated acids and a lower content of saturated acids. A lower intensity of lipid oxidation was observed in the muscles of the birds fed on mixtures supplemented with compounds of antioxidant activity. The muscles of the birds fed on a diet supplemented with the Hadox-dry preparation had the highest scores for sensory evaluation.

Key words: Oxidized fats, antioxidants, breast muscles of turkeys, fatty acids, oxidation

Introduction

The dietetic and nutritive value of poultry meat depends on numerous factors which are formed, to a high degree, *in vivo*. A wide range of quality attributes, both positive and negative, results from the feeding manner of birds. The intensive production of young slaughter turkeys requires providing the growing birds with a high energy level in feed. The main components capable of increasing the energy value of diets for turkeys are corn and soybean.

Of the components able to add energy value to diets, fats are of significant importance. They have a high caloric value, ca. 9 kcal g^{-1}, and when applied in feed mixtures, even in small doses, they make it possible to obtain feed with a desirable energy level (Lopez-Bote *et al*., 1997).

An important issue referring to poultry feeding is the supplementation of diets with oxidized fats, namely waste fats of different thermal processes, e.g. frying, and waste products obtained as a result of vegetable oil refining. The safety of administering oxidized fats to diets and their impact on live organisms have become controversial and are the subject of research by numerous authors. One of the reasons of this controversy is the anxiety that the lipid oxidation may decrease the nutritive value of a diet, increase depression and diarrhoea incidence, cause histological changes to tissues and, in some cases, even the death of birds (Izaki *et al*., 1984; Jakobsen *et al*., 1993). It may also result in the production of different compounds, including: peroxides, hydro peroxides, aldehydes, ketones and others, the majority of which may have toxic potential (Cabel *et al*., 1988). Other investigations have indicated that the products of feed lipid oxidation may lower the shelf-life of chicken meat (Asghar *et al*., 1989).

Negative results of lipid oxidation may also affect the quality of products made from the meat of those birds (Lin *et al*., 1989). The oxidation process of intramuscular lipids of poultry meat during storage and processing is one of the main causes of the worsening of its sensory attributes. The non-typical taste and aroma may disqualify the product. The intensity of oxidative processes depends on the composition of fatty acids and the content of pro- and antioxidants in meat (Engberg *et al*., 1996; Maraschiello *et al*., 1998; Ruiz *et al*., 1999).

The objective of this study was to evaluate the effects of the oxidation degree of fat and antioxidant dose added to feed mixture for turkey females on the quality of raw and processed meat.

Materials and Methods

Materials: The experimental material consisted of the breast muscles of turkeys of the BUT-9 strain. The birds were fed on the feed mixtures supplemented with 2, 3, 4, and 5% of fats in subsequent rearing periods (0 - 4, 4 - 8, 8 - 12, 12 - 16 weeks, respectively). The feed mixtures were greased with a mixture of rapeseed oil and poultry fat used in the following proportions: 66 and 34%, respectively. Turkeys were divided into 4 feeding groups depending on the oxidation degree of the fat added. The peroxide value of fat supplemented to mixtures was < 5; 50; 100; and 150 mEq O_2 kg^{-1} in groups: I, II, III, and IV, respectively. Each feeding group was divided into two sub-groups: A and B. Apart from

oxidized fat, the diets of turkeys from the B sub-group were supplemented with a powdered preparation "Hadox-dry", which consisted of butylhydroksyanisole (E 320) and ethoxyquin (E 324). The addition of preparation in the amount of 0,125 g/kg of fat was in accordance with the recommendation of the producer-Hameco Agro b. v. Twenty-four hours after slaughter, breast muscles of turkeys were vacuum packed and stored at a temperature of -18°C until analyses (12-13 months). The assays were performed in 4 stages, in weekly intervals (consecutive experimental stages involved analyses of the birds muscles of the respective feeding groups: I, II, III, and IV). The muscles were thawed at a temperature of 4°C ± 1°C for 18 h prior to consecutive experimental stages. Each muscle was dissected into 2 parts. The first part was used for the analyses of raw meat and the second one was subjected to thermal processing in a BECK FCV 4 EDS convection-steam oven with a temperature measuring probe. The steam processing was applied until the inner temperature of the muscle reached 75°C. The steam temperature reached 100°C.

Methods: The muscles were examined for the contents of water, protein and fat (AOAC, 1990). The isolation of fat, to be used for the determinations of fatty acid composition, was performed according to the method of Folch *et al*. (1957). The content of fatty acid methyl esthers was determined by the GC method after methylation with a chloroform/methanol/sulfuric acid (100:100:1) mixture (Peisker, 1964). Peaks of methyl esthers were identified by comoparision of their retention times of standard peaks of the mixture of known composition (Applied Science Corporation). Analyses were performed with a HP 6890 GC machine equipped with a 30m x 0.32 mm capillary column. As a liquid phase Supelcowax 10-0.25 µm was used. The content of malonaldehyde was assayed with the method of Tarladgis modified by Pikul *et al*. (1989). The meat products were subjected to a sensory evaluation with the method of flavour profile (Meigaard *et al*., 1999). The sensory panel consisted of 5 panelists trained according to PN ISO 3972 (1998).

The sensory evaluation was performed on coded meat samples immediately after thermal processing in a convection-steam oven. The evaluation involved 3 samples given to the panelists at random. The sensory quality attributes of a product were selected on the basis of preliminary analyses.

The following flavour attributes were used: meat-like, typical, aromatic, sour, rancid, and non-typical. The intensity of particular attributes was determined on a 5-point scale: 0 - lack of sensation; 1 - hardly noticeable sensation; 2 - slightly noticeable sensation; 3 - moderately noticeable sensation; 4 - strongly noticeable sensation; 5 - very strongly noticeable sensation.

All analyses were performed in 9 replications. The obtained results were analyzed statistically with the STATISTICA program version 6. (StatSoft, Inc.). The significance of differences was determined with Duncan's test at a significance level of $p<0.05$.

Results and Discussion

The content of fat in the muscles of turkeys fed on antioxidant-free diet reached 0.97 - 1.33%. A lower differentiation in the contents of that compound (1.01 - 1.30%) was observed in birds fed on a diet supplemented with the Hadox-dry preparation. The analyzed muscles contained from 24.18 to 24.74% and from 24.19 to 24.69% of protein from turkeys fed a mixture without and with antioxidant, respectively. The water content in raw muscles ranged from 73.42 to 73.63% in birds fed on antioxidant-free mixtures and from 72.75 to 73.54% in turkeys administered a diet with the Hadox - dry preparation.

Statiscical analysis of the results revealed that the feeding manner and the composition of mixtures for turkeys had no significant effect on the contents of basic components in the muscles under study. The above-mentioned relationships correspond to the study by Jensen *et al*. (1997), who did not report any significant impact of the manner of oxidized fat addition to a diet on the fat content in breast and thigh muscles of chickens. On the other hand, Blair *et al*. (1989) showed that a higher level of protein and fat in a feed mixture caused an insignificant increase in their percentage in meat. However, Nam *et al*. (2003) found higher amounts of fat in breast muscles of turkeys fed on a vitamin E-supplemented diet than in those of birds fed on a diet without this vitamin.

In animal carcasses, the fatty acid composition depends, to a high degree, on the type of diet, especially on the quality and type of fat it contains. The nutritive value and biological activity of fat are determined by the concentration and composition of fatty acids contained in it, with the number of double bonds and the position of the first double bond being of the highest importance (Channon and Trout, 2002 cit. after Shahidi). As other animal fats, poultry fat is characterized by the highest concentrations of the following fatty acids: palmitic, palmitoleic, stearic and oleic acid. Of the fatty acids present in feeding mixtures, polyenic acids are the most easily available to birds. The unsaturated character of poultry fats can be modified, to some extent, by supplementing diets with vegetable oils containing high levels of polyenic acids (Deaton *et al*. 1981).

In the presented study, the feed mixture for turkeys contained rapeseed oil and poultry fat, i.e. fats characterized by a high concentration of polyenic acids. The composition and content (% by weight) of fatty acids in the fat of raw and processed breast muscles, depending on the feeding manner, are presented in Table 1 and 2. Fat extracted from turkey breast muscles comprised acids containing from 14 to 20 atoms of

Table 1: The content (% by weight) of fatty acids in the fat of raw breast muscles of turkey females fed on mixtures with the addition of oxidised fat with different oxidation degree and without (-) or with (+) the addition of antioxidant (Hadox dry preparation)

Fatty acids		Type of mixture: Hadox dry - (sub-group A) Peroxide value of fat added to a diet mEq O_2 kg^{-1}				Hadox dry + (sub-group B) Peroxide value of fat added to a diet mEq O_2 kg^{-1}			
		< 5 (I)	< 50 (II)	<100 (III)	< 150 (IV)	< 5 (I)	< 50 (II)	<100 (III)	<150 (IV)
C14:0	0	0.67[a]	0.59[a]	0.63[a]	0.62[a]	0.73[b]	0.66[ab]	0.62[a]	0.66[ab]
	$S_{(x)}$	0.010	0.006	0.029	0.079	0.051	0.050	0.072	0.025
C14:1	0	0.08[a]	0.12[ab]	0.14[b]	0.13[ab]	0.22[a]	0.16[a]	0.17[a]	0.20[a]
	$S_{(x)}$	0.025	0.020	0.055	0.012	0.172	0.046	0.042	0.049
C15:1	0	0.05[a]	0.10a	0.12[a]	0.10[a]	0.12[ab]	0.13[ab]	0.09[a]	0.15[b]
	$S_{(x)}$	0.049	0.044	0.035	0.006	0.015	0.017	0.035	0.035
C16:0	0	22.19[a]	22.34[ab]	22.40[ab]	23.56[b]	23.00[a]	22.24[a]	22.23[a]	22.01[a]
	$S_{(x)}$	0.836	0.168	0.538	0.845	0.312	0.842	0.512	0.525
C16:1	0	3.12[a]	4.70[ab]	5.07[b]	5.08[b]	3.92[a]	4.59[a]	5.75[a]	4.98[a]
	$S_{(x)}$	1.110	0.834	1.142	0.126	0.630	1.157	0.424	1.614
C17:0	0	0.18[a]	0.21[a]	0.17[a]	0.23[a]	0.19[a]	0.21[a]	0.17[a]	0.21[a]
	$S_{(x)}$	0.121	0.058	0.032	0.113	0.017	0.035	0.031	0.031
C17:1	0	0.28[a]	0.31[a]	0.36[a]	0.46[a]	0.33[ab]	0.40[ab]	0.30[a]	0.48[b]
	$S_{(x)}$	0.087	0.177	0.092	0.087	0.078	0.071	0.050	0.105
C18:0	0	11.02[a]	10.06[a]	9.62[a]	10.33[a]	9.75[a]	9.50[a]	8.88[a]	9.49[a]
	$S_{(x)}$	3.282	1.581	0.587	0.720	1.035	1.361	1.164	1.711
C18:1	0	36.95[a]	37.83[a]	39.27[a]	38.36[a]	39.31[a]	39.56[a]	41.06[a]	39.47[a]
	$S_{(x)}$	1.948	2.161	1.385	1.111	1.672	1.540	2.353	2.629
C18:2	0	18.97[b]	18.02[ab]	17.30[ab]	16.40[a]	17.23[a]	17.44[a]	16.20[a]	17.36[a]
	$S_{(x)}$	0.488	0.744	1.456	0.262	0.803	1.466	0.897	1.886
C18:3	0	1.86[a]	2.09[a]	2.06[a]	1.58[a]	2.28[a]	2.32[a]	1.91[a]	2.05[a]
	$S_{(x)}$	0.355	0.207	0.299	0.238	0.071	0.075	0.284	0.271
C20:0	0	trace	trace	trace	trace	trace	trace	trace	trace
C20:1	0	0.46[a]	0.50[a]	0.44[a]	0.42[a]	0.48[a]	0.55[a]	0.45[a]	0.41[a]
	$S_{(x)}$	0.1734	0.014	0.092	0.067	0.076	0.269	0.070	0.017
C20:4	0	4.15[b]	3.25[ab]	2.36[a]	2.74[ab]	2.40[a]	2.45[a]	2.18[a]	2.52[a]
	$S_{(x)}$	1.176	0.930	0.343	0.119	0.598	0.829	0.873	0.719
ΣSFA	0	34.13[a]	33.34[a]	32.98[a]	34.84	33.81[a]	32.74[a]	32.07[a]	32.54[a]
	$S_{(x)}$	2.607	1.654	0.737	1.570	1.236	0.484	1.347	1.615
ΣUSFA	0	65.87[a]	66.66[a]	67.02[a]	65.16[a]	66.19[a]	67.26[a]	67.93[a]	67.46[a]
	$S_{(x)}$	2.607	1.654	0.737	1.570	1.236	0.484	1.347	1.615
Σmonoenoic	0	40.89[a]	43.29[a]	45.29[a]	44.44[a]	44.28[a]	45.06[a]	47.63[a]	45.53[a]
acid	$S_{(x)}$	3.226	3.064	2.387	1.367	2.387	2.670	2.708	4.140
Σpolyenic	0	24.97[c]	23.36[bc]	21.73[ab]	21.70[a]	21.92[a]	22.20[a]	20.29[a]	21.93[a]
acids	$S_{(x)}$	0.811	1.430	1.990	0.313	1.305	2.214	1.365	2.659

a, b, c - mean values determined with the same letters in rows, for individual feeding groups, are not significantly different

carbon. The content of particular fatty acids and the sum of acids with different unsaturation degrees were different depending on the feeding manner and antioxidant addition.

The contents of polyenic acids (Table 1) in raw breast muscles of the turkeys fed on the an antioxidant-free diet was significantly differentiated. The breast muscle fat of the turkeys fed on a diet supplemented with fat with the lowest oxidation degree was characterized by a significantly higher concentration (24.97%) of polyenic acids than that of the birds fed a diet with peroxide value of fat <100 and <150 mEqO_2 kg^{-1} (21.75 and 20.71%, respectively). In the muscles of turkeys additionally receiving the Hadox-dry, the content of polyenic acids was found to be similar.

The concentration of linoleic acid (C18:2) in the fat of turkeys of sub-group A decreased along with an increase in the oxidation degree of fat added to mixtures.

Significantly higher amounts of fatty acids were observed in breast muscles fat of turkeys from control group (group I) than in fat of birds which received fat of the highest oxidation degree (group IV). Jensen *et al*. (1997) found a significantly lower concentration of C18:2 acid in the thigh muscle fat of chickens fed on a diet supplemented with oxidized fat than in birds fed on fresh fat.

In the present study, in the sub-group of birds receiving simultaneously oxidized fat and antioxidants. Contents of this fatty acid were similar in feeding groups. The percentages of C18:3 fatty acid in breast muscles fat in subgroup A as well as in subgroup B did not differ significantly depending on oxidation degree of fat added to the diets.

Of polyenic acids in the analyzed fat, arachidonic acid was the acid with the highest unsaturation degree, constituting from 2.36 to 4.15% and from 2.18 to 2.52% of fat in turkeys fed without and with the addition of the Hadox - dry, respectively. Significant differences in content of arachidonic acid (C20:4) were found only in sub-group A. Higher amounts of this acid were observed in breast muscle fat of control group (4,15%) than in group III (2,36%).

The sum of monoenoic acids in the breast muscle fat of turkeys from sub-group A was lower (40.89 - 45.28%) than in turkeys from sub-group B (44.26 - 47.73%). No significant differences were observed in the content of this group of acids depending on the oxidation degree of fat administered with a mixture in both sub-groups analyzed.

In the group of monoenoic acids, the highest contribution was reported for oleic acid (C18:1). Its content ranged from 36.95% (group I) to 39.27% (group III) in the breast muscle fat of birds fed a mixture without antioxidants and from 39.31% (group I) to 41.06% (group III) in that of birds fed on a diet supplemented with Hadox - dry. No significant effect of feeding on the content this fatty acid was found. In sub-group A significant effect of oxidized fat addition to feed mixture on the contents of palmitoleic (C16:1) and myristoleic (C14:1) was found. Significantly higher amounts of C16:1 acid were observed in groups III (5.07%) and IV (5.08%) than in group I (3.12%). The percentage of C14:1 acid was significantly higher in muscle fat of group III (0.14%) than group I (0.08%). In sub-group B significant of feeding only on content of C17:1 acid was found.

The sum of saturated acids in the breast muscle fat of birds fed on a mixture with the Hadox - dry addition accounted for 32.98 - 34.84% and was higher than in the fat of turkeys on fed a mixture without this preparation (32.07 - 33.81%). No significant differences were found between the concentrations of saturated acids depending on the oxidation degree of fat added to mixtures.

Of the saturated acids, palmitic acid (C16:0) was characterized by the highest concentration which in group A tended to increase along with an increased oxidation degree of fat added to feed mixture. Significantly higher amounts of this fatty acids were observed in group IV (23,56%) than in group I (22,19%). In sub-group B the percentage of palmitic acid was on similar level and significant differences which depended on oxidation degree of fat added to feed mixture were found in the contents of C14:0 and C15:0 fatty acids.

The contents of palmitic and palmitoleic acids were found to increase, whereas the contents of linoleic, linolenic and arachidonic acids were found to decrease in the muscle fat of the birds fed on oxidized fats without the addition of antioxidants. The results of the study indicate that the concentration of fatty acids in the breast muscle fat of turkeys examined was significantly affected by the manner of feeding the birds. The investigation by Ajuyah *et al*. (1993) showed that the source of fatty acids introduced into mixtures for broiler chickens statistically determines the fatty acid composition in tissues. While assessing the effect of a rapeseed oil-supplemented diet on the fatty acid composition in turkeys, Saadi *et al*. (1993) observed a distinct lowering of the level of saturated acids and a simultaneous increase in the unsaturated fatty acids, especially of linoleic and linolenic acids. On the contrary, Renerre *et al*. (1999) showed that feeding turkeys on a diet with a 6% addition of rapeseed oil had a greater contribution to an increase in the level of unsaturated fatty acids than the administration of a diet with a 6% addition of soybean oil.

Thermal processing applied in the study caused insignificant changes in the contribution of individual fatty acids in the breast muscle fat of the turkeys (Table 2).

In most feeding groups, thermal processing resulted in a decrease in the total sum of polyenic acids in the breast muscle fat of the birds. Similar tendencies were observed for C18:2 and C20:4 acids, whereas C18:3 acid was characterized by an opposite dependency.

As a result of thermal processing, the total sum of monoenoic acids in the analyzed fat tended to increase in most of the feeding groups.

However, the sum of saturated fat was found to decrease in the fat extracted from the muscles after thermal processing. The same tendency was found for C18:0 acid. The content of palmitic acid in the fat of the birds from groups I and II increased negligibly and that of the birds from groups III and IV decreased upon processing in a convection-steam oven, irrespective of the Hadox - dry addition.

The content of malonaldehyde (MDA) is an indicator of the intensity of oxidative changes of fats. The analyses performed indicate that MDA content in the examined muscles was affected by the feeding manner of birds and thermal processing (Table 3).

Along with an increasing oxidation degree of fat

Table 2: The content (% by weight) of fatty acids in the fat of thermally-processed breast muscles of turkey females fed on mixtures with the addition of oxidised fat with different oxidation degree and without (-) or with (+) the addition of antioxidant (Hadox dry preparation)

Fatty acids		Type of mixture: Hadox dry - (sub-group A) — Peroxide value of fat added to a diet mEq O_2 kg^{-1}				Hadox dry + (sub-group B) — Peroxide value of fat added to a diet mEq O_2 kg^{-1}			
		< 5 (I)	< 50 (II)	<100 (III)	< 150 (IV)	< 5 (I)	< 50 (II)	<100 (III)	<150 (IV)
C14:0	0	0.67^{a}	0.66^{a}	0.67^{a}	0.65^{a}	0.77^{a}	0.69^{a}	0.69^{a}	0.75^{a}
	$S_{(x)}$	0.060	0.045	0.015	0.010	0.017	0.064	0.092	0.040
C14:1	0	0.11^{a}	0.14^{ab}	0.18^{ab}	0.21^{b}	0.16^{a}	0.18^{ab}	0.21^{ab}	0.27^{b}
	$S_{(x)}$	0.038	0.040	0.074	0.042	0.055	0.044	0.045	0.031
C15:0	0	0.07^{ab}	0.06^{a}	0.05^{a}	0.14^{b}	0.09^{a}	0.09^{a}	0.07^{a}	0.15^{a}
	$S_{(x)}$	0.055	0.04	0.012	0.042	0.056	0.046	0.032	0.042
C16:0	0	22.46^{a}	22.57^{a}	22.14^{a}	22.62^{a}	24.04^{b}	22.66^{a}	21.73^{a}	21.96^{a}
	$S_{(x)}$	0.221	0.911	0.616	0.444	0.465	0.500	0.891	0.359
C16:1	0	3.27^{a}	5.20^{ab}	5.79^{b}	5.75^{b}	4.24^{a}	4.94^{a}	5.93^{a}	5.48^{a}
	$S_{(x)}$	1.355	0.937	1.664	0.580	0.626	0.892	0.204	1.786
C17:0	0	0.23^{a}	0.19^{a}	0.18^{a}	0.17^{a}	0.21^{a}	0.18^{a}	0.18^{a}	0.23^{a}
	$S_{(x)}$	0.032	0.017	0.038	0.023	0.068	0.040	0.031	0.065
C17:1	0	0.37^{a}	0.35^{a}	0.25^{a}	0.39^{a}	0.26^{a}	0.32^{a}	0.26^{a}	0.41^{a}
	$S_{(x)}$	0.035	0.075	0.076	0.112	0.031	0.129	0.096	0.012
C18:1	0	10.90^{a}	9.30^{a}	8.24^{a}	8.65^{a}	10.08^{a}	9.00^{a}	9.04^{a}	8.43^{a}
	$S_{(x)}$	2.131	1.017	1.223	0.716	0.840	0.949	0.740	1.337
C18:1	0	37.84^{a}	38.97^{a}	42.96^{a}	40.70^{a}	37.76^{a}	39.88^{ab}	40.75^{ab}	41.41^{b}
	$S_{(x)}$	3.075	1.497	4.376	1.013	1.804	0.571	1.295	2.061
C18:2	0	18.49^{b}	17.47^{ab}	16.40^{a}	16.57^{ab}	17.27^{a}	17.20^{a}	16.65^{a}	16.61^{a}
	$S_{(x)}$	1.090	0.463	1.541	0.697	0.262	0.779	0.419	1.763
C18:3	0	2.35^{a}	2.26^{a}	2.18^{a}	1.94^{a}	2.26^{a}	2.31^{a}	1.96^{a}	2.09^{a}
	$S_{(x)}$	0.322	0.0896	0.312	0.114	0.1823	0.046	0.283	0.295
C20:0	0	trace	trace	trace	trace	trace	trace	0.13	0.15
	$S_{(x)}$							0.000	0.021
C20:1	0	0.29^{a}	0.46^{a}	0.50^{a}	0.43^{a}	0.39^{a}	0.64^{a}	0.46^{a}	0.50^{a}
	$S_{(x)}$	0.240	0.057	0.138	0.072	0.175	0.237	0.079	0.081
C20:4	0	3.11^{a}	2.36^{a}	1.52^{a}	1.77^{a}	2.47^{a}	1.90^{a}	1.92^{a}	1.60^{a}
	$S_{(x)}$	1.844	0.503	0.376	0.283	0.815	0.394	0.676	0.313
∑SFA	0	34.29^{a}	32.79^{a}	31.32^{a}	32.25^{a}	35.20^{b}	32.63^{a}	31.80^{a}	31.62^{a}
	$S_{(x)}$	2.147	1.696	1.322	0.681	1.311	0.634	1.438	1.340
∑USFA	0	65.70^{a}	67.21^{a}	68.68^{a}	67.75^{a}	64.80^{a}	67.37^{b}	68.20^{b}	68.38^{b}
	$S_{(x)}$	2.137	1.696	1.322	0.681	1.311	0.634	1.438	1.340
∑monoenoic	0	41.76^{a}	45.12^{ab}	48.58^{b}	47.47^{ab}	42.80^{a}	45.96^{ab}	47.60^{b}	48.08^{b}
acids	$S_{(x)}$	4.788	2.384	3.417	1.222	2.132	1.550	1.446	3.699
∑polyenoic	0	23.94^{b}	22.09^{ab}	20.1^{a}	20.28^{a}	22.00^{a}	21.41^{a}	20.60^{a}	20.30^{a}
acids	$S_{(x)}$	2.657	0.906	2.221	0.754	0.877	0.981	0.040	2.364

a, b, c - mean values determined with the same letters in rows, for individual feeding groups, are not significantly different

administered with diets, the malonaldehyde concentration was found to increase both in the muscles of birds fed without and in those fed with the addition of antioxidants; the differences were however insignificant. The application of an antioxidant was shown to result in a significant decrease in MDA content in the muscles, thus having a beneficial effect on the stability of meat lipids. The level of MDA in the muscles of the birds fed on a diet supplemented with the Hadox - dry preparation was by 0.07-0.14 mg kg^{-1} lower than its level in the muscles of turkeys whose diets were not supplemented with antioxidants.

In evaluating the impact of turkey feeding with vitamin E-enriched mixture, Nam *et al*. (2003) and Renerre *et al*. (1999) showed that the breast muscles of birds fed on diets with the antioxidant addition were characterized by

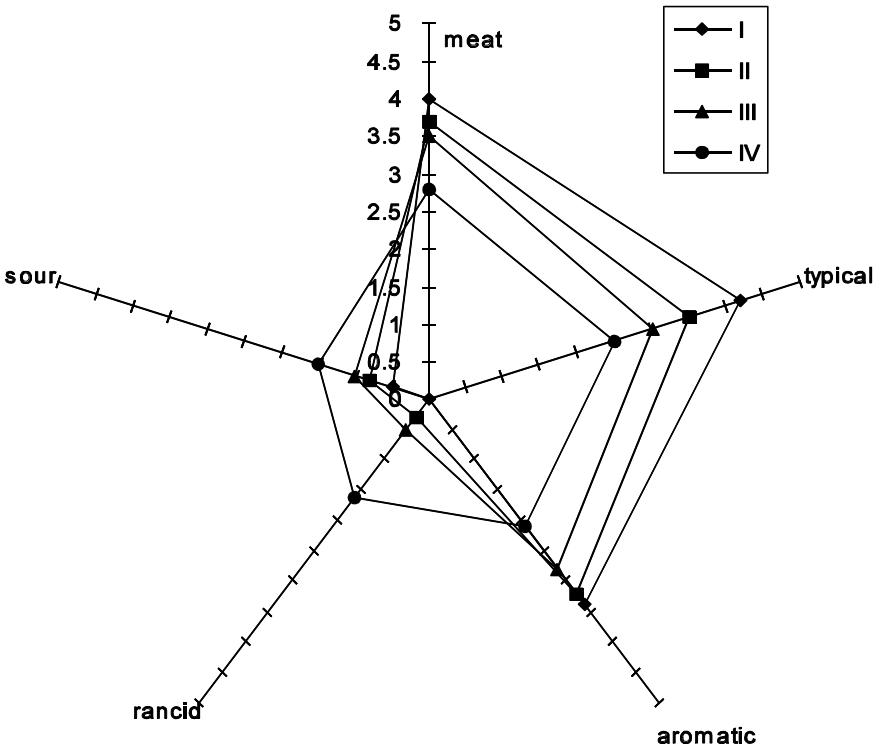

Fig. 1: The flavour profile of breast muscles of turkey females fed without the addition of Hadox dry (peroxide value of fat added to diets was <5; <50; <100 and <150 mEq O_2 kg^{-1} for groups I; II; III and IV, respectively)

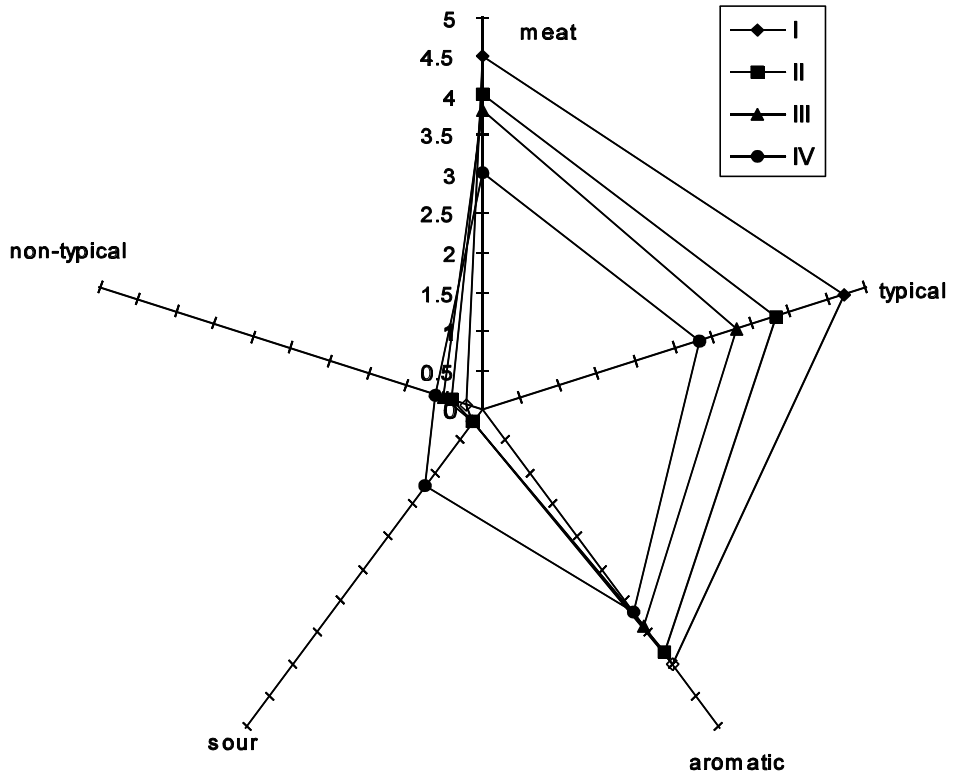

Fig. 2: The flavour profile of breast muscles of turkey females fed with the addition of Hadox dry (peroxide value of fat added to diets was <5; <50; <100 and <150 mEq O_2 kg^{-1} for groups I; II; III and IV, respectively)

Table 3: The content of malonaldehyde (mg kg^{-1} of a product) in breast muscles of turkey females fed on mixtures with oxidised fat with different oxidation degrees and without (-) or with (+) the addition of antioxidant (Hadox dry preparation)

Type of muscles		Feedind groups							
		Hadox dry - (sub-group A)				Hadox dry + (sub-group B)			
		Peroxide value of fat added to a diet mEq O_2 kg^{-1}				Peroxide value of fat added to a diet mEq O_2 kg^{-1}			
		< 5 (I)	< 50 (II)	<100 (III)	< 150 (IV)	< 5 (I)	< 50 (II)	<100 (III)	<150 (IV)
Raw	0	0.30aA	0.34aA	0.40aA	0.42aA	0.23aA	0.24aA	0.26aA	0.34aA
	$S_{(x)}$	0.049	0.021	0.121	0.023	0.040	0.079	0.045	0.111
after thermal processing	0	1.00aA	1.53bB	1.56bB	1.67bB	0.84aB	1.35bB	1.45bB	1.56bB
	$S_{(x)}$	0.236	0.150	0.049	0.156	0.249	0.092	0.115	0.156

a, b - mean values determined with the same letters in rows, for individual feeding groups, are not significantly different at $p<0.05$. A, B - mean values determined with the same letters in columns are not significantly different at $p<0.05$

lower TBA values compared to those of turkeys fed on control mixtures, i.e. without antioxidants. Botsoglou *et al*. (2002, 2003a, 2003b) recorded lower MDA levels and a lower rate of oxidative changes during cold- and frozen-storage of breast and thigh muscles of chickens or turkeys receiving a diet supplemented with oregano oil and tocopherols than in birds fed without antioxidants. In assessing the effect of diet enriched in tea catechins and tocopherols on the stability of breast and thigh muscle fat of chickens after 12 months of frozen-storage, Tang *et al*. (2002) found lower TBA values in the meat of the birds fed with the addition of antioxidants than in the meat of control birds. The thermal processing applied in the present study caused a significant increase in MDA content in the muscles analyzed. That dependency corresponded with the results of other authors (Ruiz *et al*., 1999; Botsoglou *et al*., 2003a; 2003b; Karpińska *et al*., 2000; Sheehy *et al*., 1993; O´Neill *et al*., 1999) who demonstrated the effect of different methods of thermal processing on the increase in MDA level in poultry meat.

In breast muscles of the turkeys fed on antioxidant-free mixtures, thermal processing resulted in a MDA increment by 0.70-1.25 mg kg^{-1}. In the muscles of the birds receiving the Hadox - dry preparation in a diet, the MDA increment was similar (by 0.61-1.22 mg kg^{-1}), which may point to a lowered antioxidant activity of compounds added to a diet which might have been accumulating in meat, both during frozen-storage and thermal processing as well.

The analyses performed in this study indicate that the intensity of oxidative changes in meat depends on the content of fatty acids in the breast muscle fat of turkeys. The breast muscle fat with the lowest content of unsaturated fatty acids (group I) showed the lowest level of malonaldehyde. Along with an increasing content of unsaturated fatty acids, the susceptibility of meat to oxidative processes also tended to increase. The breast muscles of the turkeys fed on diets supplemented with both oxidized fat and the Hadox - dry preparation were characterized by a higher content of unsaturated fatty acids compared to the birds not receiving antioxidants. It was observed, however, that the susceptibility of muscles to lipid oxidation was lower, which shows the beneficial effect of the Hadox - dry preparation applied. The aforementioned relationships are consistent with the results of Karpińska *et al*. (2001), who showed that, despite a higher concentration of polyenic acids, the breast muscle fat of turkeys fed on mixtures with the addition of Hadox-dry demonstrated a higher oxidative stability during freeze-storage.

The flavour of poultry meat is influenced to a high degree by its fat level. The aroma of fat isolated from raw meat is not typical of poultry meat. It is produced during thermal processing of meat as a result of fat degradation.

The sensory quality of breast muscles of turkeys depending on the feeding manner is presented in Fig. 1 and 2.

The flavour profile of meat depended on the feeding manner of birds. The supplementation of diets with fat of different oxidation degree produced differentiation in the sensory evaluation of the muscles. The intensity of meat-like, typical and aromatic attributes was observed to decrease, and that of sour sensation to increase along with an increasing peroxide value of fat added to diets. The presence of a „rancid" score was reported only in group IV of turkeys fed on an antioxidant-free diet.

The results of experiment showed the beneficial influence of the antioxidant on the stability of muscle fat, thus on the flavour of meat. These results correspond with the research by Galvin. (1993); Karpińska *et al*. (2001) as well as O'Neill *et al.* (1988), who demonstrated that the administration of mixtures with compounds of an antioxidant activity to birds prevents oxidation of muscle lipids, thus increases the shelf-life

of the meat and allows the product to obtain high scores in a sensory evaluation.

In the analyzed meat of turkeys fed on diets with the Hadox - dry addition, a higher share of “meat-like”, “typical” and “aromatic” scores and a lower share of “non-typical” and “sour” scores were observed. That dependency partly corresponded to the results of a study by Karpiñska *et al.* (2000) who reported the beneficial impact of compounds with antioxidant activity on the intensity of positive attributes of meat flavour.

On the basis of the results obtained, it was found that the results of the sensory evaluation of turkeys breast muscles correlate on the malonaldehyde content in those muscles. A relationship was demonstrated between oxidation processes and occurrence of negative flavour scores of breast muscles. The intensity of negative attributes (rancid and non-typical) increased with an elevated MDA level in meat.

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