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CHEMICAL COMPOSITION AND SENSORY TRAITS OF MEAT OF FATTENERS FED WITH MIXTURES CONTAINING CORN OIL WITHOUT OR WITH THE ADDITION OF α-TOCOPHEROL ACETATE*

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In a feed experiment carried out on 24 cross-breed fatteners [(Polish Large × Polish Landrace) × pietrain] randomly divided into two groups (12 animals in each, 6 gilts and 6 barrows), the fattening of feed mixtures with 3% corn oil and the addition of α-tocopherol acetate in the amount of 200 mg/kg of mixture for the experimental group were used. The addition of vitamin E to the diet caused a significant decrease in MUFA level in *longissimus* and *semimembranosus* muscles ($p<0.05$) along with an increase in the PUFA level in the ham and the loin respectively from 20.34% and 14.84% to 22.98% and 16.48%. The differences were not significant. The addition of α-tocopherol acetate to the diet fattened with the corn oil caused an increase in unsaturated fatty acids from the *n*-6 family, mainly the linoleic (C18:2) and arachidonic (C20:4) acids. A significant decrease of the oleic acid (C18:1) in the *semimembranosus* muscle of fatteners from the experimental group from 39.4% to 35.2% ($p<0.01$) was found. A tendency to reduce the CLA level in the *semimembranosus* muscle of pigs obtaining higher doses of α-tocopherol acetate was observed. A significant decrease in the total cholesterol level in the *semimembranosus* muscle from 68.4 to 52.8 (mg/100g) and a tendency to reduce its content in the *longissimus* muscle were found in this study. It was observed that the addition of the α-tocopherol acetate in the amount of 200 mg/kg of mixture significantly increased the α-tocopherol level ($p<0.01$) in *longissimus* and *semimebranosus* muscles respectively from 1.58 and 1.56 to 3.37 and 3.33 (μg/g of fresh meat). The effect of vitamin E on the derivative metabolites of lipid oxidation (TBARS) after 60 days of storage at -19°C was not observed. The positive influence of the α-tocopherol acetate in the diet on the improvement of the palatability and the flavour of the *semimembranosus* muscle of ham was observed in this study.

INTRODUCTION

Plant oils and oil plants seeds added to the diet cause an increase in polyunsaturated fatty acid content in tissue lipids [Barowicz & Pieszka, 2001]. The use of corn oil for pigs causes an increase in PUFA *n-6* acid level together with a decrease in MUFA content [Berlin *et al.,* 1998]. Recent research shows that the use of essential fatty acids in animal feeding could be one of the ways of limiting the total cholesterol content in muscles and fat backfat [Chichłowska & Kliber, 1998]. Ramjiganesh *et al.* [2002] noted the hypocholestemic activity of corn oil in reducing absorption from the small intestine and increasing catabolism in the liver.

Animals with plant oil added to their diets showed a higher vitamin E demand. This mechanism is explained by the usability of tocopherols for double bound stability of fatty acids in cell membranes [Monahan *et al.*, 1993]. The differences found between authors concerning the influence of vitamin E on fatty acid composition could be caused by different sources of fat used for animal feeding [Ashgar *et al.*, 1991; Rey *et al.*, 2001]. The vitamin E seems to be active towards some desaturases [Okayasu *et al.*, 1977] and its influence could be affected by the competition phenomena between fatty acid families stabilizing double bindings of fatty acids and other lipids protecting it against peroxidation.

It is true that PUFA are very desirable from the consumer point of view because they improve the dietetic value of meat, but excessive PUFA content in animal fat has a negative effect on the sensory value of meat and possibility of its storage [Buckley *et al.*, 1995; Lauridsen *et al.*, 1999]. On the other hand, the addition of vitamin E to the diet has a significant influence on meat storage and its sensoric values [Jensen *et al.*, 1997].

The aim of this study was to evaluate of the effect of α-tocopherol acetate addition to fatteners' diets enriched with the corn oil on the chemical composition, fatty acid profiles, cholesterol content and physicochemical and sensoric traits in *longissimus* and *semimebranosus* muscles.

MATERIAL AND METHODS

The research was carried out on 24 cross-bred fatteners [(Large Polish White × Polish Landrace) × pietrain], randomly divided into two feeding groups (12 animals in each, 6 gilts and 6 barrows) differing in vitamin E level. Mixtures

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were fattened with 3% corn oil and in the experimental group the addition of 200 mg/kg of vitamin E was used. Fatteners were fed *ad libitum* with complete mixtures starting from 50 kg of body weight to the slaughtering weight (105 kg). The level of vitamin E for feed mixtures of control group (I) was accepted as 30 mg/kg level [Polish Nutrient Requirement, 1993]. The experimental premix used in the study was based on α-tocopherol acetate with a concentration of 300 mg per 10 g of carrier (talcum) produced by Premix Factory BASF (Kutno, Poland). During the study, fatteners were fed according to Polish Nutrient Requirements [1993]. Animals were kept in individual pens on straw bedding in standard microclimatic conditions with free access to water. The composition and the nutritive value of the mixtures are shown in Table 1. When fatteners achieved 105 kg of body weight they were slaughtered. After dissection, samples of *longissimus* and *semimembranosus* muscles were taken for further examination. Meat samples were devoid of membranes and fascias and then mixed in Moulinette (Spain). Mixed samples were put into PCV boxes and stored at -19°C for further analysis. The chemical composition of mixtures was evaluated with conventional methods according to AOAC [1990]. In meat samples, the chemical composition was evaluated [Budsławski & Drabent, 1972]. The composition of fatty acids was determined using gas chromatography (GC) after previously extracting lipids according to Folch *et al.* [1957] and converting free fatty acids into methyl esters. Chromatography analysis of vitamin E in *longissimus* and *semimembranosus* muscles was carried out using the HPLC method using fluorescent detection, after saponification and extraction with ethyl acetate and a hexane mixture [Ueda & Igarashi, 1987].

TABLE 1. The nutritive value and the fatty acids composition (the % of total fatty acids) in the complete mixture and in fatty additions used in this study.

Energy and nutrient content	Mixture	
Total protein (%)	14.4	
EM (MJ)	12.73	
Crude fibre (%)	6.75	
Lysine (%)	0.77	
Methionine (%)	0.26	
Ca (%)	0.53	
P (%)	0.48	
Fatty acids composition	Mixture	Corn oil
SFA	23.08	15.1
UFA	76.92	84.9
MUFA	22.22	32.2
PUFA	54.7	52.7
PUFA *n*-6	49.59	51.74
PUFA *n*-3	5.11	0.96

Meat colour in L*a*b* scale [CIE, 1976] was evaluated using a deflect spectrophotometer Minolta CR-310, (Japan) 24 h after slaughtering. The water absorption was evaluated according to the Grau & Hamm method [1953] and thermal losses (loss of meat juice) – during the preparation of meat for tenderness. The estimation of the *longissimus* and *semimembranosus* muscle tenderness was marked using an Instron 5542 apparatus (England) equipped with Warner-Bratzler cell (crosshead speed at 200 mm min^{-1}). Before the evaluation, the muscles were cooked to an internal temperature of 76°C and then cooled. Following this, cylinders of 15 mm diameter were cut out of the muscles and were measured. In the lipid extracts of *longissimus* and *semimembranosus* muscles, the total cholesterol content was evaluated using the method described by Rhee *et al.* [1982]. In pork loin and ham samples, the malonaldialdehyde (TBARS) content was measured according to the procedure described by Pikul [1993] after 60 days of storage at -19°C. The sensory evaluation of the meat was also carried out after thermal dressing (cooking to the internal temperature of 85°C) on a 5-point scale according to the method described by Baryłko-Pikielna [1975].

All results were statistically verified using the Statgraphics Plus 4.0 computer program.

RESULTS AND DISCUSSION

The profile of fatty acids in *longissimus* and *semimembranosus* muscles is shown in Table 2. It was claimed in this study that vitamin E caused a significant decrease in MUFA level in the above-mentioned muscles ($p<0.05$). Unfortunately, it is difficult to explain the mechanism of the influence of vitamin E higher dose in the diet on a decrease in MUFA level in intramuscular fat because of a lack of proper literature sources. The addition of α-tocopherol acetate caused an increase in PUFA in the ham and in the loin respectively from 20.34% and 14.84% to 22.98% and 16.48%, however, the differences were not significant. The addition of α-tocopherol acetate to diets enriched with corn oil caused an increase in unsaturated fatty acids level from the *n*-6 family, mainly linoleic acid (C18:2) and arachidonic (C20:4) which is consistent with the results obtained by Berlin *et al.* [1998]. A significant decrease in oleic acid (C18:1) in the *semimembranosus* muscle ($p<0.01$) was observed in the experimental group. Moreover, the reducing tendency of CLA in the *semimembranosus* muscle in the group of pigs receiving higher doses of α-tocopherol acetate was observed ($p<0.05$).

In this study, a significant decrease in total cholesterol level in the *semimebranosus* muscle ($p<0.05$) and its tendency to decrease in the *longissimus* muscle of pigs from the group obtaining an addition of α-tocopherol acetate was observed (Table 3). These results correspond to the findings of Berlin *et al.* [1998] in pigs and Ramjiganesh *et al.* [2002], who used the corn oil in guinea pig diets.

The α-tocopherol and TBARS concentrations in the *logissimus* and *semimembranosus* muscles are shown in Table 4. The α-tocopherol concentrations in the muscles of the pigs fed with the addition of 200 mg α-tocopherol acetate per kg of the mixture were significantly higher ($p<0.01$) than in the muscles of the fatteners fed with the base diet with the addition of 30 mg α-tocopherol acetate per kg of the mixture. The α-tocopherol level in the *longissimus* and *semimembranosus* muscles in the group with and without the addition of the α-tocopherol equalled 3.37 and 3.33, respectively, and also 1.58 and 1.56 (μg/g of fresh meat). These values are similar to the results found earlier

TABLE 2. The profile of fatty acids in *longissmus* and *semimembranosus* muscles (the % of total fatty acids).

Fatty acids	*Longissimus* muscle		SEM	*Semimembranosus* muscle		SEM
	Control group	Group with vitamin E		Control group	Group with vitamin E	
C 10:0	0.12	0.13	0.008	0.11	0.12	0.009
C 12:0	0.10	0.11	0.005	0.11	0.08	0.012
C 14:0	1.37	1.57	0.08	1.35	1.58	0.05
C 16:0	25.24	25.75	0.66	24.60^{a}	26.02^{b}	0.33
C 16:1 *n*:7	3.72	3.22	0.21	3.47	3.29	0.17
C 18:0	11.51	12.07	0.40	10.56	10.72	0.37
C 18:1 *n*:9	42.99	40.57	0.69	39.40^{B}	35.22^{A}	1.03
C 18:2 *n*:6	12.53	14.14	1.00	16.88	18.96	0.84
CLA	0.16	0.13	0.01	0.17^{B}	0.08^{A}	0.01
γ C18:3	0.13	0.13	0.01	0.17	0.18	0.01
C 18:3 *n*:3	0.57	0.67	0.04	0.68	0.64	0.02
C 20:0	0.11	0.09	0.01	0.06	0.04	0.01
C 20:4 *n*:6	1.38	1.33	0.19	2.34	2.99	0.23
EPA *n*:3	0.02	0.02	0.002	0.03	0.03	0.005
DHA *n*:3	0.04	0.05	0.006	0.05	0.05	0.004
others	0.01	0.02	–	0.02	0.02	–
SFA	38.45	39.73	0.93	36.79	38.52	0.50
UFA	61.55	60.17	0.93	63.21	61.48	0.50
MUFA	46.71^{b}	43.79^{a}	0.82	42.87^{b}	38.51^{a}	1.11
PUFA	14.84	16.48	1.20	20.34	22.98	1.05
n-6 PUFA	14.04	15.64	1.16	19.40	22.13	1.06
n-3 PUFA	0.63	0.74	0.05	0.76	0.76	0.02

a, b – values in the same rows with different letters differ significantly ($p<0.05$); A,B – values in the same rows with different capital letters differ highly significantly ($p<0.01$)

TABLE 3. The influence of the α-tocopherol acetate addition on the cholesterol level in the *longissimus* and the *semimembranosus* muscles (mg/100 g of fresh tissue).

Traits	*Longissimus* muscle		SEM	*Semimembranosus* muscle		SEM
	Control group	Group with vitamin E		Control group	Group with vitamin E	
Total cholesterol	67.13	65.26	2.97	68.42^{b}	52.84^{a}	3.32

a, b – values in the same rows with different letters differ significantly ($p<0.05$)

TABLE 4. The influence of the α-tocopherol acetate addition for fatteners on the α-tocopherol deposition and the TBARS level in the ham and the loin meat (n=12).

Traits	*Longissimus* muscle		SEM	*Semimembranosus* muscle		SEM
	Control group	Group with vitamin E		Control group	Group with vitamin E	
TBARS (mg kg^{-1})	0.503	0.492	0.05	0.473	0.448	0.02
α-tocopherol (μg/g)	1.58^{A}	3.37^{B}	0.31	1.56^{A}	3.33^{B}	0.33

a, b – values in the same rows with different capital letters differ significantly ($p<0.01$)

by Ashgar *et al.* [1991] and Rey *et al.* [2001]. There were no significant differences between the α-tocopherol accumulation in the *longissimus* muscle and the *semimebranosus* muscle in the pigs fed with the addition of vitamin E. It may prove the uniform distribution of vitamin in the muscle tissue [Lauridsen *et al.*, 1999].

The oxidation stability of the loin and the ham muscle was evaluated after 60 days of storage at a temperature of -19°C. TBARS values in the control and the experimental group (with the addition of vitamin E) were similar regardless of the type of the meat examined. Rey *et al.* [2001] describes the higher values of TBARS in cooked meat and meat stored at 4°C from pigs fed with an addition of monounsaturated fatty acids. Cannon *et al.* [1996] obtained similar results to those obtained in this study. The decrease in meat lipid stability of animals fed with diets containing oils was stated by Buckley *et al.* [1995] and Barowicz & Pieszka [2001]. This status was explained by the number of unsaturated fatty acids and period of meat storage.

The evaluation of physicochemical traits of ham and loin meat did not show any differences between fatteners' group (Table 5). A slightly higher dry matter content in the meat of the fatteners fed with the addition of vitamin E and a tendency to reduce thermal losses were observed in this study. Similar results were presented by Cannon *et al.* [1996] and Jensen *et al.* [1997]. This supports the positive effect

TABLE 5. Some physico-chemical and sensory traits of the ham and the loin (n=12).

Traits	*Longissimus* muscle		SEM	*Semimembranoeus* muscle		SEM
	Control group	Group with vitamin E		Control group	Group with vitamin E	
pH	5.51	5.50	0.03	5.79	5.67	0.07
Water binding capacity (%)	25.51	25.70	1.15	26.42	26.07	0.84
Dry matter (%)	26.32	27.15	0.50	23.66	24.32	0.39
Crude protein (%)	22.23	22.05	0.23	20.54	21.79	0.35
Crude fat (%)	3.63	3.81	0.42	2.36	2.25	0.19
Colour of meat:						
L*	55.47	57.44	0.96	48.83	48.98	0.89
a*	14.01	13.50	0.24	17.82	16.60	0.45
b*	6.23	6.20	0.39	5.4	4.63	0.29
Shear force (kg)	4.47	3.85	0.20	5.26	4.27	0.60
Thermal losses (%)	34.42	33.72	0.50	38.5	36.9	0.73
Juiciness (points)	4.68	4.46	0.07	4.72	4.90	0.07
Tenderness (points)	4.76	4.52	0.07	4.80	4.45	0.10
Flavour:						
Intensity (points)	4.72	4.72	0.06	4.82	4.87	0.04
Quality (points)	4.80	4.68	0.06	4.70[a]	4.92[b]	0.05
Palatability:						
Intensity (points)	4.60	4.48	0.05	4.7	4.85	0.05
Quality (points)	4.64	4.52	0.05	4.76	4.85	0.05

a, b – values in the same rows with different letters differ significantly ($p<0.05$)

of vitamin E on the physico-chemical traits of the stored meat. The loin from experimental animals was characterised by a higher value of the colour lightness, however, the differences were not significant. The positive influence of an α-tocopherol acetate addition to the diet on the improvement of the palatability and the flavour of *semimembranosus* muscle was observed. It is consistent with the results of other authors [Jensen *et al.*, 1997; Lauridsen *et al.*, 1999].

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CONCLUSION

The results of this study showed that α-tocopherol acetate added in amounts of 200 mg/kg of a mixture to a fattener's diet increases the vitamin E content in the *longissimus* and *semimembranosus* muscles, decreases the cholesterol level in the meat and improves its sensory value.

In view of this, the obtained pork meat could have a high salubrious and culinary value for consumers.

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SKŁAD CHEMICZNY I WŁAŚCIWOŚCI SENSORYCZNE MIĘSA TUCZNIKÓW ŻYWIONYCH MIESZANKAMI Z ZAWARTOŚCIĄ OLEJU KUKURYDZIANEGO BEZ DODATKU LUB Z DODATKIEM OCTANU α-TOKOFEROLU

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W doświadczeniu żywieniowym przeprowadzonym na 24 tucznikach krzyżówkowych [(wbp × pbz) × pietrain], przydzielonych losowo do dwóch grup żywieniowych (po 12 szt., 6 loszek i 6 wieprzków) zastosowano natłuszczanie mieszanek paszowych 3% oleju kukurydzianego oraz dodatek w grupie doświadczalnej octanu α-tokoferolu w ilości 200 mg/kg paszy. W grupie kontrolnej zawartość octanu α-tokoferolu wynosiła 30 mg/kg paszy. Dodatek witaminy E do diety istotne obniżył poziom MUFA ($p<0,05$) oraz spowodował wzrost poziomu PUFA w mięśniu półbłoniastym i w mięśniu najdłuższym odpowiednio z 20,34 i 14,84 % do 22,98 i 16,48. Różnice były statystycznie nieistotne (tab. 2). Dodatek octanu α-tokoferolu do diety wzbogaconej w olej kukurydziany spowodował wzrost poziomu kwasów nienasyconych z rodziny *n*-6, głównie kwasu linolowego (C18:2) i arachidonowego (C20:4). W grupie doświadczalnej, stwierdzono istotne obniżenie poziomu kwasu oleinowego (C18:1) w mięśniu półbłoniastym odpowiednio z 39,4 do 35,2% ($p<0,01$). Obserwowano tendencję do obniżenia poziomu kwasu CLA w mięśniu półbłoniastym u świń otrzymujących zwiększone dawki octanu α-tokoferolu ($p<0,05$), (tab.2). Stwierdzono istotne obniżenie poziomu cholesterolu ogólnego w mięśniu półbłoniastym ($p<0,05$) z 68,4 do 52,8 (mg/100g) oraz tendencję do obniżenia jego zawartości w mięśniu najdłuższym (tab. 3). Dodatek octanu α-tokoferolu w ilości 200 mg/kg paszy zwiększał istotnie poziom α-tokoferolu ($p<0,01$) w mięśniu najdłuższym i półbłoniastym odpowiednio z 1,58 i 1,56 do 3,37 i 3,33 (μg/g świeżego mięsa). Nie stwierdzono wpływu dodatku witaminy E na poziom wtórnych metabolitów oksydacji lipidów (TBARS) po 60 dniach przechowywania w temperaturze -19°C. Obserwowano dodatni wpływ dodatku octanu α-tokoferolu w diecie na poprawę smaku i zapachu mięśnia półbłoniastego szynki.