EFFECTS OF ENRICHED HOUSING ON SENSORY ASPECTS AND FATTY ACID COMPOSITION OF *LONGISSIMUS* MUSCLE IN LIGHT-WEIGHT FINISHED LAMBS: DOUBLE BUNKS AND STRAW

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Abstract – We analysed the effect of an enriched housing on the sensory meat quality and fatty acid composition of *longissimus* muscle in 60 entire Rasa Aragonesa lambs, housed indoors for 5 weeks in six pens (10 lambs/pen, 0.95m^2/lamb, initial weight 17.09±0.2 kg); three control pens (barren) and three enriched pens (with straw and a double bunk). All lambs were fed *ad libitum* with commercial ground (4-6 mm sieve) concentrate (Ovirum Alta Energía ®).Enriched lambs (EDB) had lower carcass conformation score and cooking losses (P≤0.05). No differences were found in pH24. Texture values of EDB were higher (P≤0.05) than controls (CO).EDB had higher percentage of C18:0 and SFA (P≤0.05). CO had higher percentage of total*n-6* (P≤0.05) and higher PUFA: SFA ratio (P≤0.05) than EDB. Only the overall liking (OL) was slightly higher for EDB (P≤0.05). The step-wise analysis showed that OL was significantly associated to several sensory parameters. Fibrousity was the strongest parameter associated with OL in the EDB (P≤0.0001) and tenderness was the strongest parameter associated with OL in the CO and CO+EDB (P≤0.001). The results suggest that full enrichment (straw and double bunks) can have effects on instrumental meat quality, fatty acid composition and sensory meat quality.

Key Words – feedlot lambs, full enrichment, fatty acid, sensory evaluation

I. INTRODUCTION

In recent years, sheep production in several Mediterranean countries has become more intensive. In some regions of Spain, the final stage of lamb fattening occurs indoors in off-farm cooperative centres (CC) [1]. This has a number of benefits for the farmer and for production (i.e., simplifying the finishing process and more homogeneous carcasses, respectively), but could have negative effects on animal welfare and the final product (i.e meat). In Europe, the increasing public concern about animal welfare has produced important changes in European legislation regarding livestock production [2]. Recent studies conclude that the main reason consumers buy welfare friendly products is for their improved organoleptic quality, followed by improved welfare [3]. Thus, it seems important to include both aspects when analysing the effects of specific production practices such as environmental enrichment, since apparent benefits for the animal may not be good for the production system or final product. The aim of this study was to evaluate how double bunks and straw (as forage and bedding) affects productive performance traits, some instrumental meat quality characteristics, sensory aspects and intramuscular fatty acid profile during the final phase of fattening in lambs.

II. MATERIALS AND METHODS

III. Sixty Rasa Aragonesa entire male lambs of 65 days of age (17.09 ± 0.2 kg live weight) were divided in 2 treatments (enriched or standard), housed for 5 weeks in 6 pens (2.9mx 3.3m, 0.95m ² density / lamb, 10 lambs / pen in 3 replicates per treatment). The control pen (CO) was similar to cooperative feed lots (CC), without straw. The enriched pen (EDB) contained straw as forage and bedding and a double bunk (2.0 long, 0.95 m wide and 0.5 high) with two ramps on each end to

get to the upper zone. Lambs were fed *ad libitum* with commercial ground (4-6 mm sieve) concentrate (Ovirum Alta Energía ®) containing barley, wheat, calcium carbonate, sodium chloride and a vitamin supplement corrector (18% crude protein and 11.5 MJ metabolisable energy/kg DM) and consumption was recorded. Lambs were weighed at the beginning and end of the experiment to estimate the average daily gain (ADG). At 24 hrs after slaughter, the pH_{ult} were measured. Carcasses were evaluated in terms of conformation and fatness with the European classification system. The *Longissimus* muscle was removed and divided into three sections. The first section was to determine the fatty acid composition. Lipid extraction and gas chromatography analysis of fatty acid methyl esters was performed as described by Carrilho et al. 2009[4]. The second section was to measure the cooking losses (CL%) and texture by Warner-Bratzler, and the third section was to evaluate the sensory quality of the meat [5]. Meat quality variables were analysed with a fixed effects model (type of environment), co-varying carcass trait and the fatty acid composition with the weight of the cold carcass [6]. Statistical analysis of sensory variables. Mention smth. RESULTS AND DISCUSSION

Overall, lambs of both groups had similar productive traits, but the carcass conformation score of EDB was 1.3 point less than CO (5.9 and 4.6, respectively). No significant differences were found in pH24; however, as shown in Table 1, the EDB lambs had lower CL% and higher values of texture than CO (+20.6% and +15.08% of shear force and toughness, respectively).

Table 1. Least square means (±S.E.) of texture by WB in lambs subjected to barren or full enriched pen during the finishing phase of fattening.

Response variable	Control	Enriched
Final weight (kg)	26.30 (±0.38)	25.73 (±0.36)
ADG (kg)	263 (±9.34)	257 (±8.86)
Conversion index	3.30 (±0.11)	3.39 (±0.11)
pH_{ult}(24 h)	5.59 (±0.01)	5.58 (±0.01)
Cooking losses (%)	14.85 (±0.58)[a]	12.66 (0.58)[b]
Texture by WB		
Shear force (kg/cm²)	4.42 (± 0.23)[a]	5.33 (± 0.23)[b]
Max. stress (kg/cm^2)	4.41 (± 0.22)[a]	5.11 (± 0.22)[b]
Toughness (kg)	1.79 (± 0.09)[a]	2.06 (± 0.09)[b]

a, b: different letters within raw represent significant difference between treatments (P≤0.05)

Table 2.Intramuscular fat (%) and fatty acid composition (% of total fatty acids) of M. *Longissimus dorsi* from control and enriched lambs during the finishing phase of fattening.

Trait	Control [a]	Enriched [a]	SE	P values
Intramuscular fatness	3.10	3.36	0.15	n.s
C10:0	0.12	0.12	0.006	n.s
C12:0	0.13	0.17	0.01	0.067
C14:0	2.30	2.57	0.11	0.080
C15:0	0.34	0.34	0.01	n.s
C16:0	23.04	23.70	0.26	0.086
C16:1	1.41	1.54	0.06	n.s
C17:0	1.54	1.36	0.04	n.s
C17:1	0.85	0.76	0.02	0.024
C18:0	13.7	14.83	0.28	0.0074
C18:c1 *n-9*	36.88	36.83	0.2	n.s
C18:2 *n-6*	6.34	5.70	0.2	0.065
C18:3 *n-3*	0.33	0.34	0.02	n.s
CLA	0.41	0.46	0.02	n.s
C20:3 *n-3*	0.13	0.13	0.009	n.s
C20:3 *n-6*	0.18	0.16	0.008	0.052
C20:4*n-6*	2.20	1.79	0.11	0.015
C20:5 *n-3* EPA	0.18	0.20	0.02	n.s
C22:5 *n-3*DPA	0.41	0.36	0.02	n.s
C22:6 *n-3* DHA	0.12	0.15	0.02	n.s
SFA	41.46	43.46	0.29	0.0001
MUFA	45.08	44.46	0.41	n.s
PUFA	10.70	9.62	0.42	0.07
n-6	9.05	7.92	0.35	0.02
n-3	1.23	1.23	0.09	n.s
PUFA:SFA	0.26	0.22	0.01	0.02
n-6:*n-3*	7.94	7.08	0.35	0.08

Co-varied by cold carcass weight. [a]Means; SE: standard error. ns= no significant. *CLA=sum of total isomers. Significant differences = P≤0.05.

There were significant differences in fatty acid composition between treatments (Table 2). EDB had 1.13 percentage points (pp) more C18:0 (P≤0.05) and 2 pp more of total SFA (P≤ 0.05) than CO. Probably the increase of total SFA in EDB was due to their higher percentage of stearic acid (C18:0) and also to their tendency to have more C12:0, C14:0 and C16:0. It has been described that a lesser amount of C18:0 could be because a concentrate diet increases available soluble carbohydrates, resulting in lower

ruminoreticular pH, which decrease hydrogenase activity, leading to less conversion of C18:2 to C18:0 [7]. Thus, the EDB (provided with straw) could have maintained the ruminal pH, increasing the hydrogenase activity. Moreover, CO lambs had significantly more (P≤0.05) total *n-6* (+1.13 pp) due to higher (P≤0.05) C20:3 *n-6*, C20:4 *n-6* and a tendency for higher C18:2 *n-6* (+0.64 pp). Although there was no significant difference among treatments in total *n-3*, the higher percentage of total *n-6* in CO led to a slightly higher PUFA:SFA ratio (P≤0.05), which is supported by tendency of CO to have a higher *n-6:n-3 r*atio (+0.86pp) as well. Probably the presence of straw in the diet affected the fatty acid composition, because lambs could replace part of the concentrate for straw leading to a better control of the ruminant pH and, probably, lower consumption of concentrate.

Table 1. Least square means (±S.E.) of sensorial meat quality variables from lambs in control (barren) or enriched pens during the finishing phase of fattening.

Sensory variables*	Control	Enriched	SE	P value
Tenderness	5.92	5.66	0.21	n.s
Juiciness	5.19	5.28	0.12	n.s
Fibrousity	4.39	4.54	0.20	n.s
Lamb odour	5.48	5.63	0.12	n.s
Grass odour	2.74	2.68	0.11	n.s
Fat odour	3.43	3.54	0.09	n.s
Lamb flavour	5.92	5.91	0.10	n.s
Metallic flavour	3.65	3.74	0.12	n.s
Fat flavour	4.60	4.68	0.09	n.s
Bitter flavour	2.96	2.83	0.13	n.s
Hot flavour	2.75	2.81	0.09	n.s
Overall liking	4.65	5.07	0.11	0.02

*Numerical scale from 0 to 10, with higher values indicating higher levels of that item. n.s= no significant. Significant differences = P≤0.05

Sensory analyses showed no significant differences in specific sensory variables; however, a slightly difference in favour to EDB (P≤0.05) was found in the overall liking (OL).The step-wise analysis showed that the OL was related to several sensory parameters. Tenderness was the strongest parameter associated with the OL in the CO lambs and CO+EDB combined (P≤0.0001 and P≤0.006, respectively); however, fibrousity was the strongest parameter associated with OL in EDB lambs (P≤0.0001), which makes sense if the latter is related with the higher values of texture of the EDB. Flavour was another sensory parameter that was related with overall liking.

Table 2. Step-wise multiple regression analysis of the relationship between the overall liking of the meat and other sensory parameters in lambs subjected to enriched or barren environments during the finishing phase of fattening.

Step	Overall			Control			Enriched		
	Var.	R^2	P	Var.	R^2	P	Var.	R^2	P
1st	TE	32	0.0001	TE	35	0.0006	FIBR	49	0.0001
2nd	BF	40	0.007	BF	44	0.04	HF	56	0.04
3rd	FF	45	0.04	FO	49	0.10	FF	68	0.003
4th	JU	47	0.14	JU	51	0.34	BF	71	0.16
5th	LF	49	0.14	LF	53	0.32	TER	73	0.19
6th	FIBR	50	0.18	GO	54	0.42	LF	76	0.11
7th	GO	52	0.21	FF	55	0.47	FO	78	0.20

TE: tenderness. BF: bitter flavour. FF: Fat flavour. MF: Metallic flavour. JU: Juiciness. FIBR: Fibrousity. FO: Fat odour. LO: lamb odour. LF: lamb flavour. GO: grass odour. HF: hot flavour. Significant difference=P≤0.05.

IV. CONCLUSION

Full enrichment (straw, double bunks and ramps) affected texture values and fatty acid composition of the *longissimus* muscle, but had less of an effect on sensory aspects of the meat. The main reason is probably the forage straw; however the presence of the double bunk could be responsible for the high toughness meat. The results of this study provide evidence to suggest that providing something good for the animal (enrichment), may not be positive in all aspects for the quality of the final product.

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REFERENCES

1. deRancourt, M., Fois, N., Lavin, M.P., Tchakérian, E., &Vallerand, F. (2006) Mediterranean sheep and goats production: An uncertain future. Small Ruminant Research: 62, 167-179.
2. European Commission (2006). Commission working document on a community actionplan on the protection and welfare of animals 2006–2010.
3. Miranda-de la Lama, G.C., Sepulveda, W., Villarroel, M., & María, G.A. (2013). Attitudes of meat retailers to animal welfare in Spain. Meat Science:95, 569-575.
4. Carrilho, M.C., López, M., & Campo, M.M. (2009). Effect of the fattening diet on the development of the fatty acid profile in rabbits from weaning. Meat Science: 83, 88-95.
5. Campo, M.M., Sañudo, C., Panea, B., Alberti, P., &Santolaria, P. (1999). Breed type and ageing time effects on sensory characteristics of beef strip loin steaks. *Meat Science: 51*, 383–390.
6. Statistical Analysis System Institute, 1988. SAS/STATS User's Guide (Release 6.03). SAS Institute, Cary, NC.
7. Tove, S.B, &Matrone, G. (1962). Effect of purified diets on the fatty acid composition of sheep tallow. Journal of Nutrition: 76, 271-277.