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EFFECT OF YEAST SUPPLEMENTS ON SELECTED HEALTH-PROMOTING PROPERTIES OF LAMB MEAT

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Abstract

The objective of this study was to determine the effect of yeast preparations on selected properties of meat from suckling lambs. The experiment was conducted on 30 Kamieniec rams divided into three groups: I – control, II and III – experimental. Throughout the 100-day rearing period, the experimental animals were fed diets supplemented with *Saccharomyces cerevisiae* prebiotics: Inter Yeast S® brewer's yeast in group II, and Biolex®-Beta S in group III. Fat content was determined by Soxhlet extraction. The fatty acid composition of intramuscular fat was determined by esterification followed by gas chromatography analysis. The content of vitamins A and E was determined by liquid chromatography. A significant increase in the content of fat, cholesterol, and vitamin E was noted in the meat of lambs of group II in comparison with control. The fat of animals in group II contained more fatty acids: C14:1, C18:2, C22:6 ($P \leq 0.05$), and C18:2 n-6 *cis9trans11* ($P \leq 0.01$), and less C20:4 ($P \leq 0.01$). The fat of animals of group III contained more C18:0 and C22:6 fatty acids ($P \leq 0.05$), and less C18:0 ($P \leq 0.05$). The fat in this group had also lower concentrations of MUFA ($P \leq 0.05$), UFA, and, consequently, a lower UFA/SFA ratio ($P \leq 0.05$) in comparison with controls. The yeast-based supplements significantly affected selected health-promoting properties of lamb meat. The applied diet supplements had no significant effect on AI and TI values.

Key words: lambs, prebiotics, lamb meat, fat, fatty acids, cholesterol, retinol, α-tocopherol.

Meat producers are gradually recognising the possibilities offered by foods of high nutritional quality. Lamb meat will have a growing share on the meat market, resulting from popularisation of the research that shows beneficial effects of nutrition on consumers' health. Lamb meat is generally classified as easily digestible, thus, suitable for a healthy diet plan (3, 10). It is known for its specific flavour attributes and health-promoting properties (3, 16). The above qualities can be attributed to the presence of protein with high biological value (5) and a desirable fatty acid profile of intramuscular fat (4, 5). Lamb meat is also a rich source of minerals, vitamins, and functional components that significantly contribute to consumer health (16). The quality of lamb meat is largely determined by the animals' genotype (3, 10, 26), whereas its health attributes depend mainly on the applied nutritional factors. In general, the higher the share of natural feed ingredients in lambs diet, the higher the quality of the end product (20, 25).

However, the use of this kind of feed results in a slower growth rate of lambs, which reduces production effectiveness. Natural supplements are introduced to diets to stimulate animals growth. Diet supplements containing *Saccharomyces cerevisiae* yeast, dried with the application of a special processing technology, are easy to distribute and use, and they pose a viable alternative for meat producers. The stimulating effect of dried yeast on the performance of suckling lambs has been demonstrated by Milewski *et al.* (17, 18). In the above studies, the use of prebiotic yeast supplements, including Inter Yeast® S, Biolex® HP and Biolex® - MB40, was shown to stimulate lamb development and muscle growth. However, these experiments did not take into account the effect of yeast on the nutritional quality of lamb meat. Therefore, the objective of the present study was to determine the effect of *Saccharomyces cerevisiae* dried brewers' yeast and β-1,3/1,6-D-glucan extracted from yeast on selected health-promoting properties of meat from suckling lambs.

Material and Methods

The experimental material comprised 30 single-born rams of the Kamieniec, the offspring of 3-year-old ewes, born in the second half of January. The lambs were divided into three equal groups: I - control, II and III – experimental, based on body weights determined on the second day of their life.

Throughout the 100-day rearing period, all lambs were fed identical diets comprising meadow hay, hay-silage of grass and legumes, and CJ concentrate. Nutritive value of feeds, in INRA units system (12), were calculated using a computer programme WINWAR. Dry matter content in hay silage, meadow hay, and CJ concentrate was: 44.20%, 83.85%, and 88.56% respectively. UFV and crude protein concentration in feed were 0.8 and 181.86 g in hay silage, 0.69 and 89.38 g in meadow hay, and 1.11 and 169.30 g in CJ concentrate, respectively. The mothers of lambs were subjected to the same dietary regime. Young rams were fed in groups beginning from the 11th d of age. The animals from the experimental groups were fed CJ concentrate with the addition of *Saccharomyces cerevisiae* prebiotics: Inter Yeast S® dried yeast in the amount of 50 g/kg of feed in group II, and Biolex® - Beta S, containing approximately 70% β-1,3/1,6-D-glucan, in the amount of 3 g/kg of feed in group III. CJ concentrate doses were increased every 10 d by 0.05 kg/animal/day, starting from 0.05 kg/animal/day on days 11-20.

The quantity of the administered feed and leftovers was monitored throughout the experiment, and their chemical composition was analysed with the use of standard methods (2) to determine nutrient intake throughout the experimental period. Similar values were noted in all groups (Table 1), indicating that identical feeding standards were successfully maintained.

Lambs were slaughtered at the age of 100 d. Their average body weight at the end of experiment was 23.55 kg in group I, 28.65 kg in group II, and 28.63 in group III. Samples for meat quality assessment were collected from the *quadriceps femoris* muscle of the right leg after 18-24 h of carcass chilling at 4ºC. The following parameters were determined: the content of intramuscular fat, cholesterol, vitamins A (retinol) and E (α-tocopherol), fatty acid profile of intramuscular fat, values of the atherogenic index (AI), and thrombogenic index (TI). Fat content was determined by Soxhlet extraction. The fatty acid composition was determined by esterification followed by gas chromatography using a VARIAN CP-3800 chromatograph. Separation parameters were as follows: flame ionisation detector FID, capillary column - length: 50 m, internal diameter: 0.25 mm, liquid phase - CP-Sil 88, film thickness - 0.25 μm, carrier gas - helium, flow rate - 1.2 mL/min. The cholesterol content was determined enzymatically with cholesterol peroxidase (23), using Pointe Scientific test kits. The value of AI and TI was calculated based on the formulas proposed by Ulbricht and Southgate (23): IA = ($C_{12:0}$ + 4$C_{14:0}$ + $C_{16:0}$)/(PUFA n-3 + PUFA n-6 + MUFA); IT = ($C_{14:0}$ + $C_{16:0}$ + $C_{18:0}$)/(0,5MUFA + 0,5PUFA n-6 + 3PUFA n-3 + PUFA n-3/PUFA n-6).

The content of vitamins A and E was determined by the method of Hewavitharana *et al.* (11), using retinol and α-tocopherol standards (Sigma). Retinol and α-tocopherol levels were determined by RP-HPLC with the use of a Nucleosil C_{18} (250 mm x 4 mm) column, with a water-methanol solution (95:5, v/v) as the carrier phase. Retinol concentrations were determined using a UV detector (336 nm), and α-tocopherol levels were measured with the use of a fluorescence (FL) detector (Ex 293 nm, Em 326 nm).

The results were processed statistically by one-way analysis of variance in an orthogonal design. The significance of differences between groups was verified with Duncan's test using Statistica 8.0 StatSoft Inc. software.

Table 1
Total nutrient intake per group in the investigated period

Specification	Group		
	I	II	III
DM - dry matter (kg)	529.48	529.49	529.25
UFV - feed unit for meat production	393.92	394.12	394.01
CP - crude protein (kg)	65.11	65.09	64.99
PDIE (kg)	43.04	42.85	42.94
PDIN (kg)	40.64	41.24	40.83
CF - crude fibre (kg)	113.05	112.85	113.15

PDIN, PDIE: protein digestible in the small intestine when rumen fermentable nitrogen or energy, respectively, are limiting.

Table 2
Content of fat, cholesterol, and vitamins A and E in lamb meat

Specification	Group					
	I (n=10)		II (n=10)		III (n=10)	
	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
Fat (%)	2.03^{B}	0.12	2.43^{A}	0.41	2.03^{B}	0.18
Cholesterol (mg/100 g of meat)	39.78^{B}	11.99	54.68^{A}	7.47	39.31^{B}	6.01
Vitamin A (μg/100 g of meat)	38.47	10.74	43.23	18.13	33.98	9.68
Vitamin E (μg/100 g of meat)	15.79^{b}	6.13	20.93^{Aa}	5.38	12.47^{B}	2.35

A, B - P≤0.01, a, b - P≤0.05; $\overline{x}$ - arithmetic mean; SD - standard deviation.

Table 3
Fatty acid composition of intramuscular fat (%)

Specification	Group					
	I (n=10)		II (n=10)		III (n=10)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
$C_{10:0}$	0.29	0.08	0.29	0.10	0.33	0.08
$C_{12:0}$	0.76	0.25	0.74	0.27	0.82	0.22
$C_{12:1}$	0.02	0.01	0.03	0.01	0.02	0.01
$C_{14:0}$	5.77	1.23	6.14	1.15	6.13	0.81
$C_{14:1}$	0.19^{b}	0.04	0.23^{a}	0.04	0.19^{b}	0.03
$C_{15:0}$	0.72	0.08	0.71	0.11	0.74	0.08
$C_{16:0}$ izo	0.23	0.03	0.25	0.02	0.24	0.01
$C_{16:0}$	26.0	1.83	25.98	1.64	26.34	1.18
$C_{16:1}$	1.40	0.21	1.52	0.16	1.38	0.16
$C_{17:0}$	1.31	0.07	1.30	0.06	1.29	0.08
$C_{17:1}$	1.07	0.10	1.13	0.05	1.12	0.22
$C_{18:0}$	15.63^{b}	1.10	15.58^{b}	0.62	17.10^{a}	1.44
$C_{18:1}$	39.76^{a}	1.35	39.26^{a}	3.48	36.46^{b}	1.88
$C_{18:2}$ n-6	4.35	0.66	4.15	0.47	4.35	0.56
$C_{18:2}$ n-6 *cis9trans11* (CLA)	0.10^{B}	0.07	0.18^{Aa}	0.04	0.12^{b}	0.03
$C_{18:3}$ n-3	0.89	0.16	0.87	0.10	0.84	0.10
$C_{20:0}$	0.17	0.06	0.14	0.02	0.17	0.01
$C_{20:1}$	0.11	0.02	0.11	0.03	0.11	0.01
$C_{20:2}$ n-6	0.03	0.02	0.04	0.01	0.03	0.01
$C_{20:4}$ n-6	1.34	0.94	1.00^{b}	0.40	1.43^{a}	0.41
$C_{20:5}$ n-3	0.21	0.13	0.17	0.09	0.24	0.08
$C_{22:0}$	0.13	0.06	0.09^{b}	0.02	0.14^{a}	0.04
$C_{22:6}$ n-3	0.11^{b}	0.06	0.14	0.06	0.18^{a}	0.07

A, B - P≤0.01, a, b - P≤ .05; $\bar{x}$ - arithmetic mean; SD - standard deviation; CLA - conjugated linoleic acid.

Table 4
Fatty acid profile of intramuscular fat with AI and TI values

Specification	Group					
	I (n=10)		II (n=10)		III (n=10)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
SFA (saturated fatty acids)	50.99	3.58	51.23	2.87	53.30	2.17
MUFA (monounsaturated fatty acids)	42.56^{a}	1.48	42.26^{a}	3.45	39.28^{b}	1.97
PUFA (polyunsaturated fatty acids)	7.02	1.55	6.53	1.08	7.20	1.04
UFA	49.57^{a}	1.71	48.79	2.88	46.48^{b}	2.02
n-6 PUFA	5.81	1.32	5.36	0.87	5.94	0.85
n-3 PUFA	1.10	0.28	1.03	0.18	1.08	0.17
DFA (UFA + $C_{18:0}$)	65.20	1.54	64.37	3.08	63.59	1.93
OFA (SFA – $C_{18:0}$)	35.36	3.31	35.65	3.07	36.20	2.22
UFA/SFA	0.98^{a}	0.10	0.96	0.11	0.87^{b}	0.07
PUFA/SFA	0.14	0.04	0.13	0.02	0.14	0.02
n-6/n-3 PUFA	5.42	1.05	5.23	0.47	5.51	0.54
DFA/OFA	1.86	0.21	1.83	0.25	1.77	0.17
AI (atherogenic index)	1.01	0.16	1.06	0.19	1.12	0.14
TI (thrombogenic index)	1.72	0.19	1.77	0.17	1.91	0.17

a, b - P≤0.05; $\bar{x}$ - arithmetic mean; SD - standard deviation; DFA - dietary fatty acids with a desirable (neutral or hypocholesterolemic) effect on humans; OFA - dietary fatty acids with an undesirable (hypercholesterolemic) effect on humans.

Results

The content of fat, cholesterol, and vitamins in the analysed lamb meat is presented in Table 2. The highest values of the compounds were noted in rams fed a diet supplemented with dried brewers' yeast (group II). In comparison with the meat of controls and experimental group III, significant differences were observed regarding fat, cholesterol ($P \leq 0.01$), and vitamin E concentrations. The meat of lambs, whose diets were supplemented with β-1,3/1,6-D-glucan (group III), showed no significant differences in comparison with controls, but lower vitamin concentrations were observed. The most notable difference was reported in respect of vitamin E, and these differences between experimental groups were statistically significant ($P \leq 0.01$).

Diet supplementation led to changes in the fatty acid composition of intramuscular fat (Table 3). The intramuscular fat of meat from lambs of group II had higher concentrations of fatty acids $C_{14:1}$, ($P \leq 0.05$) as well as $C_{18:2}$ n-6 *cis9trans11* ($P \leq 0.01$), and a lower content of $C_{20:4}$, $C_{22:0}$ ($P \leq 0.05$). The intramuscular meat fat of lambs from group III contained larger amounts of fatty acids $C_{18:0}$ and $C_{22:6}$ ($P \leq 0.05$), and smaller quantities of $C_{18:1}$ ($P \leq 0.05$). The above changes affected the fatty acid profile of the studied meat (Table 4), but significant differences were reported only in group III. The fat of group III animals was characterised by lower concentrations of MUFA and UFA ($P \leq 0.05$), and consequently, a lower UFA/SFA ratio ($P \leq 0.05$) in comparison with control group.

Discussion

Saccharomyces cerevisiae yeast is characterised by a broad spectrum of activity in the body. It is a rich source of nutrients as well as components with immunomodulative, anti-toxic, and anti-microbial properties (6, 15). The effect of yeast on the quality of lamb meat has been demonstrated by Titi *et al*. (21), who observed significant changes in the chemical composition of meat from lambs fed the Diamond V XP supplement containing live cultures of *Saccharomyces cerevisiae* yeast and their metabolites. These authors noted higher fat levels and lower protein levels in the studied meat samples. They attributed the observed changes to the probiotic effect of yeast, which stimulates the growth of cellulolytic bacteria in the rumen, thus modifying ruminal fermentation and the metabolism of its end products. Similar effects have been demonstrated by Erasmus *et al.* (8), who noted a transition from acetic acid to propionic acid fermentation in cattle fed yeast-supplemented diet. Abd El-Ghani (1) has suggested that yeast contributes to the effectiveness of ruminal fermentation. In a study on goats, the above author reported a significant increase in volatile fatty acid concentrations in ruminal fluid, and the milk of goats fed yeast supplements was characterised by an increased fat content and a decreased protein content. The results of our study can be attributed to the prebiotic qualities of yeast, which are a rich source of substances that activate the immune system. The stimulating effect of diet supplements containing *Saccharomyces cerevisiae* yeast on immune parameters has been demonstrated in a study on lambs (15, 18, 19) and nursing ewes (17). β-1,3/1,6-D-glucan and mannanooligosaccharides (MOS), structural components of the yeast cell wall, eliminate or inhibit the growth of pathogenic bacteria, leading to a considerable improvement in lamb health and, consequently, their productivity. The exact mechanism of yeast's effects on the quality of the end product is, however, complex and difficult to determine. It is believed that yeast induces significant structural changes in the populations of ruminal bacteria by increasing the share of protozoa and decreasing the share of selected bacterial groups (8). These changes affect metabolic processes, as demonstrated by a study on lactating ewes, whose metabolism was considerably stimulated by a diet supplemented with *Saccharomyces cerevisiae* dried yeast (17). The above results could be attributed to an increase in MOS levels, which accompanies the yeast drying process. MOS are precursors of volatile fatty acids that increase metabolic parameters. The above hypothesis could explain higher fat levels in the meat of lambs fed the Inter Yeast S supplement. An increase in the content of intramuscular fat, which cannot be removed during culinary processing, could have a negative influence on consumers' perception (21). It should be noted, however, that low fat levels have an adverse effect on the sensory properties of meat. Higher fat content increased the levels of fat-soluble vitamins A and E. This is a desirable trend because carotenoids and tocopherols are vital antioxidants. Vitamins A and E are powerful hydrophobic antioxidants and free radical scavengers. Elevated cholesterol concentrations in the studied meat could also be attributed to high levels of fat, the main cholesterol carrier (21). Honikel (10) observed a positive correlation between the above parameters. His hypothesis has been validated by Brzostowski and Tański (5). Results of their studies indicate that genotype influences the correlation between the analysed traits, but the observed effects are ambiguous. In a comparative study on five sheep breeds Borys and Borys (3) noted significant variations in the concentrations of intramuscular fat, but cholesterol levels were similar in all of the examined meat samples. Brzostowski *et al.* (4) compared the meat of 100- and 180-day-old Skudde lambs to reveal significant variations in cholesterol concentrations despite similar meat fat levels. In a study investigating the quality of meat from Dorset Cross lambs, Kosulwat *et al*. (13) found that cholesterol levels decreased with an increase in the fat content.

The fatty acid profile noted in this study indicates that the intramuscular fat of rams fed the Biolex Beta S supplement was characterised by significantly lower MUFA concentrations. This resulted in a significant decrease in UFA levels as well as a drop in the UFA/SFA ratio, which is undesirable from the point of view of nutritional quality (21, 24, 25). Nonetheless, the noted changes had no significant effect

on the PUFA/SFA ratio, the DFA/OFA ratio, or AI and TI values. According to Ulbricht and Southgate (23), AI and TI values are more reliable indicators of atherogenicity and thrombogenicity than the PUFA/SFA ratio. Not all SFA are hypercholesterolemic, and in addition to PUFA, MUFA also demonstrate protective activity, although to a smaller extent. $C_{12:0}$, $C_{14:0}$, and $C_{16:0}$ are atherogenic fatty acids, which increase the plasma levels of total cholesterol and LDL- cholesterol, whereas $C_{14:0}$, $C_{16:0}$,and $C_{18:0}$ are thrombogenic fatty acids that stimulate blood platelet activity and aggregation. n-6 PUFA exhibit potent antiatherogenic activity by reducing blood plasma lipids, whereas the antithrombogenic effects of n-3 PUFA involve the reduction of blood platelet activity. The obtained values of AI and TI could suggest a decrease in the nutritional quality of lamb meat as a result of diet supplementation with β-1,3/1,6-D-glucan, but the above observations were not confirmed by statistical analysis. In our study, AI and TI values were higher than those reported by Zapletal *et al*. (25), and the cited authors attributed their findings to genotype effects.

The results of this study indicate that the yeast supplements included in diets fed to lambs had a significant effect on selected health-promoting properties of meat. The addition of *Saccharomyces cerevisiae* Inter Yeast® S increased the content of intramuscular fat, cholesterol, and vitamin A in the analysed meat. Biolex Beta S contributed to a decrease in MUFA levels in intramuscular fat, with a trend towards higher saturation.

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