MEAT QUALITY OF LAMBS FEED DIETS ENRICHED WITH FISH AND RAPESEED OILS, CARNOSIC ACID AND SELENO-COMPOUNDS

Przybylski W.[1], Jaworska D.[1] and Czauderna M.[2]

[1] Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences, 02-776 Warszawa, Poland

[2] The Kielanowski Institue of Animal Physiology and Nutrition – Polish Academy of Sciences, 05-110 Jabłonna, Poland

Abstract – The aim of the study was to evaluate the meat quality of lambs feed diets enriched with fish and rapeseed oils, carnosic acid and selenium. Lambs were feed with five types of diet: 0 – basal diet with 3% rapeseed oil (RO); 1 - control Group K: BD with 2% RO and 1% FO (fish oil); 2 - Experimental Group (CA): BD with 2% RO, 1% FO and 0.1% carnosic acid (CA); 3 -Experimental Group (CA+SeY): BD with 2%; RO, 1% FO, 0.1% CA and 0.35 ppm Se as SeY; 4 -Experimental Group (CA+SeVI): BD with 2% RO, 1% FO, 0.1% CA and 0.35 ppm Se as SeVI. The results showed significant differences between group in ultimate pH, meat color parameters, water, collagen and protein content. Sensory quality in studied groups also differs significantly. Group 1 characterized meat with higher pH and lower juiciness, tenderness and overall quality. In relations to sensory quality this group similar to group 4. On the basis of results for group 2 and 3 could be stated that CA improved lamb quality.

Key Words – diet supplementation, lambs, meat, sensory quality

I. INTRODUCTION

Meat quality includes many factors containing palatability, water-holding capacity, color, and nutritional value and it can be affected by the genetics, the production and processing environment. The dietary nutrition of animals can impact on meat quality by optimizing the intrinsic and extrinsic characteristics of muscle. The nutritional characteristics of diets (e.g.: protein, fatty acids, energy, vitamins and minerals) all can impact on value-adding properties of meat and therefore meat quality. Currently a special attention has been paid to supplementation in phenolic compounds, some of which (e.g. carnosic acid) which have the ability to modify ruminal microbiota and hence fatty acid metabolism in the rumen [5]. Dietary carnosic acid (CA) did not modify the profile composition of fatty acids (FAs) but had a significant influence on the biosynthesis of volatile compounds (like volatile fatty acids). Moreover, recent studies with CA have documented improvements in meat quality [3- 5]. Supplementing CA to the rations of lambs would change the profile of volatile fatty acids (VFAs) in ruminal fluids as well as the profile of FAs in lamb muscles. Interestingly, recent studies have established that CA (the diterpenic phenol possessing antioxidative properties) protected unsaturated fatty acids (UFAs) from peroxidation damage [1, 2]. Thus, this protective effect of dietary CA on the deposition of FAs, especially polyunsaturated fatty acids (PUFAs), in the body of ruminants may also be plausible. Moreover, we expected that dietary selenized yeast (SeY), selenate (SeVI) and especially CA would change the capacity of the biohydrogenation of UFAs in the rumen, consequently, the accumulation of PUFAs, particularly conjugated isomers of linoleic acid (CLA) and theirs precursors, in lamb muscles. Interestingly, positive correlations were observed between dietary contents of Se and concentrations of UFAs in tissues of animals [6]. Thus, the aim of our study was to evaluate the meat quality of lambs feed a diet supplemented with fish and rapeseed oils, CA, SeVI and SeY.

II. MATERIALS AND METHODS

Materials. Thirty male Corriedale lambs with an average body weight (BW) of 30.5±2.6 kg at the beginning of the experiment were individually penned and divided into 5 treatment groups of 6 lambs. During a 2-week preliminary period the animals were given free access to the standard concentrate-hay diet with vitamins and mineral premix. This basal diet contained: crude protein 120 g, crude fiber 12 g, and 11 MJ metabolizable energy in 1 kg dry mater. The three-week adaptation period was used. In this time the animals were fed *ad libitum* the basal diet consisting of: meadow hay (~36%) and a meaty mixture consisting of soybean meal

(~36%) and barley (~16.5%), wheat starch (~9%) and mineral-vitamin (20 g/kg diet). The basal diet contained: crude protein – 120g/kg DM, crude fiber - 120 g/kg DM and to provide metabolic energy: 11 MJ/kg DM. The basal diet (BD) was enriched with 3% rapeseed oil (RO) (0 – Extra group "ZERO") or 2% RO and 1% fish oil (FO) (Groups 1, 2, 3 and 4).

After a three-week of adaptation period, lambs were fed during five weeks with five types of diets:

0 - Extra Group "ZERO": BD with 3% RO;
1 - Control Group K: BD with 2% RO and 1% FO;
2 - Experimental Group (CA): BD with 2% RO, 1% FO and 0.1% carnosic acid (CA)
3 -Experimental Group (CA+SeY): BD with 2% RO, 1% FO, 0.1% CA and 0.35 ppm Se as SeY;
4 -Experimental Group (CA+SeVI): BD with 2% RO, 1% FO, 0.1% CA and 0.35 ppm Se as SeVI.

Methods. The animals were slaughtered in experimental slaughterhouse after 12-hour starvation. Before bleeding the animals were deprived of consciousness by intramuscular administration of xylazine (2-4 mg / 10 kg body weight). After slaughter and cooling carcasses was taken the *Longissimus thoracis* muscle for analyses. Value of pH was measured with a WTW-330i pH-meter in 48 h after slaughter. Meat colour, in CIE L* a* b* system, using a CR310 Minolta chromameter (Osaka, Japan) at 48 h post mortem was measured. Meat composition (water, fat, protein and connective tissue content) was determined using a near-infrared spectrometer NIRFlex N-500 (Büchi). Measurements were conducted using a NIRFlex Solids module of spectral range 12,500-400 cm^{-1} in reflectant mode. A sensory quality of meat (96 hours after slaughter) after heat treatment was determined. For sensory assessment, the sensory QDA method [7] was used; an unstructured, linear graphical scale; a 100 mm than converted to numerical values (0-10 conventional units c.u.) The marks of anchors of the tested attributes were as follows for most of them: no intensity – high intensity, for tenderness (tough – tender) and juiciness (dry – juicy). The trained 10-person assessing panel [8] was experienced (3–8 years of sensory evaluation practice), with good command of sensory methodology and familiarity with the sensory quality of meat and meat products.

The results were statistically elaborated by using Statistica Ver. 10 software. One way analysis of variance was applied and differences between means were calculated by NIR test. Between the measured traits correlation coefficients were calculated. Sensory quality was also analyzed by PCA analysis.

III. RESULTS AND DISCUSSION

The analysis of obtained data indicated that meat from group 0 (feed with 3% rapeseed oil) characterized by lowest value of pH_{48} whereas group with FO addition by highest pH_{48} (tab. 1). Not significant differences were found between other groups. Color parameters differ significantly in dependency on diet in every group of meat. The lightest meat was observed in 2 and 3 group (with fish oil, CA and SeY in the diet). In relation to a and b parameters the meat from group 0 was more red and yellow. It was also found significant differences in water, protein and collagen content. Groups 0 and 1 characterized by lower water, medium protein and higher collagen content. The higher water content and lower protein content was observed in the groups of 2 and 3 (i.e., the diets with FO, CA and SeY).

Table 1. Meat quality and chemical composition of *longissimus thoracis* muscle in studied group of lambs

	Group				
	0	1	2	3	4
pH_{48}	5.4b	5.6c	5.5a	5.5a	5.5a
L	44.0a	43.5a	46.6b	46.6b	43.3a
a	23.3d	19.3a	20.9b	20.2ab	17.6c
b	9.5c	4.3a	7.3b	6.7b	4.2a
Water (%)	74.2c	74.5bc	75.2a	75.1a	74.7ac
Fat (%)	2.5	2.5	2.1	2.4	2.0
Protein (%)	22.2b	22.2b	21.6a	21.5a	22.6c
Ash (%)	1.1	1.1	1.1	1.1	1.2
Collagen (%)	1.3a	1.3a	1.2a	1.2a	1.0b

a,b – the means are significantly different at $P_{\alpha} \leq 0.05$

Interestingly, independently of the diet, the studied meat samples did not differ in fat content. The lowest level of collagen and highest protein content was observed in lambs fed the experimental diet containing RO, FO, CA and SeVI (Experimental Group: CA+SeVI).

The characteristic of tested sensory attributes in relation to different diet are presented in Table 2. The obtained results indicated that the diet

supplementation influenced statistically fatty odor and flavor as well as tenderness and juiciness. Also the applied diet had a significant impact on acid flavor and attribute called "other" and "salty" taste. Different intensity of chosen traits resulted in significant differential overall sensory quality of tested meat samples.

Table 2. Sensory quality of *longissimus thoracis* muscle in studied group of lambs

	Group				
	0	1	2	3	4
cooked o.	7.7	8.0	7.9	7.7	8.0
acid o.	2.4	2.0	2.0	2.0	2.3
fatty o.	2.6c	2.0a	2.4abc	2.2ab	2.4bc
other o.	1.7	1.6	1.7	1.7	2.1
Tone of c.	6.0	5.7	6.2	6.5	6.2
C. homog.	6.0ac	4.4bc	6.6c	6.5c	3.7b
tenderness	7.0b	4.8a	6.4ab	6.7b	4.8a
juiciness	5.2ac	3.5bc	6.1a	5.9a	3.3b
cooked f.	8.0	8.1	8.1	8.1	8.1
acid f.	2.3a	1.8b	1.8b	1.9b	2.0b
fatty f.	2.3c	1.8a	2.0abc	1.9ab	2.2bc
salty t.	1.8a	1.5b	1.5b	1.5b	1.6b
other f.	1.5a	1.4a	1.4a	1.5a	1.8b
overall quality	7.0a	5.3b	6.7a	6.8a	4.7b

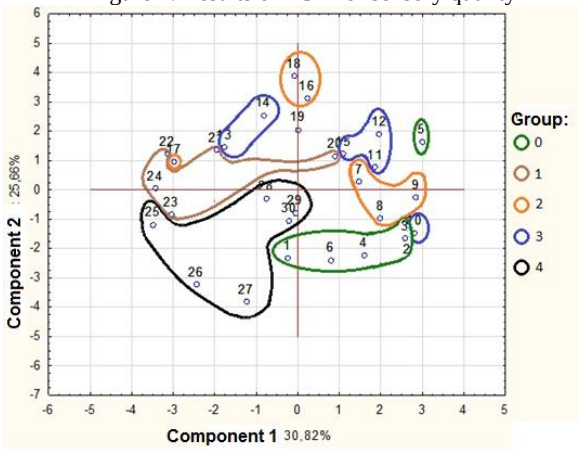
a,b – the means are significantly different at $P_{\alpha} \leq 0.05$; c – colour, o – odour, f – flavour, t - taste

The highest sensory quality characterized meat from lambs which were fed by the basal diet with only 3% RO. The lower juiciness, tenderness and overall quality characterized meat samples coming from lambs fed the diets containing RO and FO (group 1) and fed the experimental diet containing RO, FO, CA and SeVI (group 4). The same relationship was observed for color homogeneity. Regarding on these abovementioned traits group 0, 2 and 3 were not significantly different. In relation to fatty odour and flavour they are not differences between group 0, 2 and 4. Group 0 was different from others in acid flavour and salty taste as group 4 in other flavour.

Principal component analysis showed that each group has its specific sensory profile. Group 0, 1 and 4 were rather homogeneous, in group 2 and 3 were observed some variation (Fig. 1).

In conclusion it should be noted that group 1 (feed with FO) characterized by higher ultimate pH, collagen content and lower juiciness, tenderness and overall quality. In relations to meat color parameters and sensory quality this group was similar to control (0) or 4 wit FO, CA and SeVI (this group had highest protein and lowest collagen content). In contrast group 2 and 3 (both with FO, CA and latest with SeY) were similar in muscle chemical composition, meat color, pH and sensory quality.

Figure 1. Results of PCA for sensory quality



The mechanisms that underlie the effects of diet on the sensory attributes of lamb meat are complex and not fully understood. The differences in sensory characteristics of ruminant meat are mediated by factors related animal characteristics as growth rate, carcass leanness, animal age, muscle fat content and composition which are in turn influenced by the diet [9]. Some studies shown that fish oil in lamb diet increases concentrations of long chain PUFA in meat and abnormal flavous while in others did not affect the sensory or other meat quality traits [9]. In the present study, there was no effect of dietary FO for taste and odor lamb meat. Kowalska [10] showed significant effect of fish oil in diet of rabbit on fat and water content and texture of meat. Kupczyński [11] stated that fish oil in cows diet caused a reduction in blood glucose. This may be partly consistent with the presented results as in group 1 (with FO) was observed higher pH, which may be associated with low levels of glycogen.

Recently special attention has been paid to study to effect of carnosic acid on meat quality [3, 4, 5]. Morán et al. [4] showed a significant effect for crude protein content and protection of meat before discoloration after a long period of time under MAP at refrigerated storage or not effect for sensory traits. In other study Morán et al. [3] received a positive effect

of CA on meat texture. It differs from results presented in table 1 but probably effect of CA is related to form of Se in diet and FO. Nevertheless, in relations to meat color and meat texture traits evaluated by sensory panel can be observed positive effect of CA in group 2 and 3 in comparison to group 1 (FO) (tab. 1 and 2). These results are agree with work of Bañón et al. [12] and Ortuño et al. [13] in relations to color parameters. Interesting results were observed with regard to effect of form of Se in the diet of lambs on chemical composition and sensory quality of meat. There are differences between the groups 3 and 4, in relations to source of Se (organic – SeY or inorganic - SeVI). Se originated from inorganic source affected significantly total protein and collagen content and also decreases sensory quality. Ponnampalam [12] reported that in cattle Se-yeast improved tenderness color of meat or increased the lightness of lamb meat following vacuum packaging. However other studies show Se supplementation did not affect meat color in veal and lamb. Se contributions to meat pH and WHC have been found insignificant [12].

IV. CONCLUSION

The results showed significant differences between group in ultimate pH, meat color parameters, water, collagen and protein content. Sensory quality in studied groups also differs significantly. On the basis of results could be stated that FO decreased as well as CA improved lamb quality.

ACKNOWLEDGEMENTS

We thank A. Rozbicka-Wieczorek, E. Więsyk, K. Krajewska-Bienias and J. Michalski for technical help. This study was in part supported by the State Committee for Scientific Research, Grant No. 3 PO6Z 034 22.

REFERENCES

1. Hernández-Hernández E., Ponce-Alquicira E., Jaramillo-Flores M.E., Guerrero Legarreta I., 2009. Antioxidant effect rosemary (*Rosmarinus officinalis L.*) and oregano (*Origanum vulgare L.*) extracts on TBARS and colour of model raw pork batters. Meat Sci. 81: 410-417
2. Jordan M.J., Lax V., Rota M.C., Loran S., Sotomayor J.A., 2013. Effect of the phenological stage on the chemical composition, and antimicrobial and antioxidant properties of *Rosmarinus officinalis* L essential oil and its polyphenolic extract. Ind. Crop. Prod. 48: 144–152
3. Morán L., Andrés S., Bodas R., Prieto N., Giráldez F.J., 2012a. Meat texture and antioxidant status are improved when carnosic acid is included in the diet of fattening lambs. Meat Sci. 91: 430–434
4. Morán L., Rodríguez-Calleja J., Bodas R., Prieto, N., Giráldez F.J., Andrés S., 2012b. Carnosic acid dietary supplementation at 0.12% rates slows down meat discolouration in gluteus medius of fattening lambs. Meat Sci. 90: 789–795
5. Morán L., Giráldez F.J., Panseri S., Aldai N., Jordán M.J., Chiesa L.M., Andrés S., 2013. Effect of dietary carnosic acid on the fatty acid profile and flavour stability of meat from fattening lambs. Food Chem. 138: 2407-2414
6. Ortman K., Andersson R., Holst M., 1999. The influence of supplements of selenite, selenate, and selenium yeast on the selenium status of dairy heifers. Acta Vet. Scand. 40: 23-34
7. ISO 13299.2:1998. Sensory analysis–methodology–general guidance for establishing a sensory profile.
8. ISO 8586-2:1996. Sensory analysis. General guidance for the selection, training and monitoring of assessors part II – Experts.
9. Ponnampalam E.N., Holman B.W.B., Kerry J.P., 2015. The impact of animal nutrition on muscle composition and meat quality. In The Effect of Genetic and Environmental Factors on the Quality of Meat, pp. *in press*, (Ed Przybylski, W. and Hopkins, D.L.), CRC Press, Taylor & Francis Group, USA.
10. Kowalska D., 2011. Enrichment of rabbit meat with unsaturated fatty acids and vitamins and prevention of oxidation processes (in polish). Rocz. Nauk. Zoot. 38: 227-243.
11. Kupczyński R., 2012. Influence of fish oil on fatty acids profile of milk, biochemical paramatares of blood and productive coefficiens in dairy cows. Wrocław University of Environmental and Life Sciences Press, pp. 1-89.
12. Bañón S., Méndez L., Almela E., 2012. Effects of dietary rosemary extract on lamb spoilage under retail display conditions. Meat Sci. 90: 579-583.
13. Ortuño J., Serrano R., Jordán M.J., Bañón S., 2014. Shelf life of meat from lambs given essential oil-free rosemary extract conatining carnosic acid plus carnosol at 200 or 400 mg $kg^{-}1$. Meat Sci. 96: 1452-1459.