EFFECT ON LAMB MEAT OF SUPPLEMENTING WITH CALCIUM SOAP FATTY ACIDS

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Abstract – The objective of this study was to determine the effects of calcium soap of fatty acids (CSFA) on meat quality traits of lambs when included in a finishing diet. Cooking loss was reduced in CSFA fed lambs, but there was no effect on any other traits. Samples of *longissimus* muscle were evaluated at 0 and 10 days postmortem. Shear force was significantly reduced by ageing, and this was matched by an increase in myofibrillar fragmentation index values with ageing. *L, *b** and pH values increased with ageing. There was no detrimental effect of feeding CSFA on the measured traits.**

Key Words – lamb, ageing, collagen, shear force

I. INTRODUCTION

At the production level there is pressure for productivity increases and using supplements can increase the energy density of feeds so that ruminants can store more energy with less dry matter consumption. One such potential supplement are calcium soaps. These are produced in a granulated-solid form and are easily incorporated into ruminant diets; affordability will depend largely upon duration and amount of supplementation [1]. Protected lipids are present in an inert form in the rumen; and apparently do not interfere with rumen metabolism, but they are efficiently digested in the lower tract [2] and subject to minimal biohydrogenation [3]. Previous research found no effect on carcass characteristics from including calcium soap fatty acid (CSFA) in the diet of lambs [4]. When high levels of calcium soaps of palm oil fatty acids oil were fed to lambs, ether extract digestibility and the feed conversion ratio were improved without affecting carcass yield and chemical composition [5].

Several studies have evaluated the impact of the diet of ruminants supplemented with CSFA on the composition of ewe milk [6-8], but there is a paucity of knowledge about the impact on meat quality traits. Numerous studies have evaluated the effect of ageing on the tenderness of meat post-mortem [9-11], but whether there is any interaction of CSFA and ageing is unknown. Therefore, the objective of this study was to determine the effects of replacing dietary carbohydrate with CSFA on the meat quality of lambs finished in a feedlot, where the meat was subsequently subjected to different ageing times.

II. MATERIALS AND METHODS

Sixty-three Santa Inês and crossbreed lambs (Santa Inês over Black Dorper, White Dorper, Texel, Lacaune and East Friesan ewes) were used in this study. The feeding period started with lambs weighing on average 26.0 ± 1.06 kg at 3-4 months of age. Twenty-nine lambs were fed with diets containing 85% concentrate and 15% roughage, with the control diet based on oat hay, coffee hulls, corn, soybean meal, limestone, mineral supplement and Rumensin®. The remaining lambs 34 lambs were fed the same diet, but with calcium soap fatty acid Megalac® at 5.4% of the ration, maintaining the isoenergetic and isonitrogenous diets (Table 1). The ME Mcal/kg and crude protein levels were 2.89 and 13.96 for the control diet and 3.11 and 14.00 for the CSFA diet, respectively. Each lamb was fed individually. The lambs were slaughtered after 72 ± 23.85 days on feed and weighed on average 44.0 ± 1.14 kg. The carcasses were kept at room temperature for 6 h and chilled for 18 h at 2-4°C. At 24h postmortem (pm) the carcasses were split down the midline and from the right side of

each carcass the *Longissimus lumborum* (LL) and subcutaneous fat were collected. The muscle was cut into 2.54-cm thick slices and vacuum-packaged. Day 1 pm samples were stored immediately a -20°C for subsequent analysis. Other samples were vaccum packed and stored at 2°C for 10 d pm, then frozen at -20°C for subsequent analysis. The slices were thawed for 18 h at 4°C and the slice used for shear force measurement was weighed individually before and after broiling on a grill for determination of cooking loss. The slice was cooked on a grill to an internal temperature of 71°C, monitored using copper constatan thermocouples. After cooking, slices were cooled at room temperature and four or five 1cm^2 cross-sectional round cores were taken at approximately the same location from each cooked slice and running parallel to the longitudinal axis of the muscle fibers. The cores were sheared on a TA-XT2 Texture Analyser (Stable Micro Systems Ltd., London, UK) with a Warner-Bratzler V-shaped cutting blade that sheared down through the sample and the shear force was recorded as Newtons (N).

Table 1 Ingredients of the experimental diets

Ingredient	Control (%)	CSFA (%)
Oat hay	12.3	12.3
Coffee hulls	2.5	2.5
Corn	69.8	64.8
Soybean meal	12.7	13.7
Megalac®*	-	5.4
Rumensin®	0.02	0.02
Limestone	1.7	0.3
Mineral supplementation	0.9	0.9

*Calcium soap fatty acid (CSFA).

The pH of the sample LL was measured using a Jenco 6009 meter with temperature compensation and an Ionode IJ42 spear electrode, with the electrode inserted into the muscle at 0 and 10 days pm. The electrode was calibrated in buffers at pH 4.0 and 7.0. One steak from LL was allowed to bloom for 30 min at room temperature before color measurement at 0 and 10 days pm. Color measurements were collected using a Minolta CM-700 (Konica Minolta, Japan). A total of 5 readings were taken on each steak and averaged. CIE lightness (L^*), redness (a^*) and yellowness (b^*) were recorded.

Myofibrillar fragmentation index (MFI) was determined as described previously [12]. Sarcomere length was determined on cooked cores samples prior to measurement for shear force as described previously [10]. From each core, sarcomere length of eighteen fiber samples was determined by helium neon laser diffraction (model 05-LHR-073, Melles Griot, Carlsbad, CA) as described previously [13]. Collagen content and heat solubility were determined by Hill's method [14] with slight modification, such as, after cooling to room temperature the extract was centrifuged for 10 min at 3,000 x *g*, the hydrolysis was performed in an oven for 18 h at 105°C and the dilution was 1:10 for supernatant and 1:25 for residual. The amount of hydroxyproline was determined using a procedure described previously [15]. To determine the collagen content, hydroxyproline amount was multiplied by 7.52 for the supernatant and 7.25 for the residual [16]. The supernatant indicated soluble collagen (mg/g muscle) and the residual as the insoluble collagen (mg collagen/g meat). Water holding capacity was determined according to methodology described previously [17] with slight modifications. Briefly, samples of 200-400 mg were placed between filter papers and a 5 kg-weight exerted pressure for 5 minutes. The pressed meat area (MA) and the fluid area (FA) were estimated and the WHC expressed in terms of the ratio of meat to total area, i.e., WHC = MA/(MA + FA).

Statistical analysis: REML Linear mixed models were generated through Genstat 16th Edition [18] using the factors diet (treatment), ageing and the diet x ageing interaction as fixed effects and genotype and animal identification as random terms. pH was tested as a covariate for colour traits, cooking loss and shear force.

III. RESULTS AND DISCUSSION

In our study, there was no significant interaction ($P > 0.05$) between both fixed effects (diet and ageing) for any traits. In Table 2, summary results for pH, b^*, L^*, shear force, cooking loss and MFI are given.

Table 2 Predicted mean and standard error for pH, yellowness (b^*), lightness (L^*), shear force (SF), cooking loss (CL) and myofibrillar fragmentation index (MFI)

Trait	Control		CSFA		Significance (P value)	
	0	10	0	10	Diet	Ageing
pH	5.66 ± 0.02	5.67 ± 0.02	5.65 ± 0.01	5.70 ± 0.01	0.544	0.048
b^*	8.9 ± 0.34	9.8 ± 0.34	8.9 ± 0.32	9.7 ± 0.32	0.920	0.008
L^*	48.8 ± 0.71	50.1 ± 0.71	48.2 ± 0.68	49.5 ± 0.68	0.285	0.020
SF (N)	46.8 ± 3.11	33.4 ± 3.11	44.6 ± 2.96	31.1 ± 2.96	0.380	<0.001
CL (%)	25.1 ± 0.61	24.7 ± 0.61	22.8 ± 0.55	23.4 ± 0.55	0.005	0.807
MFI (%)	34.8 ± 2.18	50.0 ± 2.18	35.2 ± 2.07	53.0 ± 2.07	0.285	<0.001

In general, there were no differences due to diet, except for cooking loss with lower values in lambs fed CSFA ($P < 0.05$). In general, a more energetic diet produces rapid gains and fatter carcasses [19]. The degree of cooking loss from muscle tends to decrease with increasing marbling scores [20] and this is a plausible explanation for the effect found in this study.

Ageing was the main factor that affected the meat characteristics, such as pH, b^*, L^*, shear force and MFI. The pH ranged from 5.65 to 5.70, indicating that animals were not stressed at the time of slaughter. According to previous research [21], pH values ranging from 5.5 to 5.8 are normal 24 h after slaughter. The pH value was higher 10 days after the slaughter.

These results may have been due to microbial growth in the vacuum packaging, resulting in elevated pH because of amine compounds produced from bacterial activity in meat proteins may increase pH [22].

Meat colour was influenced by ageing, with the meat being lighter (L^*) and more yellow (b^*) 10 days post mortem (Table 2). Others have shown a positive correlation between ageing time for $L^*$and b^* [23] and similar to our study they didn't find a significant change in a^* values until after 12 days of ageing attributing this to the short time to bloom (only 20 min), which may not be enough time for maximum red colour development, which is similar to the 30 min bloom time applied in our study.

At 10 days post mortem, shear force measurements were lower than the unaged meat as expected. It is well established that myofibrillar degradation increases during post-mortem meat storage, which can be seen in our study with an increase of 32% in MFI values and a 30% reduction in shear force with ageing for 10 days. The calpains have established effects on muscle during post-mortem storage and play an important physiological role in intracellular protein degradation [11]. There was however, no effect of diet on these traits, although it has been found in previous work that a 22% improvement in tenderness was achieved based on sensory tests when CSFA was added to the diet [24]. Ageing had no impact on collagen solubility.

No differences in meat colour and collagen concentration or solubility due to diet were found (Tables 2 & 3) and this may have been due the similar slaughter weight for all animals (44.0 ± 1.14 kg).

Table 3 Predicted means and standard error for sarcomere length (SL), water holding capacity (WHC), redness (a*) and collagen soluble (Sol) and insoluble (Ins) concentration

Trait	Control	CSFA	P value
SL (µm)	1.40 ± 0.02	1.44 ± 0.02	0.20
WHC (%)	0.19 ± 0.03	0.19 ± 0.03	0.20
a^*	10.5 ± 0.33	10.5 ± 0.30	0.98
Sol (mg/g muscle)	0.60 ± 0.03	0.61 ± 0.03	0.56
Ins (mg/g muscle)	1.62 ± 0.05	1.60 ± 0.05	0.76

In Table 3, summary results for sarcomere length and water holding capacity are given. There were no significant effects on these traits due to diet or ageing ($P > 0.05$). The sarcomere length values ranged from 1.40 to 1.44 µm, and this result agrees with results previously presented [10].

IV. CONCLUSION

There was no detrimental effects of feeding CSFA in the diet of lambs, and there was a small beneficial reduction in cooking loss.

Ageing for 10 days produced meat of an acceptable tenderness level, without any adverse effects in the traits measured in this study.

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