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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Fattening performance, slaughter indicators and meat chemical composition in lambs fed the diet supplemented with linseed oil and mineral bioplex

Antoni Baranowski, Artur Jóźwik, Elżbieta Bernatowicz, Wojciech Chyliński

Polish Academy of Sciences Institute of Genetics and Animal Breeding, Jastrzębiec, 05-552 Wólka Kosowska, Poland

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Crossbred (F1) Booroola × Olkuska ewe-lambs were randomly assigned to control (C, n=8) and experimental (E, n=9) group with initial mean body weight of 7.6 and 7.3 kg, respectively, and fattened up to the mean live body weight of 24 kg. Lambs from both groups were fed *ad lib*. the concentrate mix containing 207 g crude protein and 12.5 MJ metabolizable energy per kg dry matter of feed. During fattening each lamb from group E was administered *per os* with 3 g of lineseed oil and 3 g mineral bioplex daily. The lambs were slaughtered at the live weight of 22.8 (group C) and 24.2 (group E) kg. No significant differences between groups were found in mean daily live weight gain (111 and 125 g in C and E lambs, respectively). Concentration of blood plasma cholesterol and its fractions did not differ significantly between groups. Dressing percentage, valuable cuts and perirenal fat contents of right carcass side (42.05%, 42.20%, and 2.65% in C *vs*. 43.13%, 42.38% and 3.04% in E lambs, respectively) were similar in groups. The supplements applied (group E) did not significantly influence dry matter, protein and fat content of *longissimus dorsi* muscle, but significantly (P≤0.002) altered its cholesterol level (group C – 60.47, group E – 75.56 mg/100 g tissue). The fatty acid profile of intramuscular fat reflected more favourable meat dietetic value in lambs E compared to lambs C.

KEY WORDS: fattening / fatty acids / lambs / linseed oil / slaughter performance / meat composition

Fat of animal origin is accused for the development of arteriosclerosis, diabetes, tumours and other civilization diseases. This forced the food producers to deliver to the market some animal products with minimum content of fat characterized with favourable fatty acid profile, to protect better the consumers health [Wood and Enser

1997, Obiedziński 2002]. To improve the dietetic value of ruminant meat, in the feeding programmes of animals the supplementation of the diet with either seed of oil-bearing plants or plant oils rich in unsaturated fatty acids allows to modify the profile of fatty acids in the animal tissues [Jakobsen 1999, Oprządek and Oprządek 2003]. In the fattening of lambs, the fatty acids profile can be altered by supplementing the animals' daily ration with 5-10% of oil seeds or their oils [Potkański *et al*. 2001, Borowiec *et al*. 2004, Czauderna *et al*. 2004, Borys and Borys 2005]. However, Reklewska *et al*. [2000] showed, that 3 g linseed together with 3 g mineral bioplex fed daily per goat during a month favourably affected cholesterol content and the profile of fatty acids of milk. Such a low addition of oil seeds does not increase the diet energy level significantly, which in the case of higher doses applied to ruminants may reduce milk production or increase the fattening rate of fattened animals.

In light of this, small doses of linseed (experiment A) or linseed oil (experiment B) both fed together with a mineal bioplex were used to estimate their effect on growth rate, slaughter value and chemical composition of meat in fattening lambs. The results of experiment A were presented in earlier authors' report [Baranowski *et al*. 2007] while in the current report the results of experiment B are described.

Material and methods

The crossbred ewe-lambs (F1 of Booroola × Olkuska sheep) at the age of 22 (±2.4) days and live body weight of 7.5 (±1.3) kg were randomly assigned to control (C, n=8) and experimental (E, n=9) group and fed according to feeding standards recommended by the National Research Instituite of Animal Production [1996]. Ewes of each group were kept together in a common straw-bedded pens and fed *ad libitum* a concentrate mixture with simultaneous free access to their dams to suck milk (up to the age of two months) and free access to water (up to the live body weight of 23.5 (±2.2) kg and the age of 158 (±2.8) days. To ensure proper rumen function about 0.1 kg first-cut meadow hay was offered per ewe/day. The daily intake of feeds was not recorded. During the fattening period each lamb from group E was administered 3 g of lineseed oil and 3 g of mineral (Mg, Fe, Cu, Co, Mn, Zn, Se, Cr) bioplex (PH POLMARCHE, Warsaw) *per os* daily, between 9.00 and 10.00 a.m. Mixed supplements were introduced directly through the oesophagus using the tube. The proximate analysis of feeds (Tab. 1) was performed using standard procedures, while their ME level was calculated based on proximate analysis and regression equation recommended by Urbaniak [1994]. At the beginning and at the end of experiment blood was withdrawn once from jugular vein of lambs for determination of plasma total cholesterol (CHOL), triglycerides (TGL) and HDL-cholesterol fraction content using Alpha Diagnostics Kits, Warsaw, Poland. The LDL-cholesterol content of plasma was calculated using formula: LDL=CHOL-HDL-TGL/5 given by Reklewska *et al*. [2000]. At the end of experiment all ewes were slaughtered and the carcasses subjected to cutting and dissecting according to Nawara *et al*. [1963]. After dividing the carcass

Table 1. Proximate composition and energy level of feeds

Component		Concentrate[1]	Hay
Dry matter (g/kg feed)	mean	891	871
	SE	4.5	24.4
In dry matter (g/kg)			
ash	mean	47	65
	SE	0.8	8.1
crude fibre	mean	116	347
	SE	7.1	10.6
ether extract	mean	38	18
	SE	0.5	0.7
crude protein	mean	207	120
	SE	2.8	16.7
N-free extractives	mean	592	450
	SE	5.6	17.5
metabolizable energy (MJ/kg dry matter)	mean	12.53	10.03
	SE	0.057	0.161

[1]37% oats, 10% triticale, 15% rapeseed oil meal, 35% wheat bran, 3% minerals.

into cuts, samples were taken from the middle part of *longissimus dorsi* (LD) muscle to determine the dry matter [Polish Standard 1973], protein [Polish Standard 1975], fat [Polish Standard 1972], cholesterol [Folch *et al*. 1957, Searcy and Bergquist 1960, Rhee *et al*. 1982] and fatty acids profile, including the content of conjugated linoleic acid (CLA). Meat samples freeze-dried for 48 hours were extracted using chloroform-methanol and water mixtures (4:2:1, v/v) and derivatization reaction was carried out according to Czauderna and Kowalczyk [2001] and Czauderna *et al*. [2001]. The derivatized samples were filtered through a 0.2 μm membrane filter (WHATMAN). The resulting filtrates were injected onto chromatographic columns on Spheri–5 RP–18,5 μm, 220×4.6 mm columns (PERKIN-ELMER). Dibromoacetophenacyl ester of fatty acids was identified on a HPLC system Series 200 PERKIN-ELMER. The development of the gradient elution system, collection, and data integration were performed with TURBOCHROM Workstation Ver. 6.1.2 software. All solvents were degassed under vacuum and then flushed with helium (99.996%, PRAXAIR, Warsaw, Poland). The column temperature was maintained at 35°C and the eluted dibromoacetophenylacyl esters of fatty acids were detected at 242 nm. Elution was performed using a concentration of a methanol (MeOH) and acetonitryl-water (ACN-H_2O, 40-60, v/v) mixture. The elution of dibromoacetophenacyl ester of C 12:0-20:5 fatty acids was completed within 40 min at a flow rate of 2.6 ml/min.

The data were evaluated with the analysis of variance [Harvey 1990] according to the following model:

$$Y_{ij} = \mu + a_i + e_{ij}$$

where:

Y_{ij} – an observation;

μ – overall mean;

a_i – fixed effect of i-th feeding regimen (C or E – without or with the supplementation, i =1, 2);

e_{ij} – random error.

The experimental procedure was approved by the Local Ethics Commission in Animal Experiments (Notification No. 36/2002).

Results and discussion

At the start of experiment means for body weight and age for lambs from group C were similar to those recorded for group E (7.6 kg and 22.3 days in group C *vs*. 7.3 kg and 21.8 days in group E) – Table 2. During fattening the mean daily live weight gain

Table 2. Fattening performance indicators in lambs

Indicator		Group C (n=8)	Group E (n=9)	P
Age at start (days)	mean	22.3	21.8	0.702
	SE	0.80	0.89	
Age at slaughter (days)	mean	159.3	156.8	0.059
	SE	1.25	1.41	
Live weight at start (kg)	mean	7.6	7.3	0.649
	SE	0.43	0.45	
Live weight at slaughter (kg)	mean	22.8	24.2	0.215
	SE	0.72	0.75	
Daily live weight gain (g)	mean	111	125	0.058
	SE	5.98	3.69	

reached by E lambs (125 g) did not differ significantly from that by lambs C (111 g). Similar relations (no significant intergroup differences in mean daily live weight gain) were found in earlier authors' study [Baranowski *et al*. 2007] conducted on lambs fattened with the diet supplemented with small doses of linseed and mineral bioplex (3 and 3 g/animal/day). These observations are in accordance also with the data found in lambs fattened with rations containing 5% linseed oil [Czauderna *et al*. 2004], 10% sunflower seed [Rizzi *et al*. 2002], or linseed and linseed-rapeseed mixture [Borowiec *et al*. 2004, Borys and Jarzynowska 2005].

In contrast to studies conducted on goats by Reklewska *et al*. [2000] and in accordance with data obtained on lambs fed linseed (10% diet weight) or linseed oil

(5% of dry matter-based diets – Micek *et al*. [2004] and Cieślak *et al*. [2004] – or diet supplemented with linseed and bioplex [Baranowski *et al*. 2007], the additives used in this study had no effect on the CHOL, HDL and LDL content of blood plasma of ewes (Tab. 3). At the end of experiment these indicators in E lambs (1.76, 0.79 and 0.91 mmol/l, respectively) did not differ significantly from those found in C lambs (1.59, 0.73 and 0.85 mmol/l, respectively) and were comparable to the values found in the young traditionally fattened lambs studied by Barowicz *et al*. [1994].

Table 3. Cholesterol, triglycerides, HDL and LDL content of blood plasma in lambs (mmol/l)

Component		At start of fattening			At slaughter		
		group C (n=8)	group E (n=9)	P	group C (n=8)	group E (n=9)	P
Cholesterol	mean	3.20	3.09	0.683	1.59	1.76	0.227
	SE	0.216	0.222		0.071	0.097	
Triglycerides	mean	0.89	0.81	0.547	0.23	0.32	0.112
	SE	0.089	0.092		0.029	0.035	
HDL	mean	2.14	1.96	0.351	0.73	0.79	0.240
	SE	0.125	0.132		0.034	0.031	
LDL	mean	0.90	0.91	0.968	0.85	0.91	0.548
	SE	0.158	0.139		0.067	0.069	

The dressing percentage (Tab. 4) in lambs C (42.05%) was similar to that found in lambs E (43.13%). Similarly, the share of valuable cuts and perirenal fat in the right carcass-side of lambs C (42.20% and 2.65%, respectively) did not differ from values observed in lambs E (42.38% and 3.04%, respectively). No significant differences between C and E lambs were found in loin eye area (7.16 and 8.42 cm^2, respectively), weight of leg (1.25 and 1.26 kg, respectively) and in leg tissue (meat, fat and bones) composition. All the results concerning slaughter parametres were not significantly affected by combined supplements used and occurred similar to the data obtained for lambs fed diets containing linseed with mineral bioplex [Baranowski *et al*. 2007] or 10% of oilseeds [Borowiec *et al*. 2004, Grześkowiak *et al*. 2004, Borys and Jarzynowska 2005]. However, in the experiment of Rizzi *et al*. [2002], the lamb diet containing 20% sunflower seeds led to a higher intramuscular fat per cent of leg muscle, and in studies by Borys and Borys [2005] the diet supplemented with 10% of rapeseed and linseed mix (2:1) caused the greater external fatness of carcass. In the current investigation the slaughter value of lambs of both groups can be assumed as satisfactory from the point of view of fattenig efficiency, comparable with resultes reached in other experiments conducted on growing crossbred lambs [Borys and Osikowski 1998, Janiuk *et al*. 1998, Lipecka *et al*. 2001, Baranowski and Klewiec 2004].

Table 4. Slaughter indicators in lambs

Indicator		Group C (n=8)	Group E (n=9)	P
Cold carcass weight (kg)	mean	9.39	9.67	0.698
	SE	0.492	0.500	
Dressing percentage (%)	mean	42.05	43.13	0.388
	SE	0.830	0.881	
Right carcass-side weight (kg)	mean	4.64	4.77	0.707
	SE	0.248	0.252	
Valuable cuts content of carcass-side (%)	mean	42.20	42.38	0.723
	SE	0.418	0.279	
Perirenal fat content of carcass-side (%)	mean	2.65	3.04	0.392
	SE	0.200	0.372	
Loin weight (kg)	mean	0.19	0.22	0.214
	SE	0.010	0.016	
Loin eye area (cm^2)	mean	7.16	8.42	0.059
	SE	0.289	0.521	
Leg weight (kg)	mean	1.25	1.26	0.878
	SE	0.062	0.060	
Meat content of leg (%)	mean	71.60	71.91	0.777
	SE	0.993	0.556	
Fat content of leg (%)	mean	13.01	12.28	0.573
	SE	0.955	0.849	
Bone content of leg (%)	mean	15.63	15.72	0.884
	SE	0.483	0.446	

Table 5. Chemical composition of LD muscle

Item		Group C (n=8)	Group E (n=9)	P
Dry matter (%)	mean	23.27	23.56	0.383
	SE	0.195	0.249	
Protein (%)	mean	20.51	20.55	0.894
	SE	0.188	0.245	
Fat (%)	mean	1.80	2.12	0.293
	SE	0.198	0.210	
Cholesterol (mg/100 g fresh tissue)	mean	60.47	75.56	**0.002**
	SE	2.29	3.229	

No significant differences were identified between C and E lambs in the dry matter (23.27 *vs*. 23.56%), protein (20.51 *vs*. 20.55%) and fat (1.80 *vs*. 2.12%) content of LD muscle (Tab. 5). Similar results referring to the effect of diets supplemented with oilseeds (10-22% of the concentrate) on dry matter, protein, and fat content of lamb meat were found by Piechnik *et al*. [1999], Rizzi *et al*. [2002], Borowiec *et al*. [2004] and recently by Borys and Borys [2005]. Feeding linseed oil with bioplex, as in the other experiments conducted on lambs [Piechnik *et al*. 1999, Borowiec *et al*. 2004,

Borys and Borys 2005, Baranowski *et al*. 2007] had no effect on lowering muscle cholesterol concentration. Cholesterol content of LD muscle was higher (P≤0.002) in lambs E (75.56 mg/100g) than in lambs C (60.47 mg/100 g). However, both values were within the range of 52-100 g/100 tissue considered typical for sheep meat by Barowicz and Janik [1998].

The fatty acid (FA) profile expressed as a per cent of a sum of total FAs of intramuscular fat of LD muscle is presented in Table 6. The supplements applied in group E led to the decrease (by 49.4%, P≤0.002) in margaric acid content (C17:0), but to increase (by 73.8%, P≤0.001) in myristic acid (C14:0) content, undesirable from viewpoint of human diet. Simultaneously, no negative effect of diet supplementation in group E was identified on LD intramuscular fat SFAs, appearing lower than in group C (48.06% *vs*. 49.91% of total SFAs, P=0.071). There were no significant differences in the unsaturated fatty acids (UFAs) content between groups (50.10% *vs.* 48.74% in group E and C, respectively). However, from the dietary point of view the composition of UFAs of the intramuscular LD fat in E lambs appeared more desirable than that in C lambs. This statment is supported by the markedly (P=0.065) higher content of CLA isomers and significantly (P≤0.047) greater MUFA/SFA ratio in intramuscular fat of E than of C lambs (1.66% and 0.84 *vs* 1.39% and 0.78, respectively). Moreover, the PUFA*n*-6/*n*-3 ratio in E lambs was more favourable in terms of recommended dietary value [Ziemlański 1998] than in lambs C (6.15 *vs*. 6.42). The positive effect of diet supplementation on FAs profile described in E lambs in this report was generally lower compared to the animals fed the diet supplemented with 5-6% plant oils by Potkański *et al*. [2001], Czauderna *et al*. [2004] or 10-22% oilseeds by Piechnik *et al*. [1999], Wachira *et al*. [2002], Rizzi *et al*. [2002] and Borowiec *et al*. [2004] and similar to that reached by lambs fattened using diet enriched with small doses of linseed and bioplex (3 g and 3 g/animal/day) – Baranowski *et al*. [2007].

Results presented in this report show that low linseed oil and mineral bioplex supplements (3 and 3 g per animal daily) administered *per os* to fattening lambs (from 8 to 24 kg live body weight) had no significant effect on their daily live weight gain, slaughter value and basic chemical composition (dry matter, protein, fat) of *longissimus dorsi* muscle. Supplements used positively affected fatty acids profile of fat, improving the dietetic value of meat. However, the meat contained more undesirable myristic acid and cholesterol as compared to control lambs.

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Table 6. Profile of fatty acids in the intramuscular fat (% of sum) of LD muscle

Indicator		Group C (n=8)	Group E (n=9)	P
∑ SFA	mean	49.91	48.06	0.071
	SE	0.692	0.652	
C 12:0	mean	0.08	0.09	0.775
	SE	0.008	0.007	
C 14:0	mean	0.61	1.06	**0.001**
	SE	0.070	0.066	
C 16:0	mean	2.70	2.66	0.462
	SE	0.033	0.031	
C 17:0	mean	0.77	0.39	**0.002**
	SE	0.074	0.070	
C 18:0	mean	21.46	19.85	0.125
	SE	0.717	0.676	
∑ UFA	mean	48.74	50.10	0.160
	SE	0.670	0.631	
∑ MUFA	mean	38.63	40.11	0.079
	SE	0.571	0.538	
C 12:1*c*5	mean	0.03	0.05	0.148
	SE	0.007	0.007	
C 14:1*c*9	mean	0.09	0.11	0.148
	SE	0.012	0.011	
C 16:1*c*9	mean	3.24	3.45	0.531
	SE	0.238	0.225	
C 18:1*c*9	mean	32.51	33.02	0.549
	SE	0.613	0.578	
C 18:1*t*11	mean	2.77	3.48	0.067
	SE	0.262	0.247	
∑ PUFA	mean	10.11	10.00	0.882
	SE	0.565	0.532	
C 18:2*n*-6 (*c*9,12)	mean	7.51	7.14	0.594
	SE	0.494	0.465	
C 18:3*n*-3 (*c*9,12,15)	mean	0.84	0.90	0.653
	SE	0.088	0.083	
C 20:3*n*-3 (*c*11,14,17)	mean	0.36	0.29	0.148
	SE	0.035	0.033	
C 20:5*n*-3 (*c*5,8,11,14,17)	mean	0.02	0.02	0.999
	SE	0.003	0.003	
∑ PUFA*n*-3	mean	1.22	1.20	0.087
	SE	0.129	0.095	
CLA (sum of isomers)	mean	1.39	1.66	0.065
	SE	0.097	0.091	
PUFA*n*-6/*n*-3	mean	6.42	6.15	0.468
	SE	0.539	0.446	
UFA/SFA	mean	0.98	1.05	0.108
	SE	0.029	0.028	
MUFA/SFA	mean	0.78	0.84	**0.047**
	SE	0.021	0.020	
PUFA/SFA	mean	0.20	0.21	0.764
	SE	0.014	0.013	
PUFA/MUFA	mean	0.26	0.25	0.564
	SE	0.016	0.015	

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Antoni Baranowski, Artur Jóźwik,
Elżbieta Bernatowicz, Wojciech Chyliński

Wyniki tuczu, wartość rzeźna i skład chemiczny mięsa jagniąt żywionych z dodatkiem oleju lnianego i mineralnego biopleksu

S t r e s z c z e n i e

Maciorki mieszańcowe F1 (50% boorooli i 50% owcy olkuskiej) o średniej wyjściowej masie ciała 8 (±1,3) kg tuczono do średniej masy ciała 24 (±2,2) kg, a następnie ubijano i poddawano analizie rzeźnej. W okresie tuczu maciorki grupy kontrolnej (C, n=8) i doświadczalnej (E, n=9) żywiono indywidualnie do woli mieszanką treściwą zawierającą 207 g białka ogólnego i 12,5 MJ energii metabolicznej w kg suchej masy. W okresie tuczu każdemu jagnięciu z grupy E podawano dustnie 3 g oleju lnianego i 3 g biopleksu mineralnego dziennie. Średni przyrost dzienny masy ciała maciorek grupy C był zbliżony do uzyskanego przez maciorki grupy E (odpowiednio 111 g i 125 g). W dniu zakończenia tuczu maciorki grup C i E charakteryzowały się podobnym poziomem cholesterolu całkowitego w osoczu krwi (odpowiednio 1,59 i 1,76 mmol/l), frakcji HDL (odpowiednio 0,73 i 0,79 mmol/l) i frakcji LDL (odpowiednio 0,85 i 0,91 mmol/l). Zastosowane dodatki nie wpłynęły istotnie na wydajność rzeźną maciorek (42,05% w grupie C i 43,13% w grupie E) oraz zawartość wyrębów wartościowych (42,20% w grupie C i 42.38% w grupie E) i tłuszczu okołonerkowego (2,65% w grupie C i 3,04% w grupie E) w tuszy, a także na podstawowy skład chemiczny mięśnia LD (odpowiednio w grupie C i E: sucha masa 23,27% i 23,56%, białko 20,51% i 20,55%, tłuszcz 1,80% i 2,12%). W mięsie jagniąt grupy E stwierdzono istotnie (P≤0,002) wyższą zawartość cholesterolu (75,56 mg/100 g tkanki) niż w mięsie jagniąt grupy C (60,47 mg/100 g tkanki). W porównaniu z maciorkami kontrolnymi, śródmięśniowy tłuszcz maciorek żywionych z udziałem stosowanych dodatków charakteryzował się korzystniejszym profilem kwasów tłuszczowych.