Annals of Warsaw University of Life Sciences – SGGW
Animal Science No 58 (2), 2019: 169–179
(Ann. Warsaw Univ. of Life Sci. – SGGW, Anim. Sci. 58 (2), 2019)
DOI 10.22630/AAS.2019.58.2.18

The effect of the brewing and milling by-products containing in the lambs diet on body weight growth, slaughter value and meat quality

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Abstract: *The effect of the brewing and milling by-products containing in the lambs diet on body weight growth, slaughter value and meat quality*. The aim of the study was to evaluate the growth rate, slaughter value and meat quality characteristics of lambs fed of fresh brewer's grain and by-product of the milling industry. Research was conducted on 45 Polish merino ram lambs, which were divided into three feeding groups and fattened to their slaughter weight of 40 kg (±2.0 kg). Lambs in control group were fed meadow hay, oat meal and steamed potatoes. In one of experimental group (WBG group) 35% of wet brewer's grain was added to the feed. The second experimental group (BPM group) received 44% of by-product of the milling industry in the form of crushed grains of various cereal species. The obtained results indicated that the by-products of the brewing and milling industry used in nutrition on fattened lambs did not negatively affect the body weight growth and slaughter value. The application of these components also did not affect the quality of meat in respect to its chemical composition and physical characteristics. The brewer's grain share in the ration increased the content important for human health monounsaturated and polyunsaturated fatty acids and the isomer C18:2 *cis*9, *trans*11 (CLA).

Key words: lambs, by-products, slaughter value, meat quality

INTRODUCTION

The high quality and health benefits of lamb meat, which are increasingly perceived by consumers are a challenge for producers of slaughter lambs. Maintaining this niche type of meat on the market requires both a reduction in the production costs without reducing its quality. In order to increase the efficiency of fattening, producers of lamb meat are looking for less expensive fodder, because expenses related to animal nutrition may amount to 60–70% of the total costs incurred (Korman 2001). The one of the cheapest feeds that can be used in animal nutrition are the by-products of the agri-food industry. However, the condition for use of these feeds is a short transport and ensuring the appropriate value, especially microbiological (Ben-Hamed 2011).

The by-products of distillers, millers, sugar and oil industry are successfully used in nutrition not only ruminant but also monogastric animals (Hetherington and Krebs 2002, Aguilera-Soto et al.

2008, Essien and Udotong 2008, Homm et al. 2008, Grześkowiak et al. 2010, Borys et al. 2013, Borzuta et al. 2014, Peña and Posadas 2016). However, there is concern if the use of such components will not reduce the slaughter value and does not negatively affect the quality of meat. Many studies have confirmed the positive effect of both fresh and dried brewers, providing high quality protein (21–33%), on the increase of body weight gain and the quality of lamb meat (Anigbogu 2003, Mussatto et al. 2006, Aguilera-Soto et al. 2007). Similarly, the lack of a decrease in the growth rate and a beneficial effect on the content of bioactive components such as polyunsaturated n-3, C18:2 *cis*9, *trans*11 (CLA) and the ratio n-6 / n-3 were registered using rapeseed and sunflower cake in the diet (Grześkowiak et al. 2010).

In sheep nutrition, the by-products from the milling industry are also commonly used. Wheat bran is the most popular. Their availability and low cost can affect fattening economics, especially in a more extensive way and to higher weight standards (Borys 2011). A very valuable but not very popular by-product of the milling industry is bread. It contains about 70% easily digestible starch and about 13% of protein. This product belongs to the energetic feed material and according to Afzalzadeh et al. (2007) should not exceed a 25% of the feed ration. Although, Hetherington and Krebs (2002) using a 50% share of this product in the diet of fattened merino lambs obtained daily gain comparable to the control group.

The dynamic development of biofuel production has created the possibility of using by-products in the form the distilers grain solubles (DGS) in animal nutrition. In sheep nutrition, a corn pulp is particularly useful, which can replace soybean meal. It has a significant amount of protein and fat, although a small dry matter content (Borys 2011). Nevertheless, studies conducted on lambs showed that even a large proportion of destilers in concentrate, up to 60%, had no negative effect on fattening characteristics and carcass quality (Estrada-Angulo et al. 2008, Van-Emon et al. 2008).

The aim of the present study was to determine the effect of the use of fresh brewer's grain and by-product of the milling industry in the form of crushed grains of various cereal species in the diet of fattened lambs on the growth rate, slaughter value and quality characteristics of the meat.

MATERIAL AND METHODS

The research was carried out on 45 ram lambs of polish merino breed. The weight-balanced lambs were divided into 3 feeding groups (15 animals in each): control group, experimental with the proportion of brewers' grain in the diet (WBG group), experimental with the by-product of the milling industry (BPM group). After 14-days adaptation period, the lambs were fattened to achieve slaughter weight of 40 kg (±2.0kg).

Ethical approval for the experiment was obtained from the Local Ethics Commission in Warsaw. The animals were maintained under uniform environmental conditions with constant zootechnical and veterinary supervision. The lambs were fed in groups according to the standards for fattened lambs up to a body weight of 30–40 kg (Osikowski et al. 1998). In the control group lambs received meadow hay 28%, oat meal 32%, steamed potatoes 39% and mineral mixture 1%. In the experimental WBG group a 35% share of fresh brewer's grain (WBG) was used in the ration and 18% meadow hay, 22% oat meal, 24% of steamed potatoes and 1% mineral mixture. In BPM group, oat meal was replaced by a by-product of the milling industry in the form of crushed grains of various cereal species 44%, meadow hay accounted for 25%, steamed potatoes 30%, and mineral mixture 1%. The chemical composition and nutritional value of fodder are presented in Table 1. The animals were fed twice a day, and they had constant access to water.

In order to analyze the growth rate of lambs, the control weighing was carried out: at the beginning of fattening after adaptation period, than every 14 days and on the day of slaughter. On this basis the daily gain (g/day) and total body weight gain (kg) for fattening period for each group were estimated.

After reaching assumed body weight lambs were slaughtered in a slaughterhouse according to accepted procedures. The slaughter value evaluation of carcasses was carried out after 24 h cooling at 4°C in the hanging position.

The carcasses were weighed and the hind leg was measured according to method given by Niżnikowski (1988). Then, the carcase was divided into two halves. The right half-carcasses were cut into joints, which were weighed and the percentage of each in half-carcass was calculated.

The measurements of width (cm), depth (cm) and area (cm^2) of *longissimus dorsi* muscle (LD) as well as fat thickness over LD muscle (mm) were also performed.

From the lumbar region of each carcass the LD muscle was sampled in order to determine the quality traits of the meat. Than the samples were vacuum packed and stored at –22°C (about 30 days) until chemical analysis.

The meat pH was measured 24 h after slaughter using Elmetron CP-411 pH-meter with dagger electrode calibrated at 4.0, 7.0 and 9.0 pH values.

The expressed juice was determined according to Grau and Hamm (1953) method. The meat color was measured

TABLE 1. The chemical composition and nutritional value of feeds used in lambs fattening

Specification	Grass hay	Oat meal	Steam potatoes	WBG	BPM
Dry matter g·kg^{-1}	870.4	873.5	192.8	260.9	851.0
Crude protein g·kg^{-1} DM	129.8	97.0	115.0	255.0	130.2
Ether extract g·kg^{-1} DM	22.0	34.0	3.0	59.0	18.9
Crude fiber g·kg^{-1} DM	317.0	120.0	37.0	147.0	54.6
Ash g·kg^{-1} DM	36.5	27.4	52.9	37.2	27.9
EN (MJ/1kg DM)	3.72	6.82	8.87	4.75	7.81

EN – net energy; MJ – megajoule; DM – dry matter; WBG – wet brewer's grain; BPM – by-products of the milling industry.

24 h after slaughter on the LD muscle surface by Konica-Minolta CR-410 device specifying lightness – *L**, redness – *a** and yellowness – *b**.

The chemical composition and nutritional value of lambs fodder were analyzed according to AOAC standard methods (1990). The basic chemical composition of LD muscle was determined by analyzing the contents of moisture, crude protein, intramuscular fat and collagen using a spectrometric technique with near-infrared transmission (NIR) method (PN-A-82109). The meat samples (200 g) were homogenized in an Elektrolux DITO K35 processor. Afterwards unified samples were placed in a measuring cell of FoodScan analyzer. The device uses the near-infrared transmission method within 850–1050 nm range and is fitted with ANN calibration developed using a model of artificial neural networks. The analysis is performed by indicating in the computer program the number of measurements in the sample, and then the program automatically calculates the average and presents the result.

The LD muscle samples were analyzed for fatty acids contents. The lipids from the muscle were extracted according to Folch et al. (1957). Saponification of fat made in 0.5 M KOH in methanol and esterification in 10% BF_3 in methanol. The fatty acid methyl esters extracted in the hexane.

Fatty acid profile of lipids was performed by gas-chromatograph analysis using Agilent Technologies GC 6890 N instrument equipped with capillary column BPx70 (length 60 m, internal diameter 0.22 mm, film thickness 0.25 μm). Operation conditions were: helium gas (41 psi); a FID detector at 240°C. The temperature programme was: 3 min at 130°C, an increase to 235°C by 2°C/min; 4 min at 235°C.

The fatty acids were identified via reference material BCR 163 (Beef/Pig Fat Blend). The isomer linoleic acid (CLA) was determined by standard *cis*9, *trans*11 octadecadienoic acid-Larodon AB, Sweden.

Statistical analyses of the data obtained was performed using the SPSS 23.0 packet software (2016), based on a linear model that included the effect of treatment group. In analysis of slaughter value the life body weight at slaughter was included to the model as a covariate. All effects were tested against residual middle-squares to determine the level of significance.

The results are presented as the means of least squares for each trait (*LSM*) and standard deviation (*SD*).

RESULTS AND DISCUSSION

Analysis of the development of body weight showed no differences between the lambs from the control group, the group fed with WBG and the group in which the by-product of the BPM mill industry was used, both in terms of growth rate and fattening time (Table 2). The fattening in all groups lasted 76 days, and the lambs in this period reached almost the same weight. Similarly, Aguilera-Soto et al. (2008) did not register differences in the growth rate between the control group fed without WBG and experimental groups using different levels of supplementation at Rambouillet × Pelibuey ewes, although the growth rate during 90 days of fattening was higher (216 g) compared to the present study. In a study conducted by Hetherington and Krebs (2002) the application in Merino ewes diet 25 and 50% share of waste bakery also had no effect on lowering daily gains. In turn, an increase in the growth rate of lambs fed with the participation of dried brewers' grain (DBG) expressed in daily gains and final body weight was obtained by Anigbogu (2003) and Moges et al. (2008). Better results of final body weight and faster growth of heifers fed by WBG were also obtained by Homm et al. (2008).

The use of WBG and BPM by-products in the diet of tested lambs did not affect the linear measurements made on the hind leg and *longissimus dorsi* muscle (Table 3). Slightly higher value of the hind leg tightness index and a larger area of LD muscle were registered in the BPM group in comparison to other groups and a slightly higher fat thickness measured over LD in the WBG group, but the differences were not statistically significant. The better muscling parameters of the lumbar part both in width and depth of LD muscle was reported by Radzik-Rant et al. (2018) in previous studies conducted on lowland lambs fed with fresh brewers' grain. In turn, Homm et al. (2008) on the carcasses heifers recorded a reduction in the area of the *longissimus* muscle and increased fatness along with an increase in the level of WGB in the diet.

The results of the analysis of slaughter traits and the share of cuts of the

TABLE 2. The fattening performance of lambs from examined groups

Item	Control group		WBG group		BPM group	
	LSM	*SD*	*LSM*	*SD*	*LSM*	*SD*
Initial body weight (kg)	27.76	3.32	28.06	3.61	27.88	3.13
Final body weight (kg)	39.36	2.90	39.84	3.80	39.70	3.96
Fattening period (days)	76.50	7.23	76.50	7.06	76.50	7.21
Average daily gain (g/day)	155.34	23.03	152.63	40.95	156.25	47.96
Total body weight gain (kg)	11.81	1.75	11.60	3.11	11.88	3.65

TABLE 3. The hind leg and LD muscle measurements traits

Item	Control group		WBG group		BPM group	
	LSM	SD	LSM	SD	LSM	SD
Hind leg length (cm)	23.33	1.18	23.40	1.06	23.17	1.50
Hind leg perimeter (cm)	38.63	1.94	38.93	2.24	39.37	1.48
Hind leg tightness index (%)	166.05	12.96	166.61	11.02	170.66	13.60
Fat thickness over LD muscle (mm)	1.14	0.33	1.19	0.36	1.15	0.41
Width of LD muscle (cm)	6.02	0.43	5.97	0.35	5.90	0.38
Depth of LD muscle (cm)	2.49	0.34	2.55	0.42	2.54	0.34
LD muscle area (cm^2)	13.86	2.03	13.89	2.20	13.99	1.97

Hind leg tightness index = (hind leg perimeter/hind leg length) × 100%

tested lamb carcasses are presented in Table 4. The dressing percentage in all groups was at a similar level, although the highest value exceeding 42% was achieved by lambs from the BPM group. The slaughter analysis also did not show differences in relation to the weight and share of individual cuts in lamb carcasses from the control group and experimental groups, except for the rack and hind legs. The content of the rack in the carcass from WBG group was smaller ($P \leq 0.01$) in comparison to the BPM group, and the percentage of hind leg in this group was greater ($P \leq 0.01$) than in the control group and also higher than in the BPM group, although not statistically confirmed (Table 4). The share of valuable cuts remained at the same level in all groups. Thus, it can be concluded that used in fattening by-products of the distillery and milling industry did not have negative impact on obtaining the most desirable commercially parts of carcasses.

The pH of the meat, expressed juice and meat color showed no significant differences between the analyzed groups

TABLE 4. Slaughter and carcass traits

Item		Control group		WBG group		BPM group	
		LSM	*SD*	*LSM*	*SD*	*LSM*	*SD*
Cold carcass weight (kg)		16.88	1.22	16.83	1.55	17.19	1.29
Cold dressing yield (%)		41.70	2.60	41.62	3.24	42.18	2.65
Kidney with fat	(kg)	0.16	0.04	0.14	0.03	0.16	0.03
	(%)	1.89	0.38	1.67	0.38	1.90	0.34
Neck	(kg)	0.71	0.17	0.71	0.13	0.75	0.13
	(%)	8.48	2.03	8.65	1.02	8.66	1.68
Middle neck	(kg)	0.57	0.07	0.53	0.08	0.56	0.05
	(%)	6.76	0.53	6.33	0.81	6.49	0.50
Rib and flank	(kg)	1.35	0.14	1.34	0.12	1.38	0.13
	(%)	16.15	0.75	16.05	0.67	16.07	1.17
Shoulder	(kg)	1.34	0.09	1.32	0.15	1.34	0.10
	(%)	15.70	0.62	15.74	0.60	15.63	0.61
Rack	(kg)	0.50	0.06	0.47	0.08	0.52	0.07
	(%)	5.88^{B}	0.41	5.54^{A}	0.59	6.06^{A}	0.53
Loin	(kg)	0.60	0.11	0.58	0.09	0.64	0.11
	(%)	7.10	1.02	6.91	0.63	7.42	0.85
Hind leg	(kg)	2.31	0.18	2.40	0.24	2.41	0.20
	(%)	27.52^{A}	1.31	28.67^{A}	1.00	28.08^{B}	1.08
Valuable cuts	(kg)	3.40	0.30	3.45	0.39	3.57	0.35
	(%)	40.51	1.34	41.13	1.36	41.55	1.56

Within a row, means denoted with same letters are statistically different a, b $P \leq 0.05$; A, B $P \leq 0.01$.

of lambs. The pH value of the meat was insignificantly lower in the control group. The meat from lambs fed with WBG was characterized by poorer expressed juice and was slightly lighter in color, but the differences were not confirmed statistically (Table 5). Likewise, no difference in the value of the *L** parameter in beef meat derived from animals fed with different amounts of both fresh and dry distillery grains was registered by Roeber et al. (2005). The differences in the research of these authors concerned the *a** and *b** parameters, which were not observed in present studies.

Analysis of the chemical composition of the meat of the studied groups of lambs showed no differences in the content of the tested parameters (Table 6). The content of protein, collagen and water was very similar in all groups, only the share of intramuscular fat was higher in meat of lambs from the WBG group, especially when compared to the BPM, but the differences were not confirmed statistically (Table 6). Similarly, Shand et al. (1998) did not observe differences in the content of basic ingredients in beef meat between the control group and a group of steers in which WGB diet was used. In other studies, the 15% share of maize "Dried Distilers grain with Solubles" DDGS in the concentrate significantly affected the increase in intramuscular fat content (Borzuta et al. 2014). In turn, the use of bakery waste in the diet, regardless of its level, did not change the content of this ingredient in sheep meat of Zandi breed (Afzalzadeh et al. 2007). Although, higher intramuscular fat content may have a positive effect on meat tenderness and its culinary usefulness, most consumers are looking for lean meat.

TABLE 5. The meat quality traits

Item	Control group		WBG group		BPM group	
	LSM	*SD*	*LSM*	*SD*	*LSM*	*SD*
pH_{24h}	5.72	0.50	5.80	0.57	5.89	0.31
Expressed juice (cm^2/g)	11.17	2.84	12.56	4.34	11.03	2.58
Meat color						
Lightness – L*	34.83	2.76	36.30	3.18	35.82	3.64
Redness – a*	17.23	2.69	17.41	2.70	16.15	2.17
Yelowness – b*	1.35	0.99	1.38	1.08	1.35	0.81

TABLE 6. The chemical composition of meat

Item	Control group		WBG group		BPM group	
	LSM	*SD*	*LSM*	*SD*	*LSM*	*SD*
Protein (%)	20.25	0.33	20.31	0.53	20.74	0.94
Collagen (%)	1.31	0.11	1.35	0.16	1.39	0.29
Fat (%)	4.64	1.26	5.06	1.84	4.00	1.14
Moisture (%)	74.53	1.02	74.09	1.37	74.68	0.97

The profile of fatty acids in intramuscular fat was the most favorable in lambs carcasses from the WBG diet group (Table 7). The meat of these animals contained a higher ($P \leq 0.01$) amount of MUFA compared to the BPM group and a higher ($P \leq 0.05$) PUFA also relative to the control group. In the intramuscular fat of lambs from the experimental group fed with the by-products of the

TABLE 7. The fatty acid composition in meat (mg/100 g fat)

The fatty acid	Control group		WBG group		BPM group	
	LSM	*SD*	*LSM*	*SD*	*LSM*	*SD*
C10:0	0.10	0.02	0.11	0.03	0.11	0.02
C14:0	2.00	0.31	2.11	0.48	2.14	0.39
C15:0	0.42	0.05	0.48	0.08	0.43	0.12
C16:0	23.43	0.92	23.51	1.53	23.36	1.43
C17:0	1.64^{A}	0.22	2.11^{AB}	0.20	1.51^{B}	0.60
C18:0	17.83^{a}	1.69	17.63^{ab}	2.70	19.32^{b}	1.64
C20:0	0.09	0.02	0.10	0.04	0.10	0.03
C14:1	0.06	0.01	0.06	0.01	0.06	0.01
C16:1	2.11	0.18	2.10	0.30	2.13	0.31
C17:1	0.77^{A}	0.17	1.01^{AB}	0.16	0.66^{B}	0.25
C18:1n9	38.18^{a}	1.95	39.37^{B}	2.04	36.53^{Ba}	2.92
C18:1n7	1.15	0.12	1.29	0.20	1.03	0.18
C20:1	0.10	0.02	0.09	0.03	0.11	0.02
C18:2n6	3.91^{A}	0.65	4.09^{AB}	1.08	3.18^{B}	0.78
C18:2 *cis*9, *trans*11 (CLA)	0.34^{ab}	0.04	0.38^{ac}	0.06	0.31^{bc}	0.04
C18:3n3	1.81^{a}	0.04	1.86^{B}	0.08	1.77^{Ba}	0.07
C20:3n6	0.08	0.02	0.08	0.03	0.08	0.03
C20:4n6	0.82	0.25	0.85	0.33	0.84	0.25
C20:5n3	0.06	0.01	0.05	0.02	0.05	0.02
C22:5n3	0.10	0.03	0.11	0.04	0.11	0.03
C22:6n3	0.14	0.01	0.14	0.02	0.15	0.01
Σ SFA	45.61^{a}	1.70	46.15^{b}	2.31	47.14^{ab}	2.43
Σ MUFA	46.50^{A}	1.78	46.72^{B}	2.54	44.66^{AB}	2.17
Σ PUFA	7.39^{ab}	0.88	7.68^{ac}	1.44	6.67^{bc}	0.99
Σ n-6	4.81	0.84	5.01	1.38	4.10	0.96
Σ n-3	2.11	0.05	2.16	0.10	2.08	0.08
n-6/n-3	2.27	0.38	2.31	0.52	1.96	0.42
PUFA/SFA	0.16	0.02	0.17	0.03	0.14	0.02

Within a row, means denoted with same letters are statistically different a–c $P \leq 0.05$; A–C $P \leq 0.01$.

milling industry the highest content of SFA ($P \leq 0.05$) was registered. It should be noted, that in the muscle tissue of these lambs a significantly larger share ($P \leq 0.05$) in the group of saturated acids concerned only stearic acid, whose impact on human health is not defined as negative, on the contrary, its bioactivity is compared to bioactivity of polyunsaturated acids (Tholstrup et. al. 1994). The higher content of monounsaturated fatty acids in the group of WBG lambs was determined by the higher ($P \leq 0.01$) content of oleic acid C18:1 *cis*9, and in the group of polyunsaturated acids the higher ($P \leq 0.01$) content of C18:2 *cis*9, 12 and C18:3 *cis*9,12,15 (Table 7). In contrast to these studies, the lower PUFA content and the higher SFA have been determined by Shand et al. (1998) in intramuscular fat of steers fattened with the participation of WBG. Other authors investigate the impact of the use of by-products in the form of maize DGS or sunflower cake on the quality of meat of fattened lambs also noted a significant increase in the content of PUFA and MUFA. However, in the study of these authors, the diet was enriched with flax seeds (Borzuta et al. 2014). Similarly, Dierks et al. (2017), using in the diet DDGS and WDGS also obtained a significant increase in PUFA but in cooked meat. On the other hand, Afsalzadeh et al. (2007) stated that using the by-products of the baking industry did not affect the level of C16:0 content which is one of the main acids from the SFA group, but increased the linoleic acid content in the intramuscular fat of Zandi sheep.

In meat tissue of lambs from the WBG group, except C18:3 *cis*9,12,15 and C18:2 *cis*9,12, a higher ($P \leq 0.05$) content of C18:2 *cis*9, *trans*11 (CLA) isomer compared to the BPM and control group have been recorded (Table 7). This isomer, determined to as rumen acid, prevents atherosclerosis, osteoporosis, stimulates the immune system and also has anticancer properties (Collomb et al. 2006). Higher C18:2 *cis*9, *trans*11 content was also recorded in intramuscular fat of lambs from lowland sheep fed with fresh brewer's grain (Radzik-Rant et al. 2018). The growth of CLA was not recorded by Borzuta et al. (2014) under the influence of the use of DDGS in fattening.

CONCLUSION

On the basis of the conducted research, it can be concluded that the by-products of the brewing and milling industry used in fattening lambs did not negatively affect the development of body weight and slaughter value. These products also did not worse the quality of meat in respect of chemical composition and physical characteristics.

The by-product used in fattening lambs like wet brewer's grain, had a positive effect on the health benefits of meat. The brewer's grain participation in the diet increased the content important for human health monounsaturated and polyunsaturated fatty acids and the isomer C18:2 *cis*9, *trans*11 (CLA).

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Streszczenie: *Wpływ zastosowania ubocznych produktów przemysłu browarnianego i młynarskiego w diecie jagniąt na wzrost masy ciała, wartość rzeźną i jakość mięsa*. Celem badań była ocena tempa wzrostu, wartości rzeźnej i cech jakościowych mięsa jagniąt żywionych z udziałem świeżego młóta browarnianego i produktu ubocznego przemysłu młynarskiego. Badania prowadzono na 45 jagniętach merynosa polskiego, które podzielono na trzy grupy żywieniowe i tuczono do masy ciała 40 kg (±2,0 kg). Jagnięta z grupy kontrolnej były żywione sianem łąkowym, śrutą owsianą i parowanymi ziemniakami. W jednej grupie doświadczalnej (grupa WBG) zastosowano 35% dodatek świeżego młóta browarnianego. Druga grupa doświadczalna (BPM) była żywiona z 44% udziałem produktu ubocznego przemysłu młynarskiego w postaci pokruszonych i uszkodzonych ziaren różnych gatunków zbóż. Uzyskane wyniki wykazały, że produkty uboczne przemysłu browarnianego i młynarskiego wykorzystywane w tuczu jagniąt nie miały negatywnego wpływu na rozwój masy ciała i wartość rzeźną. Zastosowanie tych komponentów nie wpłynęło również na skład chemiczny i cechy fizyczne mięsa. Udział młóta browarnianego w dawce pokarmowej spowodował wzrost ważnych dla zdrowia człowieka jedno- i wielonienasyconych kwasów tłuszczowych oraz izomeru C18:2 *cis*9, *trans*11 (CLA).

Słowa kluczowe: jagnięta, produkty uboczne, wartość rzeźna, jakość mięsa

MS received 27.02.2019

MS accepted 26.04.2019

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