Animal Science Papers and Reports vol. 25 (2007) no. 1, 35-44
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

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

Antoni Baranowski, Mirosław Gabryszuk, Artur Jóźwik, Elżbieta Bernatowicz, Wojciech Chyliński

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

(Received January 20, 2007; accepted March 5, 2007)

Crossbred ram-lambs (50% Booroola and 50% Olkuska Sheep) aged 55 days were assigned to control (C, n=8) and experimental (E, n=9) group with mean live body weight of 16.0 and 15.3 kg, respectively. Lambs of both groups were fed *ad lib*. the pelleted mixed concentrate containing 231 g crude protein (CP) and 12 MJ metabolizable energy (ME) per kg dry matter. During fattening each lamb from group E was administered *per os* 3 g of linseed with 3 g mineral bioplex daily. C and E lambs were slaughtered on day 141 of life at the mean live weight of 36.3 and 34.3 kg, respectively. Significant differences between groups were observed neither in the mean daily live weight gain (group C – 238 g *vs.* group E – 225 g) nor in CP and ME intake per kg live weight gain (group C – 890 g and 46.1 MJ *vs.* group E – 938 g and 48.6 MJ, respectively). The levels of blood plasma cholesterol and its fractions were not found to be significantly differentiated by groups. Dressing percentage, share of valuable cuts in carcass-side and perirenal fat content confirmed the similar slaughter value of C and E lambs (47.39%, 42.65%, 1.74% *vs.* 48.22%, 42.36%, 1.95%, respectively). The dietetic value of meat, based on the fatty acid profile of intramuscular fat, was generally more favourable in lambs fattened with supplement because of the higher percentage of unsaturated fatty acids (UFA) and lower of saturated fatty acids (SFA).

KEY WORDS: fattening / fatty acids / growth rate / lambs / linseed / slaughter performance / meat chemical composition

The important factor affecting consumers' decision to purchase meat is recognizing its nutritive quality. This trait is largely connected with production of animal products characterized by low content of fat and cholesterol and an optimum

ratio between unsaturated (UFA) and saturated (SFA) fatty acids [Wood and Enser 1997, Obiedziński 2002]. To improve the dietetic value of ruminant meat, in feeding programmes for animals the supplementation of the diet with either seeds of oil-bearing plants, or directly with plant oils rich in unsaturated fatty acids allows to modify the fatty acid profile of tissues [Jakobsen 1999, Oprządek and Oprządek 2003]. The fatty acids profile of lamb meat can be altered by supplementing the animals' daily ration over a period of two months with 10% of rapeseed or linseed [Borowiec *et al*. 2004, Boys and Borys 2005]. However, Reklewska *et al*. [2000] reported that even 3 g linseed with 3 g bioplex mineral supplement fed daily per goat during a month led to desirable changes in the fatty acids profile of milk. Such a low addition of oil seeds gives no significant rise to the diet energy level, which in the case of higher doses applied to ruminants may reduce the milk production or increase the fattening rate of fattened animals.

In light of this, small doses of linseed combined with bioplex were used to estimate their effect on growth rate, fattening and slaughter performance and chemical composition of meat in fattening lambs.

Material and methods

The crossbred ram-lambs (50% Booroola, 50% Olkuska Sheep) were randomly assigned to control (C, n=8) and experimental (E, n=9) group with mean live body weight of 16.0 and 15.3 kg, at the age of 54.8 and 55.3 days, respectively. The lambs from both groups were placed in individual straw-bedded pens and fed according to feeding standards recommended by the National Research Institute of Animal Production [1966]. The animals had free access to granulated concentrate mixture (Tab. 1) and water up to the final live body weight of approx. 35 kg. The daily intake of concentrate was recorded individually for each lamb. In order to ensure proper rumen function, each lamb was additionally offered about 0.1 kg first-cut meadow hay

Table 1. Proximate composition (g/kg DM) and metabolizable energy level (MJ/kg DM) of feeds

Component	Concentrate*		Meadow hay	
	mean (n=3)	SD	mean (n=3)	SD
Dry matter (g/kg feed)	897	4.8	871	24.4
Ash	73	5.7	65	8.1
Crude fibre	91	6.6	347	10.6
Ether extract	19	1.5	18	0.7
Crude protein	231	1.9	120	16.7
N-free extractives	586	12.1	450	17.5
Metabolizable energy	12.01	0.157	10.03	0.161

*Composition (%): barley 47.0, oats 10.0, horse bean 13.0, soyabean oilmeal 17.0, dried suger beet pulp 10.1, minerals 2.9.

daily, intake of which was not recorded. During the fattening period each lamb from group E was administered 3 g of lineseed with 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 given directly to the oesophagus, using the tube. The proximate analysis of feeds (Tab. 1) was performed using standard procedure, 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 fattening 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 fattening (day 141 of life, 35 kg live body weight) all lambs were slaughtered and the carcasses subjected to cutting and dissecting according to Nawara *et al*. [1963]. After cutting the carcass into cuts, samples were taken from the middle part of *longissimus dorsi* (LD) muscle to determine the dry matter [Polish Standard 1973], ash (ashing at 550^0C), fat [Polish Standard 1972], protein [Polish Standard 1975], cholesterol [Folch *et al*. 1957, Searcy and Bergquist 1960, Rhee *et al*. 1982] and fatty acids profile, including the content of conjugated diene of 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 esters of fatty acids were 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 maintained 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.

Results and discussion

At the beginning of experiment the mean live body weight and age in C lambs (16.0 kg, 54.8 days) were similar to those recorded in E group (15.3 kg and 53.3 days) – Table 2. During the fattening period (of similar length in both groups) the mean daily live weight gain in C lambs (238 g) was not significantly different from that found in lambs E (225 g). Moreover, no significant differences between groups were identified in the feed (concentrate) conversion rate (intake of hay was not recorded and not included in calculating of feed conversion) – per 1 kg weight gain C lambs consumed 890 g CP and 46.10 MJ ME while lambs E 938 g and 48.64 MJ. Similar relations (differences in growth rate and feed conversion between control and experimental group not significant) were observed in experiments conducted on lambs fattened with

Table 2. Fattening performance of lambs

Indicator	Group C (n=8)		Group E (n=9)		P
	mean	SE	mean	SE	
Age (days)					
initial	54.8	0.86	55.3	0.93	0.654
final	141.0	5.96	140.6	5.14	0.955
Body live weight(kg)					
initial	16.0	1.13	15.3	0.61	0.550
final	36.3	1.09	34.3	1.21	0.249
Days of fattening	86.3	6.55	85.2	5.35	0.904
Daily live weight gain (g)	238	13.1	225	6.0	0.371
Concentrate intake/kg live weight gain					
dry matter (kg)	3.84	0.212	4.05	0.180	0.451
crude protein (g)	890	49.1	938	41.6	0.451
metabolizable energy (MJ)	46.10	2.547	48.64	2.155	0.451

the concentrate containing 10% of sunflower seeds [Rizzi *et al*. 2002] or linseed and rapeseed [Borowiec *et al*. 2004, Borys and Jarzynowska 2005]. The live weight gain and feed conversion reached in the present study by lambs of both groups corroborate the results reported by Janiuk *et al*. [1998] and Baranowski and Klewiec [2004] for crossbred lambs sharing Booroola and Olkuska Sheep genes (daily gain less than 300 g, about 4 kg concentrate dry matter consumed per kg live weight gain).

Contrary to studies conducted on goats by Reklewska *et al*. [2000] and in accordance with data obtained for rams fed linseed-based diet by Micek *et al*. [2004],

Table 3. Content (mmol/l) of cholesterol, triglycerides and cholesterol fractions in blood plasma of lambs

Component	Initial				P	Final				P
	group C (n=8)		group E (n=9)			group C (n=8)		group E (n=9)		
	mean	SE	mean	SE		mean	SEM	mean	SE	
Cholesterol	2.80	0.219	2.43	0.285	0.173	1.46	0.086	1.52	0.123	0.985
Triglycerides	0.75	0.192	0.61	0.196	0.384	0.26	0.037	0.28	0.029	0.286
HDL	1.39	0.200	1.29	0.221	0.302	0.56	0.063	0.46	0.029	0.250
LDL	1.27	0.207	1.02	0.182	0.185	0.85	0.050	1.00	0.108	0.800

the results presented in Table 3 show that the ration supplemented daily with 3 g linseed and 3 g bioplex had no effect on the CHOL, HDL and LDL content of blood plasma in E lambs. At the end of fattening, these indicators in C lambs (1.46, 0.56 and 0.85 mmol/l, respectively) did not differ significantly from those recorded in lambs E (1.52, 0.46 and 1.00 mmol/l, respectively), and were comparable to the values found in the young fattened lambs by Barowicz *et al*. [1994].

Dressing percentage (Tab. 4) in C lambs (47.39%) was similar to that found in lambs E (48.22%). Similarly, the share of valuable cuts and perirenal fat in the right carcass-side of C rams (42.65% and 1.74%) did not differ from values found in lambs E (42.36% and 1.95%, respectively). No significant differences were found between C and E lambs in loin eye area (14.14 and 12.94 cm^2 respectively), weight of leg (2.20 and 2.10 kg, respectively) and in leg tissue (meat, fat and bone) composition. All the slaughter parametres were not significantly affected by combined supplement used and occurred similar to the data reported for lambs fed diets containing 10% oilseeds

Table 4. Slaughter value indicators in lambs

Indicator	Group C (n=8)		Group E (n=9)		P
	mean	SE	mean	SE	
Cold carcass weight (kg)	16.58	0.474	16.00	0.699	0.517
Dressing percentage (%)	47.39	0.606	48.22	0.848	0.446
Side-carcass weight (kg)	8.26	0.241	7.97	0.347	0.507
Share in a carcass-side (%)					
valuable cuts	42.65	0.244	42.36	0.194	0.355
perirenal fat	1.74	0.112	1.95	0.248	0.471
Loin weight (kg)	0.38	0.017	0.35	0.017	0.317
Loin eye area (cm^2)	14.14	1.086	12.94	0.672	0.353
Leg (kg)	2.20	0.074	2.10	0.087	0.380
Content of leg (%)					
meat	70.33	0.731	68.46	0.608	0.066
fat	14.88	0.769	16.39	0.809	0.198
bone	14.89	0.258	14.91	0.515	0.969

[Rizzi *et al*. 2002, Borowiec *et al*. 2004, Borys and Jarzynowska 2005]. However, in experiment by Rizzi *et al*. [2002] the lamb diet containing 20% of sunflower seeds led to higher fat per cent of leg muscles, and in studies by Borys and Borys [2005] the diet supplemented with 10% of rapeseed and linseed (2:1) promoted greater external fatness of carcass. The slaughter value of all lambs (C and E) examined in the current work was satisfactory and comparable to the results reached in the other experiments conducted on growing crossbred lambs [Borys and Osikowski 1998, Janiuk *et al*. 1998, Lipecka *et al*. 2001, Baranowski and Klewiec 2004].

No significant differences were identified between C and E group means for dry matter (23.63 *vs*. 23.24%), protein (20.37 *vs*. 20.44%), ash (1.08 *vs*.1.05%) and fat (1.81 *vs*.1.75%) content of LD muscle – Table 5. Similar results referring to the effect of concentrates supplemented with 10-22% oil seeds on dry matter, protein, ash and fat content of lamb meat were reported by Piechnik *et al*. [1999], Rizzi *et al*. [2002], Borowiec *et al*. [2004] and Borys and Borys [2005]. No significant differences were found between groups in cholesterol content of LD muscle (69.10 and 75.31 mg/100 g in group C and E, respectively). Feeding linseed with bioplex, as in the other experiments conducted on lambs [Piechnik *et al*. 1999, Borowiec *et al*. 2004, Borys and Borys 2005], showed no significant effect on lowering muscle cholesterol concentration, which remained within the range of 52-100 mg/100 g considered typical for sheep meat by Barowicz and Janik [1998].

Table 5. Chemical composition of LD muscle

Item	Group C (n=8)		Group E (n=9)		P
	mean	SE	mean	SE	
Dry matter (%)	23.63	0.231	23.24	0.444	0.557
Protein (%)	20.37	0.227	20.44	0.373	0.905
Fat (%)	1.81	0.135	1.75	0.105	0.985
Ash (%)	1.08	0.011	1.05	0.012	0.079
Cholesterol (mg/100g fresh tissue)	69.10	4.187	75.31	2.995	0.086

Fatty acids (FA) profile expressed as a percentage of the sum of fatty acids in the intramuscular fat of LD muscle is presented in Table 6. The supplementation applied in group E increased (P≤0.023) the lauric acid (C 12:0) content of saturated FA (SFAs) with no, however, effect on SFAs concentration in that group, lower than in group C (46.24% *vs.* 46.66% of total FAs). The principal differences between groups were found in the composition of monounsaturated fatty acids (MUFAs). The intramuscular fat of E lambs was characterized by significantly (P≤0.001) higher percentage of c-5 dodecenoic acid (C 12:1, by 66.7%) and vaccenic acid (C 18:1*t*11 by 33.5%) in comparison with C lambs. Similar changes in MUFAs profile of intramuscular fat in lambs fed complete diet supplemented with 10% of linseed were reported by Wachira *et al*. [2002] and Borowiec *et al*. [2004]. In the present study also the content

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

Trait	Group C (n=8) mean	Group E (n=8) mean	SE	P
∑ SFA	46.66	46.24	0.732	0.696
C 12:0	0.16	0.20	0.011	**0.023**
C 14:0	0.49	0.52	0.043	0.589
C 16:0	26.71	26.58	0.354	0.787
C 17:0	0.35	0.31	0.026	0.343
C 18:0	18.90	18.60	0.630	0.740
∑ UFA	51.55	52.03	0.679	0.628
∑ MUFA	42.42	42.61	0.557	0.812
C 12:1	0.03	0.05	0.004	**0.001**
C 14:1	0.20	0.26	0.028	0.149
C 16:1	2.34	2.56	0.179	0.410
C 18:1*c*9	36.50	35.27	0.625	0.186
C 18:1*t*11	3.34	4.46	0.186	**0.001**
∑ PUFA	9.14	9.42	0.335	0.559
C 18:2	6.58	6.59	0.247	0.964
C 18:3	0.44	0.49	0.027	0.216
C 20:3	0.32	0.38	0.056	0.410
C 20:5	0.03	0.04	0.006	0.266
CLA	1.78	1.92	0.096	0.302
UFA/SFA	1.11	1.13	0.033	0.634
MUFA/SFA	0.91	0.93	0.026	0.707
PUFA/SFA	0.20	0.21	0.010	0.545
PUFA/MUFA	0.22	0.22	0.008	0.645
SFA/MUFA	1.10	1.09	0.030	0.760
SFA/PUFA	5.17	4.95	0.225	0.506

of all investigated polyunsaturated fatty acids (PUFAs) was greater in E than in C group – C 18:3 (linolenic acid) by 11.4%, C 20:3 (eicosatrienoic acid) by 18.8%, C 20:5 (eicosapentaenoic acid) by 33.3%, and CLA by 7.9%. However, in contrast to experiments by Wachira *et al*. [2002], Rizzi *et al*. [2002], and Borowiec *et al*. [2004] the inter-group differences observed were not statistically confirmed. The analysed MUFA and PUFA profiles of intramuscular LD fat in E lambs appeared more desirable from the viewpoint of human health than those in lambs C. Such statement is supported also by the higher UFA content and the greater UFA/SFA ratio in fat of E (52.03% and 1.13) than in C (51.55% and 1.11) lambs. These observations are in accordance with Piechnik *et al*. [1999], Wachira *et al*. [2002], Rizzi *et al*. [2002] and Borowiec *et al*. [2004] who reported beneficial effects of rapeseed, linseed or sunflower seed used in a diet (10-22%) on fatty acid profile of intramuscular fat in lambs.

Results described in the present report show that low supplement composed of linseed and mineral bioplex (3 g of each per animal daily) and administered *per os* to fattening lambs (day 55 to 141 of life) did not affect significantly their daily live weight gain, feed conversion, slaughter indicators and basal chemical composition of *longissimus dorsi* muscle. The combined supplement positively affected the fatty acid profile of intramuscular fat reflecting the tendency of improving the dietetic value of lamb meat.

Acknowledgement. *The authors express their gratitude to Professor J. Klewiec for help in statistical evaluation of results.*

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Antoni Baranowski, Mirosław Gabryszuk,
Artur Jóźwik, Elżbieta Bernatowicz, Wojciech Chyliński

Wyniki tuczu, wartość rzeźna i skład chemiczny mięsa tryczków żywionych z dodatkiem siemienia lnianego i mineralnego biopleksu

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

Tryczki mieszańce (50% boorooli i 50% owcy olkuskiej) o średniej wyjściowej masie ciała 16 kg tuczono do masy ciała około 35 kg, a następnie ubijano i poddawano analizie rzeźnej. W okresie tuczu tryczki grupy kontrolnej (C, n=8) i doświadczalnej (E, n=9) żywiono indywidualnie do woli pełnoporcjowym granulatem, zawierającym 231 g białka ogólnego i 12 MJ energii metabolicznej w kg suchej masy. Przez cały okres tuczu każdemu tryczkowi z grupy E podawano doustnie 3 g siemienia lnianego i 3 g biopleksu mineralnego dziennie. Średnie przyrosty dobowe masy ciała w grupie C i E okazały się do siebie zbliżone (odpowiednio 238 g i 225 g, różnica nieistotna). Istotnych różnic między grupami nie stwierdzono także w zużyciu białka ogólnego (odpowiednio 890 i 938 g w gupie C i E) i energii metabolicznej (odpowiednio 46,10 i 48,64 MJ w grupie C i E) na kg przyrostu masy ciała tryczków. W dniu zakończenia tuczu osocze krwi tryczków z grupy C i E charakteryzował podobny (różnice nieistotne) poziom cholesterolu całkowitego (odpowiednio 1,46 i 1,52 mmol/l), cholesterolu frakcji HDL (odpowiednio 0,56 mmol/l i 0,46 mmol/l) oraz cholesterolu frakcji LDL (odpowiednio 0,85 i 1,00 mmol/l). Stosowane dodatki paszowe nie wpłynęły istotnie na wydajność rzeźną tryczków (C – 47,39%, E – 48,22%), udział wyrębów wartościowych w tuszy (C – 42,65%, E – 42,36%), udział tłuszczu okołonerkowego (C – 1,74%, E – 1,95%) i skład chemiczny mięśnia najdłuższego grzbietu (odpowiednio w grupie C i E: sucha masa – 23,63% i 23,24%, białko – 20,37% i 20,44%, tłuszcz – 1,81% i 1,75%, popiół – 1,08% i 1,05%, cholesterol całkowity – 69,10 i 75,31 mg/100 g tkanki). W porównaniu z tryczkami kontrolnymi, śródmięśniowy tłuszcz tryczków żywionych z udziałem nasion lnu i biopleksu mineralnego charakteryzował się istotnie (P≤0,001) większym udziałem kwasu oleolaurynowego (C 12:1) i transwakcenowego (C 18:1*t*11) w puli jednonienasyconych kwasów tłuszczowych (MUFA).