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ANIMAL SCIENCE

The Effect of Corn and Wheat Glutens Fed to Lambs on Some Microbial and Chemical Properties of Musculus Longismus Dorsi and Determination of Intramuscular and Tail Fatty Acid Profile

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Abstract: This study examined the effects of wheat and corn gluten added to lamb diets as a unilateral protein source on some microbial and chemical properties of *Musculus Longismus dorsi* (LD), determination of intramuscular and tail fat profile. It was found that TBARS levels in LD muscle on the days of storage were highest in the wheat gluten-treated groups ($p<0.01$). It was found that the changes in pH values in LD muscle were different on days ($p<0.05$). It was found that the change of L*, a ve b values on days differed between groups during the storage period ($p<0.05$). It was found that the numbers of TMAB, *Enterobacteriaceae*, *Lactobacillus* spp., *Pseudomonas* spp. and TPAB changed significantly ($p<0.05$) during the storage process. While a significant difference was found between the MUFA levels of dorsal muscle intramuscular adipose tissue of the groups ($p<0.05$). As a result, it was determined that the metabolic differences of the one-way protein sources fed to the lambs in the digestive system and other organs had an effect on the meat quality, intramuscular fat and fatty acid profile of the tail.

Key words: *Musculus Longismus dorsi,* meat quality, fatty acid, MUFA, PUFA.

INTRODUCTION

Meat yield and the quality of animals depend on many factors. These factors include age, sex, environmental conditions, breed, and diet. It is well known that the nutrient content of the ration, chemical components of the feed, and additives play an important role in nutrition (Santos-Silva et al. 2002, Ye et al. 2020). Barley, wheat, and corn are now intensively used as energy sources in ruminant diets. On the other hand, soybean meal is widely used as a protein source in animal feed (Fahmy et al. 1992, de Morais et al. 2021). Recently, corn gluten and safflower meal have also been used (De Oliveira et al. 2021). However, there are no studies on the use of wheat gluten. Wheat gluten is known to cause various health problems in some creatures, especially celiac disease (Cabanillas 2020). These health problems result from the inability of these living beings to metabolize wheat gluten (Gumus et al. 2021, Imik et al. 2022). These health problems are likely the reason that wheat gluten has not been adequately researched in livestock.

Ruminants digest a large portion of the carbohydrates and proteins in the feed they eat in their anterior digestive organs. They ferment carbohydrates in the rumen and convert them into short-chain fatty acids. They then metabolize them and use them for survival and yield in body tissues. Ruminants perform most of their protein digestion in the rumen and use the ingested proteins for a variety of tasks. At

the beginning of these tasks are the growth of tissues and the building of hormones and enzymes. Ruminants first convert the excess nutrients they ingest in their feed into glycogen and store the rest in the body in the form of adipose tissue (Baldwin 1995.). It is known that the structure of these fats, which are stored in different tissues of animals, may show some variability depending on the metabolic activities they have undergone in the organism and the organ in which they are stored (Bessa et al. 2005, Bezerra et al. 2016, de Abreu et al. 2019, Fahmy et al. 1992). Protein sources used in ruminant nutrition have a positive effect on meat quality and increase muscle mass (Andersen et al. 2005). Zaretabar et al. (2021) reported in their study that the addition of wheat gluten and barley protein instead of fishmeal to trout feed changed the lipid profile of the meat to a certain extent. Messina et al. (2013) found in their study that the lipid profile of the muscle tissue of sea bass changed significantly when they added different variants of wheat gluten instead of fishmeal. This shows that the protein source used has an influence on the lipid profile of the muscles.

Morkaraman sheep are classified as easily adaptable to poor environmental conditions, resistant to diseases, combined productive and fat-tailed. In lean or thin-tailed sheep, the fat is formed around the internal organs, especially around the kidney tissue, while in Morkaraman sheep the tail is formed (Pourlis 2011, Cicek et al. 2018). For this reason, the tails of Morkaraman lambs are genetically formed in parallel with body growth (Sirin et al. 2017).

Recently, there has been interested in nutritional strategies to improve the quality of natural, safe, and healthy animal products. In this context, studies are being conducted on extracts and essential oils derived from aromatic or medicinal plants (Gumus et al. 2017a). Although in this study the energy and protein ratio of the diets fed to all experimental groups was the same, meeting protein requirements from unilateral sources (soybean meal and safflower meal in the control group, wheat gluten in the wheat group, and corn gluten in the corn group) is a unique approach. Therefore, the effect of metabolic differences in the digestive system and other organs of these feeds on the quality of meat quality, intramuscular fat, and tail fat was investigated.

MATERIALS AND METHODS

Animal material, experimental groups, and nutrition

This study was approved by the Ethics Committee of Atatürk University according to the decision number 2021/39. Eighteen male Mor Karaman lambs with an average age of 9 months were used for the study. The study was designed with 6 animals in each group. The sample size of the animals in the study was calculated according to the "Power Analysis" method. The groups were divided into a control group, a wheat group and a corn group. The rations given to the study groups were isonitrogenous (HP 17%) and isocaloric (ME: 2700 kcal/kg). The control group received soybean meal + safflower meal, the wheat group received wheat gluten, and the corn group received corn gluten. In the study, the animals were fed for 56 days after a 21-day acclimation period. The animals were given feed and water *ad libitum*. The animals used in the study were fed twice daily, in the morning at 8:00 am and in the evening at 16:00 pm. Sawdust was used as substrate material. During the study period, it was ensured that lickstones were present in each compartment. In this way, the mineral and salt needs of the lambs are met. All animals in the study were maintained and fed under the same conditions and temperature

until the end of the study. The composition of the lamb fattening feed used in the study is given in Table I.

Meat quality parameters

Microbial analyzes

The microbiological analyses of the samples were performed in compliance with the method described by Baumgart et al. (1993). Accordingly, 25 g of the meat samples was homogenized in 225 mL of sterile Ringer's solution. Subsequently, the other solutions were prepared. Inoculations were made using the spread plate technique. The TMAB count was determined using Plate Count Agar (PCA, Merck). The petri dishes were incubated under aerobic conditions at 30±1 °C for 72±1 h. The TPAB count was also determined using the Plate Count Agar (PCA, Merck), and the petri dishes were incubated under aerobic conditions at 7±1 °C for 10 d. For the determination of *Enterobacteriaceae* counts, 1 mL of the appropriate dilutions was inoculated into Violet Red Bile Dextrose Agar (VRBDA, Merck).

Table I. Lamb fattening feed composition used in the study.

Ingredients, %	Groups		
	Control[1]	BG[2]	MG[3]
Barley	60	52.5	60
Soybean meal	15.93	-	-
Rice Bran	10	-	-
Safflower Pulp	7.47	-	-
Wheat	-	30	-
Corn	-	-	18.22
Corn Gluten	-	-	14.78
Wheat Gluten	-	10.3	-
Molasses	3	3	3
Marble dust	2.4	1.65	2.35
DCP 18	-	1.51	0.96
Soy oil	0.6	0.33	-
Salt	0.3	0.3	0.31
Ammonium chloride	0.2	0.3	0.28
Vitamin-Mineral[4]	0.1	0.1	0.1
Nutrient composition			
Crude protein, %	17	17	17
Metabolisable energy, (kcal/kg)	2700	2700	2700

[1] Control: Control group. [2] BG: Wheat group. [3] MG: Corn group. [4] The vitamin & mineral premix provided the following (per kg): 13.000.000 IU vitamin A, 4.000.000 IU vitamin D3, 25.000 mg vitamin E, 10.000 mg vitamin B2, 4.000 mg vitamin B1, 12 mg vitamin B12, 20.000 mg Niacin, 80.000 mg Mn, 30.000 mg Fe, 80.000 mg Zn, 300 mg Co, 2.000 mg I, 300 mg Se, 50.000 mg Mg.

The petri dishes were incubated at 30 °C under anaerobic conditions for 2 d. *Micrococcus*// *Staphylococcus* spp. counts were determined using Mannitol Salt Agar (MSA). The plates were incubated under aerobic conditions at 30±1 °C for 48±1 h. *Pseudomonas* spp. counts were determined using Pseudomonas Agar (Oxoid CM 0559) supplemented with CFC supplement (Oxoid SR 0103), and the plates were incubated under aerobic conditions at 25±1 °C for 48±1 h. *Lactobacillus* spp. counts were determined using MRS Agar (De Man Rogosa and Sharpe) (Oxoid CM 1153), and the plates were incubated under anaerobic conditions at 37±1 °C for 48±1 h. Bacterial counts were expressed in log cfu g^{-1}.

Chemical analyzes

Water activity values were measured using an AQUALAB 4TE (USA) device. Meat samples were placed in the container of the device for the reading of the aw values. The pH values of the samples were measured as described by Gokalp et al. (2001). Accordingly, 10 g portions of the homogenized samples were weighed and each portion was added 100 mL of distilled water. Homogenization was performed for 1 min using an Ultra-Turrax (IKA Werk T 25, Germany) homogenizer, and the pH values were measured using a pH meter (WTW Inolab, Germany). The color intensities (L*, a*, b*) of the cross sectional areas of the drumstick and breast meat samples were determined using a Minolta colorimeter (CR-200, Minolta Co, Osaka, Japan). Color measurements were performed directly on the surface of muscle tissue by removing the skin.

For thiobarbituric acid reactive substance (TBARS) value analysis, taking 2 g of homogenized samples, 12 mL TCA solution (7.5 % TCA, 0.1 % EDTA, 0.1 % propyl gallate (dissolved in 3 mL ethanol) was added, and after homogenization in Ultra-Turrax for 15–20 s, it was filtered through Whatman 1 paper filter; 3 mL of the filtrate was taken and transferred to the test tube, and 3 mL of TBA (0.02 M) solution was added and made homogeneous. The test tubes were kept in a water bath at 100 °C for 40 min and then cooled in cold water for 5 min. After centrifugation (5 min at 2000 g) absorbance values were read at 530 nm in a spectrophotometer (Aquamate, Thermo Electron Corporation, England). Results are given in µmol malonaldehyde kg^{-1} (Lemon 1975).

The determination of fatty acid compositions in meat samples

The meat samples (approx. 20 g) were homogenised with tissue grinders (50 mL, 32x195 mm) in a potter (50 mL) using a tissue homogenizer (HS-30E Wisd Homogenizer Stirres, Witeg Labortechnik GmbH, Wertheim, Germany). The homogenised samples were methylated with the three-stage modified procedure of Wang et al. (2015). The percentages of individual fatty acid methyl esters (FAME's) in total fatty acid methyl esters were detected in a gas chromatograph with flame-ionization detection (GC-FID, Thermo Scientific, USA), which have automatic sampler device (Thermo AI 1310, USA). The GC-FID was studied with a FAME column (Thermo Scientific™ TRACE™, TR-FAME GC Columns, Catalogue number: 260M153P, USA) and injection split temperature 255°C, column 140°C, and flow rate 30 ml/min processing method for 42 minutes. The FAME's identification was performed by comparing the retention times with the expected retention times of standard mixture in chromatograms (Kara 2020).

Statistical analysis

All statistical analyses were performed using the SPSS 20.00 software. One-way analysis of variance (ANOVA) was used to detect whether there was a statistical difference between the data in all parameters. The data were expressed

as mean ± standard error of mean (SEM). Differences were considered to be significant at $p < 0.05$ and $p < 0.01$.

RESULTS

In this study, the longissimus dorsi muscle was analyzed during storage to determine the meat quality of lamb. The analysis was performed to determine the chemical properties, i.e., water activity, reactive thiobarbituric acid (TBARS), pH, and color parameters (L*=lightness, a*=redness, b*=yellowness) on the 1st, 3rd, 5th, 7th, and 9th day of storage. While there was no difference in the water activity values of the longissimus dorsi muscle between groups during storage, it was found that there was a difference in the TBARS value on the 1st, 5th, and 7th days of storage. It was found that the lowest TBARS values occurred in the groups that received corn gluten and the highest values occurred in the groups that received wheat gluten. It was found that the pH of this muscle tissue was significantly different between groups on the 1st, 7th, and 9th day of storage. The pH of the control group was generally high and low in the corn gluten-treated groups. In the study, the effects of the groups on L value, one of the color parameters of the longissimus dorsi muscle, on the 5th and 9th day of storage; effects on a value on the 1st day of storage; and effects on a value on the 2nd day of storage. The some chemical quality parameters of longissimus dorsi muscle tissue is reported in Table III. Microorganisms in the longissimus dorsi muscle were counted to determine the antibacterial effect of the feeds the animals had eaten against some microorganisms. The number of TMAB on the 3rd, 7th and 9th day of storage; on the 3rd day, the number of *Enterobacteriaceae*; on the 3rd, 5th and 7th day, the number of *Pseudomonas* spp; on the 1st and 9th day, the number of TPAB, it was found that there were significant differences between the groups. The number of *Lactobacillus* spp. in the control group was significantly lower than in the corn and wheat groups on the 5th day of storage. The some microbial quality parameters of longissimus dorsi muscle tissue is reported in Table II.

The intramuscular fatty acid profile of the longissimus dorsi muscle tissue and the acid profile of the tail fat were determined and are shown in Table IV. There was no significant difference between the ratios of total saturated fatty acids (SFA) of intramuscular adipose tissue and tail fat of the study groups. However, it was found that there was a significant difference between the groups for 5 of the 15 fatty acids composing the SFA analyzed in the tail fat and for 2 of the fatty acids of the intramuscular adipose tissue of *Musculus longissimus dorsi*. The ratios of unsaturated fatty acids in both tail fat and intramuscular adipose tissue were similar between groups. While tail fat MUFA levels were statistically similar between groups, a significant difference was found between MUFA levels, one of the parameters of intramuscular adipose tissue of longissimus dorsi muscle. It was found that the difference between PUFA, w3, w6, w9, and w3/w6 ratios making up the tail fatty acid profile was significant. It was also found that the values obtained in 6 of the 11 fatty acids in PUFA were statistically significant between groups.

DISCUSSION

The quality of meat depends on postmortem metabolism. It is known that postmortem metabolism varies according to the age, sex, genetic structure, rearing conditions, and diet of the animal (Santos-Silva et al. 2002, Ye et al. 2020).

Table II. The effect of storage time and groups on some bacterial counts in the lamb *M. longissimus dorsi* (log cfu g^{-1}).

DAYS	GROUPS	TMAB	*Enterobacteriaceae*	*Lactobacillus* spp.	*Micrococcus/ Staphylococcus*	*Pseudomonas* spp.	TPAB
1	Control	3.11±0.05	2.20±0.09	3.02±0.08	3.21±0.27	1.25±0.25	2.50±0.29
	Wheat Gluten	3.42±0.05	2.02±0.11	2.93±0.32	3.59±0.22	1.99±0.21	3.17±0.03
	Corn Gluten	3.28±0.12	1.95±0.26	2.56±0.24	3.33±0.13	1.49±0.17	2.24±0.09
3	Control	3.15±0.03b	2.37±0.16b	3.02±0.08	3.21±0.27	2.00±0.00b	3.00±0.00
	Wheat Gluten	3.44±0.03a	2.19±0.07b	2.93±0.32	3.59±0.08	2.62±0.13a	3.17±0.28
	Corn Gluten	3.41±0.09a	2.97±0.12a	3.59±0.15	3.81±0.23	2.61±0.15a	2.73±0.28
5	Control	3.44±0.09	2.41±0.27	3.03±0.03b	3.39±0.08	2.25±0.25b	3.25±0.25
	Wheat Gluten	3.68±0.31	2.47±0.04	3.55±0.16a	3.60±0.15	3.62±0.13a	3.42±0.11
	Corn Gluten	3.66±0.33	2.36±0.09	3.59±0.15a	3.81±0.23	3.61±0.15a	3.48±0.21
7	Control	4.51±0.17b	2.51±0.13	4.46±0.39	4.73±0.30	3.75±0.25b	4.75±0.48
	Wheat Gluten	5.26±0.07a	3.21±0.32	3.62±0.28	4.79±0.28	4.44±0.13a	5.33±0.14
	Corn Gluten	4.40±0.29b	2.76±0.15	4.11±0.38	4.14±0.29	4.40±0.04a	4.43±0.20
9	Control	6.20±0.08a	2.63±0.32	4.64±0.48	5.34±0.26	4.79±0.26	7.09±0.01
	Wheat Gluten	5.46±0.13b	3.21±0.32	4.64±0.37	4.79±0.29	5.12±0.18	6.28±0.23
	Corn Gluten	5.42±0.09b	3.02±0.14	4.66±0.14	5.48±0.01	5.05±0.02	5.73±0.10
p	Application	0.093	0.205	0.619	0.611	0.000	0.376
	Day	0.000	0.000	0.000	0.000	0.000	0.418
	Application*Day	0.001	0.051	0.203	0.059	0.052	0.449

a-b: Means in the same column with different superscripts differ (p<0.05).

In this study, wheat and corn gluten were added instead of soybean meal, which is traditionally used in feeds. In addition, to better understand the effect of the diet, barley was given as an energy source to the control group, barley and wheat to the wheat group, and barley and corn to the corn group. At the end of the fattening experiment, the dorsal muscles (M. longissimus dorsi) of the slaughtered animals were harvested and water activity, pH, TBARS, color parameters (L*, a* and b*) and the number of microorganisms were determined on the 1st, 3rd, 5th, 7th and 9th day of storage. In addition, the fatty acid profile of the intramuscular dorsal muscle and tail was determined. It is known that postmortem metabolism in muscle tissue after animal slaughter and the proliferation of some microorganisms are directly related to the water activity of muscle tissue (Iulietto et al. 2016).

Rezar et al. (2017) reported that chestnut juice added to pig rations in different amounts significantly altered the water-holding capacity of the carcass. On the other hand, some studies reported that vitamins (Imik et al. 2013) and yucca plant (Gumus & Imik 2016) added to the ration did not affect the water activities of the meat. In our study, it was found that the water activities of the back muscles of the groups were similar during the 9-day storage period. The fact that the water activities of the groups determined in

Table III. The effect of storage time and groups on some chemical properties in the lamb *M. longissimus dorsi.*

DAYS	GROUPS	Aw	TBARS	pH	L	A	B
1	Control	0.995±0.001	0.35±0.01a	5.79±0.04a	40.33±0.57	18.23±0.65	4.65±0.35
	Wheat Gluten	0.993±0.001	0.35±0.02a	5.69±0.02b	41.65±1.10	15.68±0.32	4.74±0.35
	Corn Gluten	0.995±0.001	0.20±0.02b	5.71±0.01ab	42.12±0.61	16.38±0.22	5.01±0.24
3	Control	0.993±0.001	0.36±0.03	5.71±0.03	42.72±0.52	15.26±0.68	3.74±0.24a
	Wheat Gluten	0.980±0001	0.50±0.06	5.76±0.02	42.14±1.26	15.61±0.24	4.20±0.27a
	Corn Gluten	0.994±0.000	0.43±0.06	5.77±0.06	44.03±0.56	15.23±0.42	2.89±0.18b
5	Control	0.996±0.000	0.60±0.08b	5.79±0.04	40.36±0.87	15.11±0.41	3.70±0.34
	Wheat Gluten	0.993±0.001	1.50±0.09a	5.27±0.37	44.19±0.67	16.20±0.64	4.52±0.35
	Corn Gluten	0.996±0.001	0.64±0.04b	5.71±0.00	42.74±0.49	16.44±0.34	4.53±0.20
7	Control	0.993±0.001	2.19±0.04b	5.69±0.02a	41.81±0.17	16.52±0.57	4.58±0.55
	Wheat Gluten	0.991±0.000	2.45±0.06a	5.71±0.01a	42.37±0.71	16.23±0.61	4.52±0.36
	Corn Gluten	0.993±0.001	1.55±0.09c	5.65±0.01b	40.85±0.75	15.57±0.12	3.46±0.25
9	Control	0.991±0.001	3.04±0.18	5.87±0.08a	40.38±1.42	15.70±0.51	3.49±0.34
	Wheat Gluten	0.995±0.002	2.98±0.12	5.70±0.01b	43.45±0.51	16.44±0.32	4.07±0.27
	Corn Gluten	0.990±0.001	2.62±0.42	5.64±0.01b	43.71±0.85	15.83±0.44	3.96±0.23
p	Application	0.157	0.000	0.074	0.010	0.384	0.078
	Day	0.003	0.000	0.263	0.034	0.424	0.000
	Application*Day	0.029	0.000	0.102	0.083	0.456	0.033

a-b: Means in the same column with different superscripts differ (p<0.05).

this study were similar implies that the effects of meat on postmortem metabolism and other responses should be similar.

Free radicals increase adenosine monophosphate-activated protein kinase (AMPK) activity in muscle tissue (Cao et al. 2020) and accelerate lipid peroxidation (Koc et al. 2008, Imik et al. 2010), as evidenced by a decrease in DNA and RNA synthesis (Cadenas & Davies 2000). Today, TBARS is referred to as the major manifestation of oxidative stress. TBARS is a reaction process that begins with the oxidation of polyunsaturated fatty acids with radicals, continues with autocatalytic chain reactions, and overall causes damage to many biological structures (Davies & Goldberg 1987). There are many studies reporting that lipid oxidation decreases in studies when additional antioxidants are added to the ration (Gumus et al. 2017b, Koc et al. 2008, Imik et al. 2010). Leticia et al. (2017) stored the dorsal muscles of slaughtered animals for 12 days at the end of their study by adding sage distillation products containing phenolic compounds to the rations of lambs fed in a closed system and grazed on pasture. They reported that TBARS levels in the dorsal muscles of animals grazing on pasture did not change during this storage period, but TBARS levels of the groups fed in a closed system and having sage distillation products added to the ration increased significantly. Rezar et al. (2017) reported that chestnut tree extract added

Table IV. Fatty acid profile of the lamb tail fat and *M. longissimus dorsi*.

	Lamb tail fat				*Musculus longissimus dorsi*			
FA	**Control**	**Wheat Gluten**	**Corn Gluten**	**p**	**Control**	**Wheat Gluten**	**Corn Gluten**	**p**
MUFA	42.38±0.51	40.52±1.74	41.90±1.41	0.637	44.03±0.17a	40.80±1.00b	42.54±1.02ab	0.047
C14:1	4.45±0.14	4.34±0.24	4.34±0.45	0.953	0.57±0.26	0.43±0.12	0.26±0.05	0.437
C15:1	1.77±0.10b	0.73±0.02c	2.43±0.17a	0.004	0.09±0.05	0.05±0.01	0.05±0.01	0.438
C16:1	2.87±0.02	2.88±0.03	2.78±0.06	0.299	1.98±0.23	2.18±0.19	1.99±0.19	0.730
C17:1	0.06±0.02	0.08±0.01	0.07±0.02	0.650	0.26±0.09a	0.04±0.01b	0.05±0.01b	0.019
C18:1n9t	ND	ND	ND		1.59±0.87	0.73±0.19	0.63±0.29	0.405
C18:1n9c	32.15±0.64	31.56±1.52	31.35±1.95	0.927	39.08±1.62	37.12±1.00	38.82±0.91	0.482
C20:1	0.03±0.01	0.03±0.01	0.02±0.01	0.854	0.27±0.06	0.19±0.04	0.32±0.03	0.141
C22:1n9	0.23±0.04	0.00±0.00	0.10±0.10	0.153	0.00±0.00	0.00±0.00	0.40±0.39	0.374
C24:1	0.85±0.01	0.92±0.05	0.83±0.12	0.660	0.18±0.06	0.06±0.02	0.05±0.01	0.059
PUFA	**4.61±0.06b**	**5.80±0.18b**	**4.36±0.11a**	**0.008**	**14.01±0.66**	**16.77±1.70**	**14.45±1.48**	**0.329**
C18:2n6t	0.28±0.01b	1.32±0.11a	0.06±0.06b	0.002	0.00±0.00b	0.03±0.01a	0.00±0.00b	0.013
C18:2n6c	3.03±0.12	2.73±0.19	2.76±0.02	0.335	8.40±0.53	10.53±1.13	9.25±0.78	0.236
C18:3n6	0.11±0.01	0.10±0.01	0.13±0.01	0.268	0.60±0.15	0.53±0.04	0.53±0.07	0.856
C18:3n3	0.16±0.06b	0.34±0.03a	0.07±0.02b	0.031	0.19±0.08	0.11±0.01	0.13±0.03	0.474
C20:2	0.07±0.01	0.21±0.16	0.00±0.00	0.385	0.26±0.01	0.39±0.06	0.32±0.06	0.207
C20:3n6	0.55±0.03	0.52±0.02	0.45±0.15	0.719	0.02±0.00	0.03±0.00	0.03±0.01	0.182
C20:3n3	0.00±0.00	0.07±0.01	0.23±0.08	0.082	0.00±0.00	0.00±0.00	0.02±0.02	0.391
C20:4n6	0.23±0.03a	0.03±0.03b	0.00±0.00b	0.010	2.12±0.06	2.68±0.25	2.03±0.51	0.350
C22:0	0.00±0.00c	0.11±0.01a	0.08±0.01b	0.001	0.10±0.05	0.02±0.01	0.02±0.01	0.091
C20:5n3	0.03±0.02b	0.02±0.01b	0.10±0.01a	0.027	0.60±0.04	0.78±0.07	0.69±0.07	0.134
C22:6n3	0.17±0.02c	0.37±0.01b	0.50±0.02a	0.001	1.72±0.33	1.68±0.50	1.29±0.38	0.715
SFA	**53.02±0.51**	**53.74±1.50**	**54.05±1.50**	**0.816**	**42.04±0.56**	**42.43±0.88**	**43.18±0.97**	0.619
C6:0	0.00±0.00c	0.09±0.01b	0.15±0.00a	0.000	0.04±0.03	0.00±0.00	0.00±0.00	0.260
C8:0	0.310±0.02c	0.40±0.02b	0.55±0.00a	0.003	0.05±0.02	0.05±0.01	0.04±0.01	0.819
C10:0	0.70±0.27	0.76±0.20	0.68±0.28	0.975	0.28±0.05	0.46±0.08	0.39±0.09	0.254
C11:0	0.64±0.04	0.77±0.04	0.72±0.01	0.108	0.01±0.01	0.01±0.00	0.02±0.01	0.628
C12:0	1.78±0.44	2.94±0.15	2.17±0.03	0.116	0.19±0.05	0.15±0.02	0.17±0.04	0.729
C13:0	1.03±0.05b	1.41±0.07a	1.35±0.01a	0.021	0.00±0.00	0.01±0.00	0.01±0.00	0.112
C14:0	6.53±0.21	6.50±0.05	6.35±0.23	0.776	2.44±0.25	2.84±0.06	3.07±0.57	0.465
C15:0	3.80±0.40	3.66±0.11	3.67±0.22	0.916	1.64±0.48	1.81±0.36	1.38±0.27	0.729
C16:0	21.88±0.43	21.26±1.14	21.82±0.81	0.856	24.73±1.13	23.74±0.45	24.32±1.02	0.746
C17:0	3.83±0.38	3.65±0.25	3.64±0.24	0.884	0.75±0.07b	1.19±0.1a	1.07±0.08ab	0.037
C18:0	12.03±0.20	11.93±0.27	11.98±0.34	0.967	10.64±0.74	11.41±0.72	12.03±0.61	0.388

Table IV. Continuation.

C20:0	0.42±0.03b	0.09±0.02c	0.79±0.05a	0.002	0.052±0.01	0.087±0.02	0.067±0.01	0.224
C21:0	0.01±0.00	0.00±0.00	0.05±0.01	0.192	0.26±0.01	0.39±0.06	0.32±0.06	0.207
C23:0	0.02±0.01b	0.15±0.01a	0.01±0.00b	0.001	0.90±0.43	0.29±0.03	0.25±0.04	0.150
C24:0	0.07±0.01	0.10±0.00	0.03±0.03	0.143	0.02±0.01a	0.01±0.00b	0.01±0.00b	0.018
ω-3	0.35±0.09b	0.79±0.00a	0.90±0.08a	0.019	2.51±0.41	2.57±0.51	2.04±0.38	0.647
ω-6	4.26±0.14a	5.01±0.18a	3.47±0.19b	0.017	11.50±0.43	14.21±1.43	12.08±1.25	0.234
ω-9	36.85±0.46	35.92±1.75	35.80±1.40	0.838	41.51±0.46	38.46±1.06	40.40±1.04	0.082
ω-3/ ω-6	0.08±0.02b	0.16±0.01ab	0.26±0.04a	0.032	0.22±0.04	0.18±0.04	0.08±0.04	0.056

a-b: Means in the same column with different superscripts differ (p<0.05).

to pig rations in varying amounts increased the oxidation of lipids and proteins in the carcass. When TBARS values of longissimus dorsi muscle tissue were examined, it was found that there were significant differences between groups on the 1st, 5th, and 7th day of storage (p<0.00). These differences were highest in the control and wheat groups and lowest in the corn group on the first day of storage; on the fifth day, the wheat group was highest, and the control and corn groups were lowest; on the seventh day, the wheat group was highest and the corn group was lowest. In this study, it was found that the TBARS values of the back muscles of the animals during storage were low in the corn group and high in the wheat group, which can be attributed to the different chemical contents, antioxidant content and oil profile of the feed raw materials given to the experimental groups. The results are also supported by literature references.

Meat pH varies depending on the amount of glycogen present in muscle tissue and the conversion of this glycogen to lactic acid (Henckel et al. 2002, Ferguson et al. 2014). Li et al. (2017) used waxy cornstarch as an energy source in the isonitrogenous and isocaloric pig rations they prepared; wax-free cornstarch and pea starch were used. At the end of the experiment, they reported that the levels of creatine kinase, phosphocreatine, adenosine triphosphate, adenosine diphosphate, adenosine monophosphate, and hexokinase were significantly different in the longissimus thoracis muscle. These parameters were indicated as the most important parameters affecting postmortem energy metabolism of meat. In addition, the glycogen and glycolytic potential of this muscle varied considerably, whereas the lactate level was similar between the study groups. De Otmani et al. (2021) studied the effect of olive cake and cactus peel fed to kids on the longissimus dorsi and semimembranosus muscles. They reported that the diet had no effect on the pH of the longissimus dorsi muscle, while the effect on the semimembranosus muscle was significantly different. Hisano et al. (2016) reported that corn gluten used in varying proportions instead of soybean meal in fish diets had no effect on fillet pH. De Abreu et al. (2019) reported that 0%, 33%, 66%, and 100% of cactus plant added to lamb feed instead of wheat bran did not change the pH of the meat and was within normal limits. Ye et al. (2020) reported in their study with lambs in different farms that the pH of meat varies according to sex, age, breed, and diet. In this study, it was found that the pH of the control group was significantly higher on the 1st, 7th, and 9th day of storage (p<0.03). It was found that the pH values of wheat and corn groups changed during storage. It can be concluded that the pH of the meat of the groups changed depending

on the different glycogen and/or metabolic rates in the muscle tissues of the groups given to the experimental groups. In fact, it is also supported by information from the literature that the pH of meat can change depending on many factors.

The natural color of meat is due to the pigments of myoglobin and hemoglobin. These pigments consist of globin, a porphyrin ring, and iron ions. Myoglobin (Mb) has a pink color and turns into red colored oxymyoglobin (MbO_2) under the influence of oxygen. The color change of lamb meat depends on the amount of pigments in the meat and the oxidation of these pigments (Barbut 2016). In the study we conducted, the L* value of the back muscle was determined on the 5th and 9th day of storage; the a* value was determined on the 1st day; the b* value was significantly different between groups on the 3rd day ($p<0.05$). Some studies have been conducted to determine the effects of feeding on meat color parameters. Bezerra et al. (2016) reported that the addition of peanut meal as a protein source to the lamb diet at levels of 0.0%, 25.0%, 50.0%, 75.0%, or 100.0% instead of soybean meal had no effect on meat marbling, color, and texture. Ye et al. (2020), in their study with lambs in different farms, reported that the L*, a*, and b* values of the meat varied depending on sex, age, breed, and diet. De Oliveira et al. (2021) reported that the color parameters of the meat were similar to those of safflower seeds added to the lamb diet at 0%, 7.5% and 15%.

The quality of meat is inversely proportional to the number/capacity of microorganisms. It is known that maturing and acidification of meat after slaughter inhibits the growth of microorganisms in meat. When live animals are slaughtered, their natural protective barriers and defense mechanisms (antimicrobial peptides) are disrupted. Therefore, microorganisms in meat multiply rapidly and cause deterioration of muscle tissue (Iulietto et al. 2016). The number of microorganisms in meat depends on the packaging system of the meat and the storage time (Charles et al. 2006, Bórnez et al. 2009), the microbial flora of the digestive system (Goksoy et al. 2010), and the feed additives added to the ration (Imik et al. 2010, Leusink et al. 2010). It is known that the proliferation of many pathogenic microorganisms is inversely proportional to the acidification (pH) of the environment. In addition, the proliferation of microorganisms in food can be prevented by antimicrobial agents. Antimicrobials have been reported to prevent the growth of pathogenic microorganisms through various modes of action, such as inhibition of cell wall/nucleic acid/protein synthesis (Kumariya et al. 2019). In our study, the TMAB count of the meat was detected on the 3rd, 7th, and 9th day of storage; the *Enterobacteriaceae* count on the 3rd day; the *Lactobacillus* spp. count on the 5th day; the *Pseudomonas* spp. count on the 3rd, 5th, and 7th day; and the TPAB count was not detected on the 1st and 3rd day of storage. In the study by Leticia et al. (2017), by adding sage distillate products containing phenolic compounds to the rations of lambs fed a closed system and grazing on pasture, the numbers of lactic acid bacteria, *B. thermosphacta*, and *Enterobacteriaceae* on the stored tenderloin meat of these animals were counted on days 0, 6 and 12 and reported that there was no significant difference between groups. Calo et al. (2015) reported that many plant-derived essential fatty acids are more sensitive to Gramme-positive microorganisms than Gramme-negative ones. The results obtained in this study can probably be explained by the antibacterial capabilities of the feeds given to the research groups. This is because factors other than the baits used in the experimental groups are similar.

The animals convert the nutrients contained in the structure of the feed into the form of body

tissues. In this study, the effects of the diets given to the experimental groups on the fatty acid profile of intramuscular fat and tail tissue were determined. In this study, although there was no difference between groups in the total MUFA fatty acids that make up the structure of the tail ($p>0.05$), it was observed that the fatty acids stored in the dorsal muscle were different between groups ($p<0.047$). The lowest MUFA value was in the wheat group and the highest in the control group. In addition, C15:1 ($p<0.004$) in the tail fatty acids, one of the MUFA fatty acids analyzed in this study; it was observed that there were significant differences between groups in C17:1 of the back muscles ($p<0.019$). There were also significant differences between groups (p0.019).

Total PUFA of tail tissue was found to be significantly different between groups ($p<0.008$). Of the PUFAs analyzed in this study, C18:2n6 (p0.002), C18:3n3 ($p<0.03$), C20:4n6 ($p<0.01$), C22:0 ($p<0.00$), C20:5n3 ($p<0.02$), and C22:6n3 ($p<0.001$). It was found that there was no significant difference between back muscle structure and total PUFA values. It was found that C18:2n6, one of the fatty acids that form only the back muscle, differed between groups ($p<0.013$).

While there were no significant differences between the groups' values of the total tail SFA profile, a significant difference was found between the groups when the fatty acid values that make up the SFA were examined separately. C6:0 ($p<0.001$), C8:0 ($p<0.003$), which constitute the SFA and were analyzed, C13:0 (p0.02), C20:0 ($p<0.002$) and C23:0 ($p<0.001$) significant differences were found. While there was no significant difference between the total back muscle SFA values of the groups, among the fatty acids composing the SFA that were analyzed, C17:0 ($p<0.037$) and C24:0 ($p<0.018$). Values were found to be significantly different. While significant differences were found between the w-3 ($p<0.019$), w-6 ($p<0.017$), and w-3/w-6 ($p<0.032$) profiles of the tail tissue of the study groups, there was no significant difference between the fat profiles of the back muscle.

There are many studies that report that diet affects the quality of muscle fat. In a study in which cotton seeds were fed to lambs and kids, intramuscular adiposity increased and the fatty acids in M. longissimus dorsi increased the 18:1 trans-10, 18:1 trans-12, 18:2 and Omega6/Omega3 ratios, FA 18:1 trans-11., 18:3 and Omega3 decreased (Turner et al. 2014). They also reported that cottonseed did not affect the lipid profile in goats and lambs to the same extent. They reported that it reduced omega3 fatty acids in lamb but increased the omega6/omega3 ratio. Bessa et al. (2005) reported that the addition of soybean oil to lamb feed significantly altered the lipid profile of longissimus thoracis muscle. De Goes et al. (2018) found that the addition of sunflower to lamb feed affected the levels of C15:0, C20:0, and C20:3w-6 in lamb muscle. They reported that these synthesized fatty acids were formed from propionic acid, which is produced during fermentation of feed in the digestive system of ruminants. De Abreu et al. (2019) reported that 0%, 33%, 66%, and 100% of cactus plant added to lamb feed instead of wheat bran only slightly reduced stearic, linoleic, linolenic, eicosatrienoic, and eicosapentaenoic acid content of meat. Leticia et al. (2017) reported that intramuscular adipose tissue PUFA, MUFA, and n6/n3 ratios and some fatty acid profiles changed significantly in their study when they added sage distillate products containing phenolic compounds to the rations of lambs fed in a closed system and grazed on pasture. In the study investigating the effect of chestnut tree extract added to pig generations on carcass parameters, the fat content of the carcass decreased and the percentage of polyunsaturated fatty acids in the carcass increased. In this study,

intramuscular fat and subcutaneous adipose tissue profile were found to be differentially affected by diet (Rezar et al. 2017). De Oliveira et al. (2021) reported that safflower seeds added to the diets of lambs at 0%, 7.5%, and 15% did not alter the polyunsaturated and unsaturated fatty acids (except C22:1) intramuscular fat profiles of the meat. Bezerra et al. (2016) reported that the addition of peanut flour to lamb diets as a protein source instead of soybean flour at levels of 0.0%, 25.0%, 50.0%, 75.0% or 100.0% altered the fatty acid profile. The findings obtained in the study show that the meat fatty tissue of animals can change depending on the feed or structure of the feed they eat. Considering the findings obtained in our study, only the change in MUFA levels of intramuscular adipose tissue is supported by the literature. In this study, the tail fat profile was also determined. We can consider this information as original. Indeed, in this study, it was observed that wheat and corn gluten used as unilateral protein sources significantly altered the tail fat profile. Furthermore, since we did not find any study on tail fat, our comments on this issue are limited.

CONCLUSIONS

It was found that different protein sources added to the lamb feed had different effects on the chemical and microbial quality of the meat during the 9-day storage period. The effects of the wheat and maize gluten used in our study on microbial growth were limited. However, the effect of the gluten source on the pH and TBARS values of the lamb meat was found to be significant. The use of different protein sources was found to have an effect on intramuscular and tail fat profiles. The information obtained in this study shows that the use of wheat and corn gluten in the diet affects meat quality and fat profile. However, it was concluded that further studies are needed on the effects of the use of different gluten sources in the diet of ruminants on meat quality.

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