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EFFECT OF NAKED OAT AND ENZYMES IN DIETS FOR BROILER CHICKENS ON QUALITY, FATTY ACID PROFILE AND OXIDATIVE STABILITY OF BREAST MUSCLE

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Key words: broiler chicken, breast meat, fatty acids, naked oat, enzyme, colour, TBARS

The effect of dietary oat and enzymes on chicken meat quality: colour, fat content, fatty acid composition of lipids and their oxidative stability was evaluated. A total of 200 one-day-old chickens (Cobb) were randomly allocated to five dietary treatments. Experimental diets contained 300 or 500 g/kg (in starter and grower, respectively) of dehulled oat or naked oat cv. Polar. Diets were unsupplemented or supplemented with enzyme preparation. The control diet was based on soybean, maize and wheat and contained no enzymes. A higher concentration of polyunsaturated fatty acids and lower content of monounsaturated fatty acids in breast muscle was found in chickens receiving naked oat as compared with birds fed with dehulled oat ($p<0.05$). The results obtained in control chickens was similar to those in the group with dehulled oat ($p>0.05$). Enzymes supplement to oat based diets decreased concentration of saturated fatty acids. Addition of enzyme caused a decrease of fat content in chicken meat ($p<0.05$) but no significant differences in fat content between experimental and control birds were found. After 6-month storage of meat at –20°C TBARS level was lower in the groups fed diets with the oats compared with control group ($p<0.05$). The cultivars of dietary oat and enzyme supplementation of diets did not cause any significant changes in the colour of meat but the values of yellowness (b*) in broilers fed naked oat were significantly lower than in control chickens ($p<0.05$).

INTRODUCTION

Many studies have shown that naked oat can satisfactory substitute for other grains in broiler chickens diets [Kamińska *et al*., 2003; Osek *et al.*, 2003, Szymczyk *et al*., 2005]. Its composition can modify quality of chicken meat. Naked oats have a relatively high concentration of fat reach in polyunsaturated fatty acids [Svihus & Gullord, 2002]. In addition, oat is concentrated sources of antioxidants, include vitamins [vitamins E, beta-carotene], trace minerals which are components of enzymes performing antioxidant functions [selenium, copper, zinc, and manganese], phytoestrogens, phenolic acids and phytic acid. Several oat phenolics have been identified, including ferulic acid, caffeic acid, p-hydroxybenzoic acid, p-hydroxyphenylacetic acid, vanilic acid, protocatechuic acid, p-coumaric acid and others [Peterson *et al.*, 2001; Chen *et al.*, 2004]. It was found that the susceptibility to oxidation of meat from broilers receiving 200 g/kg oats in the diet was compared to the stability of meat from broilers receiving 200 mg/kg alpha-tocopherol acetate [Lopez-Bote *et al.*, 1998]. On the other hand, the beta-glucans present in oat can reduce nutrient utilization and have negative effect on growth rate. The use of feed enzymes including beta-glucanase in oat-based diets has in some experiments improved broiler performance [Osek *et al.*, 2003, Szymczyk *et al.*, 2005]. Similarly, Café *et al.* [2002] and Saleh *et al*. [2005], found significant relationship between enzyme supplementation of broiler diets and meat composition and abdominal fat level. The objective of this study was to determine the effect of enzyme supplementation of mixtures with different cultivars of oat on chicken meat quality: colour, fat content, fatty acid composition and oxidative stability of fat.

MATERIAL AND METHODS

A total of 200 one-day-old chickens of a commercial strain (Cobb) were randomly allocated to five dietary treatments (four replications of ten birds) and kept in battery cages. They were given a starter diet (22.2% CP and 12.5 MJ ME/kg) from 7 to 21 days and a grower diet (19.7% CP and 12.9 J ME/kg) from 22 to 42 days. Diets contained 300 or 500 g/kg (in starter and grower, respectively) of dehulled oat or naked oat cv. Polar. Diets were unsupplemented or supplemented with enzyme preparation (1 g/kg) which contained: 15 U amylase, 14 U protease, 400 U beta-glucanase, 400 U xylanase and 600 U cellulase per gram. The control diet was based on soybean, maize and wheat and contained no enzymes. At 42 days of age four birds from each replication were killed and the samples of breast muscles (*pectoralis major* and *pectoralis minor)* were obtained from the carcass 24 h after slaughter. Chemical composition of meat was determined by standard methods [AOAC, 1995]. The total muscles lipids were extracted according to the method of Folch *et al.* [1957]. They were saponified in 0.5 mol/L KOH/Me-OH and then methylated in 14% BF_3/Me-OH [Morrison & Smith, 1964]. Fatty acid methyl esters were identified by comparison of their retention times with

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standards purchased from Sigma-Aldrich. Lipid oxidation of breast muscle was determined at 24 h post-slaughter and after 6-month storage at –20°C using Salih method described by Pikul [1989] by assaying 2-thiobarbituric acid-reactive substances (TBARS). Meat colour was measured in five locations of breast muscles and mean values were calculated for color lightness (L*), redness (a*) and yellowness (b*) with Minolta Chromometer CR-310. The results obtained in experimental groups were analyzed using two-way MANOVA generated by the STATISTICA v. 5.1 package. Duncan's multiple range test was used to determine the significance of differences between means. The control group was compared with experimental groups by means of linear contrasts of each dietary treatment.

RESULTS AND DISCUSSION

Feeding broilers with different cultivars of oat resulted in significantly different gross composition of breast muscle (Table 1). In the case of birds receiving diet with dehulled oat and control diet dry matter content in meat was significantly higher than this observed in group fed naked oat. Addition of enzyme to the oat based diets caused a decrease in fat content in chicken meat ($p<0.05$) but no significant differences in fat content between experimental and control birds were found. The influence of enzymes was most effective in the case of chickens receiving diet with dehulled oat (OxE). Similar results were obtained by Kondzielska & Pisarski [2001]. In their study the enzyme preparation with a dominant proportion of beta-glucanase used in mixture with barley decreased the fat content of breast muscle. TBARS values, a measurement related to oxidation of lipid, were all relatively low (Table 1). No significant differences in TBARS values were found in the meat of chickens receiving different cultivars of oats. It was shown that after 6-month storage of meat at –20°C TBARS level was lower in the groups fed diets with the oats compared with control group ($p<0.05$). Lopez-Bote *et al.* [1998] also observed lower TBARS level in breast muscle of broilers fed with oat based diet in comparison to meat of chicken receiving control diet without oat. Similarly, lower content of lipid peroxidation products of carcass of broiler chicken fed oat or dehulled oat had was observed in the previous study of Cave & Burrows [1993]. Smaller changes in TBARS value for oat based diets than for control diet indicated that the oxidative stability of breast muscle lipids was improved by natural antioxidants of oat. Recent reports indicated that specific polyphenols play role as antioxidants inhibiting lipid peroxidation, low-density lipoprotein oxidation and scavenging oxygen radicals [Sanchez-Moreno *et al.*, 2000; Benvenuti *et al*., 2004]. Handelman *et al.* [1999] and Brat *et al.* [2003] demonstrated the antioxidant capacity of oat phenolics in *in vitro* studies.

The cultivars of dietary oat and enzyme supplementation of diets did not cause any significant changes in the colour of meat but the values of colour redness (a*) and yellowness (b*) in broilers fed naked oat were significantly lower than in control chickens ($p<0.05$). In addition, the value of b* in broilers fed with naked oat was significantly lower than in control

TABLE 1. The effect of dietary oat and enzymes on quality of broiler meat.

Group[1]	Gross composition (%)			TBARS		Colour of meat after 6 month		
	Dry matter	Crude protein	Crude fat	After slaughter	After 6 months	L	a	b
1 C	25.92	24.41	1.03	0.320	0.393	55.44	11.81	7.42
2 D	25.80	23.68	1.11	0.318	0.368	55.58	11.83	6.86
3 DE	25.74	24.00	1.01	0.308	0.356	55.57	11.76	6.97
4 N	25.26	23.89	1.09	0.323	0.374	55.40	11.73	6.66
5 NE	25.28	24.06	1.04	0.310	0.364	55.65	11.70	6.77
Contrasts[2]:								
C1 (1 vs 2)	NS	*	NS	NS	*	NS	NS	NS
C2 (1 vs 4)	NS	NS	NS	NS	*	NS	NS	NS
C3 (1 vs 3)	*	NS	NS	NS	*	NS	NS	*
C4 (1 vs 5)	*	NS	NS	NS	*	NS	NS	*
Oat (O):								
D	25.77a	23.84	1.06	0.313	0.362	55.57	11.79	6.91
N	25.27b	23.98	1.06	0.316	0.369	55.52	11.71	6.71
Enzyme (E):								
-	25.53	23.79	1.10a	0.320	0.371	55.49	11.78	6.76
+	25.51	24.03	1.02b	0.309	0.360	55.61	11.73	6.87
O x E	NS	NS	*	NS	NS	NS	NS	NS
SEM	0.490	0.488	0.110	0.098	0.016	1.230	0.116	0.121

[1]Groups: C – Control; D – Dehulled oat; DE –Dehulled oat + enzymes; N – Naked oat; NE –Naked oat + enzymes; [2]Contrasts: C1 = C vs D; C2 = C vs N; C3 = C vs DE; C4 = C vs NE; a, b – values in the same columns with different letters differ significantly ($p<0.05$); * - $p<0.05$; NS -$p\geq 0.05$

TABLE 2. Fatty acid composition (% of total fatty acids) of experimental mixtures for broiler chickens.

Fatty acids	Experimental mixtures[1]					
	Starter			Grower/Finisher		
	C	D	N	C	D	N
C 14:0	0.05	0.09	0.10	0.05	0.09	0.08
C 16:0	6.26	8.52	8.35	6.25	8.41	7.91
C 16:1	0.14	0.15	0.14	0.12	0.12	0.10
C 18:0	1.56	1.40	1.65	1.11	1.23	1.28
C 18:1	40.56	37.97	39.50	39.90	37.59	38.39
C 18:2	41.58	43.71	41.87	41.81	44.48	44.01
C18:3	7.50	6.04	6.04	8.25	6.23	6.03
C 22:1	0.60	0.51	0.50	0.76	0.49	0.60
Total SFA[2]	8.63	10.67	10.10	8.14	10.23	8.89
Total MUFA[3]	41.30	38.63	40.14	40.79	38.21	39.10
Total PUFA[4]	50.07	50.70	49.29	51.07	51.56	51.02

[1]Experimental mixtures: C-Control diet without oat; D-diet with dehulled oat; N-diet with naked oat; [2] SFA – saturated fatty acids; [3] MUFA – monounsaturated fatty acids; [4] PUFA – polyunsaturated fatty acids

chickens ($p<0.05$). It is thought that yellowness reflects the intensity of the meat lipid autooxidation process [Wiegand *et al.*, 2002]. Lower value of TBARS and higher yellowness may support the hypothesis about the higher oxidative stability of meat of broilers fed naked oat.

The contents of the major fatty acids (C16:0, C18:1 n-9, C18:2 n-6) in meat reflected the fatty acid profile of the dietary fat (Table 2). Fatty acid composition of breast muscle lipids, expressed as a percentage of total methyl esters of fatty acids was significantly altered by cultivar of oats (Table 3). This results are in accordance to earlier findings of Lopez-Ferrer *et al.* [2001] and Ortiz *et al*. [2006]. A higher concentration of polyunsaturated fatty acids (PUFA) and lower content of monounsaturated fatty acids (MUFA) was found in chickens receiving naked oat as compared with birds fed with dehulled oat ($p<0.05$). The results obtained in control chickens was similar to those in group with dehulled oat ($p\geq0.05$). Kamińska *et al*. [2003] found the higher level of PUFA in lipids of broilers receiving both dehulled and naked oat. The enzymes supplementation of oat based diets decreased concentration of saturated fatty acids (SFA) but there were no significant effects of enzymes on MUFA and PUFA concentrations in meat.

CONCLUSIONS

It is concluded that feeding broilers with oat generally improved the oxidative stability of chicken meat. Fat content of breast muscles was modified by enzyme x cultivars of oat interaction. The enzymes supplementation of oat based diets significantly decreased fat content and saturated fatty acid concentration in meat. In addition, naked oat might be used in broiler feeding in order to increase PUFA content in intramuscular fat and to improve meat colour.

TABLE 3. The effect of dietary oat and enzymes on fatty acid composition (% of total fatty acids) of breast muscle in experimental chickens.

Group[1]	Fatty acid composition (% of total FA)													
	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:4	C22:1	EPA	DHA	Total SFA	Total MUFA	Total PUFA
1 C	0.21	12.24	0.65	8.08	33.72	30.57	3.69	5.27	0.22	0.51	1.78	20.54	37.59	41.82
2 D	0.28	13.26	1.11	7.55	36.39	30.99	2.94	4.49	0.20	0.43	1.28	21.10	37.71	41.27
3 DE	0.22	13.25	1.18	7.68	35.65	30.09	2.74	5.22	0.13	0.53	2.16	20.13	38.02	41.13
4 N	0.27	14.25	1.18	7.68	34.84	31.26	2.77	4.44	0.10	0.43	1.40	21.97	34.75	43.49
5 NE	0.19	11.52	0.49	8.69	33.31	31.81	2.54	6.71	0.19	0.45	2.86	19.47	35.07	44.56
Contrasts[2]:														
C1 (1 vs 2)	*	NS	*	NS	*	NS	**	NS	NS	NS	NS	NS	*	NS
C2 (1 vs 4)	NS	NS	*	NS	NS	NS	**	NS	*	NS	NS	NS	NS	NS
C3 (1 vs 3)	NS	*	*	NS	NS	NS	**	NS	**	NS	NS	NS	*	*
C4 (1 vs 5)	NS	NS	NS	NS	NS	*	**	NS	NS	NS	*	NS	NS	*
Oat (O) :														
D	0.25	13.25	1.50a	7.60	36.04	34.54	2.84	4.86	0.17	0.48	1.72	20.62	37.87a	41.20a
N	0.23	12.88	0.84b	8.21	34.08	31.53	2.66	5.57	0.14	0.44	2.13	20.72	35.31b	44.03b
Enzyme (E):														
-	0.28A	13.76a	1.52a	7.62	35.62	31.13	2.86	4.47	0.15	0.43	1.35A	21.54a	36.23	42.38
+	0.21B	12.38b	0.84b	8.19	34.50	30.95	2.64	4.97	0.16	0.49	2.51B	19.80b	36.94	42.84
O x E	NS	NS	*	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS
SEM	0.051	1.570	0.413	0.909	2.111	1.687	0.050	0.669	0.015	0.018	0.014	2.420	1.1410	2.169

[1]Groups: C – Control; D – Dehulled oat; DE –Dehulled oat + enzymes; N – Naked oat; NE –Naked oat + enzymes; [2]Contrasts: C1 = C vs D; C2 = C vs N; C3 = C vs DE; C4 = C vs NE; a, b – values in the same columns with different letters differ significantly ($p<0.05$); A, B - values in the same columns with different letters differ significantly ($p<0.01$); * - $p<0.05$; ** - $p<0.01$; NS - $p\geq0.05$

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WPŁYW OWSA I ENZYMÓW PASZOWYCH W PASZY DLA KURCZĄT BROJLERÓW NA JAKOŚĆ, PROFIL KWASÓW TŁUSZCZOWYCH ORAZ STABILNOŚĆ OKSYDACYJNĄ MIĘŚNI PIERSIOWYCH

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W doświadczeniu na 200 kurczętach brojlerach (Cobb) badano wpływ dodatku owsa oraz enzymów paszowych na jakość mięsa drobiowego: barwę, skład chemiczny, skład kwasów tłuszczowych tłuszczu śródmięśniowego oraz jego stabilność oksydacyjną. Mieszanki zawierały owies oplewiony obłuszczony lub owies nagi odmiany Polar w ilości 300 (starter) lub 500 (grower) g/kg paszy, z dodatkiem lub bez dodatku 0,1% preparatu enzymatycznego o aktywności (U/g): amylaza – 15, proteazę – 14, beta-glukanaza – 400, ksylanaza – 400 i celulaza – 600. Kurczęta w grupie kontrolnej (wyłączonej) żywione były bez dodatku owsa i enzymów. W próbkach mięśni piersiowych brojlerów oznaczano: skład podstawowy, skład kwasów tłuszczowych tłuszczu oraz zawartość aldehydu malonowego (TBA) po uboju i po 6 miesiącach przechowywania w temperaturze – 20°C. Oceniano również barwę mięsa.

Wyższy poziom kwasów tłuszczowych wielonienasyconych i niższą zawartość kwasów jednonienasyconych stwierdzono w mięsie kurcząt żywionych z dodatkiem owsa nagiego, w porównaniu z grupą kontrolną i z grupą otrzymującą owies obłuszczony. Dodatek enzymów do mieszanek z owsem spowodował istotną redukcję udziału nasyconych kwasów tłuszczowych oraz zawartości tłuszczu w mięsie. Większą efektywność enzymów w redukcji tłuszczu stwierdzono w przypadku owsa obłuszczonego w porównaniu z owsem nagim (OxE). W grupach z owsem wykazano istotnie niższą niż w grupie kontrolnej zawartość aldehydu malonowego w mięsie po 6 miesiącach przechowywania w temperaturze –20°C. Odmiana owsa oraz dodatek enzymów nie wpłynęły istotnie na barwę mięsa.