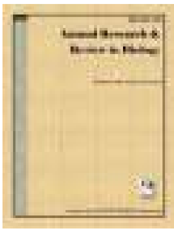

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Chemical Composition, Carcass and Sensory Characteristics of Grazing Lambs Meat, Supplemented with Different Protein Sources

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Authors' contributions

This work was carried out in collaboration between all authors. Authors JRB, MGR, MDMB and EJL designed the study, performed the data acquisition, statistical analysis, wrote the first draft of the manuscript and manuscript review. Authors EMA and AZMS managed the analyses of the study, manuscript editing and review. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: This study was conducted to evaluate the effects of different sources of protein supplementation on carcass characteristics and meat quality of Suffolk lambs in intensive grazing system.
Study Design: Samples of meat for chemical composition, carcass characteristics and meat quality were analyzed using a completely randomized design. An analysis by contrasts was carried out; C1) ryegrass hay (RGH) vs. fishmeal (FSM) and soybean meal (SBM) and C2) FSM vs. SBM treatments.
Methodology: Thirty male Suffolk lambs (37.2±5.4 kg live weight) were used to evaluate the carcass characteristics and meat sensory. Animals were grazed on perennial

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ryegrass 12h/d and supplemented (30 g/kg$^{0.75}$ live weight) with RGH, FSM or SBM diets.
Results: Carcass performance was increased (*P*=.024) in FSM and SBM lambs vs. RGH (52.7 vs. 47.9 %). A tendency (*P*=.079) was observed for the chop thickness at the 12th rib for SBM or FSM vs. RGH lambs. Organoleptic characteristics did not present differences, except juiciness (*P*=.002). Meat fat content was the only variable that showed differences between treatments (FSM > SBM and RGH; *P*=.001).
Conclusion: The use of feed supplementation with diets containing SBM or FSM in grazing lambs, did not affect directly on the carcass conformation and the sensory characteristics of meat. Meat juiciness showed a variation regarding the type of feed supplementation used, without affect on meat tenderness, flavor and aroma. Meat fat content was higher in animals feed with FSM diets.

Keywords: Lambs; grazing; protein sources; carcass characteristics; sensory analysis.

1. INTRODUCTION

Meat consumers are influenced by a series of factors such as alimentary security, health, environmental impact, and animal welfare [1]. Sensory qualities [2] and chemical composition of the meat are some of the main factors that influence the satisfaction of the consumer [3,4]. Lamb meat has a low consumption because of its specific taste and tenderness [5]. There are many pre- and post-mortem factors that may alter the organoleptic characteristics of the meat. In particular, the diet of lambs is a factor that influences these organoleptic characteristics [6–9]. The differences in the sensory characteristics of the meat in ruminants may be affected if they are exclusively fed on forages of cereals [10]. Moreover, the specific components of the diet might directly affect the quality of the meat if they are transferred to it [11]. This study was conducted to evaluate the carcass characteristics and meat quality of Suffolk lambs in an intensive grazing system and supplemented with different sources of protein.

2. MATERIALS AND METHODS

The present study was performed in the farm of the Faculty of Medicine and Livestock, of the University Autonomous State of Mexico (19º14 '20'' and 19º33' 01'' north latitude and 99º42 '07'' and 99º56' 13'' west longitude), with summer rains and an annual rainfall of 788 mm^3, humid temperate climate and an average annual temperature of 13.5 to 30.5ºC, with a height of 2600 m above sea level.

2.1 Prairie and Ryegrass Hay Procedure

A prairie of 120 x 100 m composed of 80.7% of perennial ryegrass (*Lolium perenne*), 12.1% of clover (*Trifolium repens*) and 7.2% of weeds, was divided in strips (4 x 100 m) in a rotational grazing system, grazing one day and resting 30 days. Animals were grazing during a period of 70±7 d. Prior to the beginning of the experiment the prairie was mowed and hayed, the excess of forage of the prairie where the lambs were not grazing was cut (5 cm from the ground) and dried (RGH) and then supplemented to lambs.

2.2 Animals and Diets

Thirty male Suffolk (37.2±5.4 kg live weight) were assigned to three experimental groups (10 animals of each), grazing perennial ryegrass – RGH (*Lollium perenne*) 12h/d (0700 to 1900 h), and supplemented in individual pens before (0700h) and after grazing (2000h) with RGH, 378±65 g DM/d and 0.84 g/kg live weight/d of mineral-vitamin supplement (Multitec, Malta Clayton®); Fishmeal (FSM) treatment, 30 g/kg$^{0.75}$, based on FSM diet (17.6 % fishmeal, 29.4% rapeseed meal, 50 % corn grain and 3 % vitamins and minerals) and soya bean meal (SBM) treatment, 30 g/kg$^{0.75}$, based on soybean meal diet (17.6 % hydrolyzed soybean meal, 26.4 % soybean meal, 53 % corn grain and 3 % vitamins and minerals) (Table 1). Lambs had access to water *ad libitum*.The management of the lambs and all procedures in the present study were performed according to the Animal Experimental Guidelines of the University Autonomus of the State of Mexico.

Table 1. Chemical composition (g/kg DM) of the ingredients used to prepare the supplements and the prairie (rye grass) supplemented with rye grass hay (RGH), fish meal (FSM) and soy bean meal (SBM) diets

Item	DM	OM	CP	NDF	ADF	Lignin	ME[1]
Fish meal	917	845	708	-	-	-	14.5
Soybean meal Hi-pro	899	935	659	335	47	32	13.6
Soybean meal	895	934	468	313	88	45	12.9
Rapeseed meal	891	924	435	303	158	103	12.1
Corn grain	877	986	118	119	23	36	14.5
Minerals	976	-	-	-	-	-	-
Diets							
Prairie	123	901	201	550	269	29	8.5
RGH	875	906	195	537	247	27	8.5
FSM	891	914	258	148	58	48	12.8
SBM	903	934	248	195	32	44	13.5

[1]ME, Metabolizable energy (Mj/kg DM); NDF and ADF were assayed with stable alpha amylase and expressed without residual ash

2.3 Experimental Procedure

During the development of the experiment, samples of the prairie and supplements were taken every day; the animals were weighed once every 7 days until they reached 50 kg live weight (15 days between the SBM and FSM vs. RGH treatments).

2.4 Carcass Measurements

Lambs were slaughtered after 12 hour fasting, according to Fisher and de Boer [12]. Weight of the warm carcass was determined after the slaughtering, and it was weighed again once cold at 24 h. Later the commercial carcass yield (%), thickness of chops at the 12th rib, dorsal fat at the 6th and 10th ribs were determined; the length of the carcass was measured from the 1st cervical vertebra to the last sacral vertebra, total leg, perimeter of the leg, rump, fat in kidney (1-4 scale), fat coverage of the carcass (scale: 1, normal; 2, lean; 3, moderately fatty; 4, fatty; 5, very fatty) and shape (scale: 1, very bad; 2, bad; 3, normal; 4, good; 5, very good) were determined. Carcass was divided into two along the longitudinal axis; from the left portion, five chops were taken at the level of thoracic vertebrae (6th to 10th) and were vacuum-packed at -20ºC for chemical composition. Meat samples for sensory analyses were defrost at 20 days later, due to the animals slaughter at different time.

2.5 Sensory Analysis

Meat samples of 300 g were defrost (24 h, 4ºC), placed in aluminum foil and cooked in a grill at 200ºC until they reached an internal temperature of 70ºC, monitoring with thermo plates (Omega Engineering Inc., Stamford, CT, USA) and a portable thermometer (TEK-DTM520). Once cooked, subcutaneous fat and connective tissue were removed and the muscle was cut into several portions, which were placed in aluminum foil and randomly marked using a 3-digit codeand samples were preserved hot until their evaluation. To avoid a possible effect in the order of presentation and a first order carry effect, samples were presented to the food tasters (n=30) in different order [13]. The food tasters had access to water and plain crackers, to clean the taste of each sample. The analysis was based on four sensory descriptions (Table 2) and a hedonistic scale of five points was used, from 1 (strongly disgusts) to 5 (very pleasing).

Table 2. Definition of the descriptions used in the sensory analysis of lamb meat and their scale

Description	Definition	Scale
Flavor intensity	Intensity of the taste of the cooked lamb	1-5
Juiciness	The liquid expelled by the sample, while chewed	1-5
Tenderness	Easiness of chewing with molars	1-5
Aroma	Intensity of the odor of the cooked lamb	1-5

Scale = 1, strongly disgusts; 2, slightly disgusts; 3, neither disgusts nor pleases; 4, pleasing; 5, very pleasing

2.6 Chemical Analysis

Feeds samples were analyzed for DM (#934.01), ash (#942.05), N (#954.01) and EE (#920.39) according to AOAC [14]. The neutral detergent fiber (NDF, [15]), acid detergent fiber (ADF) and lignin (#973.18) [14]; analyses used an ANKOM200 Fiber Analyzer Unit (ANKOM Technology Corporation, Macedon, NY, USA). NDF was assayed without use of an alpha amylase but with sodium sulfite in the NDF. Both NDF and ADF are expressed without residual ash.

Meat samples were unfrozen (24 h, 4ºC) and analyzed for moisture (g water/100 g sample), protein (N x 6.25) and intramuscular fat were determined according to AOAC [14]. Once the chop was thawed, the toughness of the meat was determined by means of the Shear force, using Warner-Bratzler equipment (SALTE R®, G-R Elec. Mfg. Co. Collins Lane, MA). To do so, the chop was weighed and then cooked on an electric grill (70ºC internal temperature); it was left to cool down at room temperature. An average of 8 cylinders ($1cm^2$) was obtained per chop and finally, they were cut at the central part with the blade of Warner-Bratzler, with a force of 25 kg^{-1} 100 g [16].

2.7 Statistical Analysis

The chemical composition of the meat, characteristics of the carcass, shear force, and sensory evaluation, samples were analyzed by means of a completely randomized design, yij= μ + Txi + εij, where yij=response variable; μ = general mean; Txi= effect of the treatment factor and εij= experimental error. An analysis by contrasts was carried out C1) RGH vs. FSM and SBM and C2) FSM vs. SBM treatments [17] using the statistical program SPSS version 13 [18].

3. RESULTS AND DISCUSSION

3.1 Carcass Characteristics

Animals supplemented with RGH had live and carcass weights lower (*P*=.038 and .046, respectively) than those supplemented with FSM and SBM respectively. Treatments did not affect carcass yield (*P*=.25) and chop thickness (*P* =.19), a tendency was observed for chop thickness in C1 (*P*=.08), dorsal fat at the 6th rib showed a tendency (*P*=.07) being higher in FSH compared to the rest. Nonetheless, no differences were observed (*P* =.17) for dorsal fat at the 10th rib between treatments; when the length of the carcass is compared between the different treatments, it was longer (*P*=.03) in lambs supplemented with FSM and SBM compared with RGH (82.5 cm). There were no differences (*P*=.12 and .50, respectively) for the length and perimeter of the leg between treatments; fat coverage was higher (*P*=.06) for FSM and SBM than RGH (Table 3).

Table 3. Carcass characteristics of Suffolk lambs feed on grazing and supplemented with rye grass hay (RGH), fish meal (FSM) and soybean meal (SBM)

Characteristics	Treatments				***P- value***		
	RGH	**FSM**	**SBM**	**SEM**	**Tx**	**C1**	**C2**
Live weight (kg)	47.1^b	50.5^{ab}	53.7^a	1.57	0.038	0.024	0.181
Hot carcass weight (kg)	18.8^b	21.9^{ab}	23.1^a	1.12	0.046	0.018	0.455
Carcass yield (%)	38.0	40.3	39.7	0.96	0.253	0.114	0.666
Chop thickness 12th rib (cm)	5.1	6.15	6.14	0.80	0.191	0.079	0.718
Dorsal fat 6th rib (cm)	0.24	0.44	0.26	0.06	0.069	0.160	0.055
Dorsal fat 10th rib (cm)	0.24	0.38	0.26	0.05	0.178	0.246	0.139
Carcass length (cm)	82.5^b	88.0^a	87.5^{ab}	1.43	0.035	0.011	0.809
Leg length (cm)	31.0	29.8	30.7	0.39	0.121	0.166	0.114
Leg perimeter (cm)	34.0	34.8	35.2	0.75	0.508	0.286	0.673
Rump perimeter (cm)	57.7^b	63.9^a	61.7^{ab}	2.60	0.015	0.007	0.257
Kidney fat (score) [2]	3.0	2.6	2.8	0.04	0.790	0.559	0.735
Widest thorax (cm)	34.2^a	27.2^b	29.5^b	1.14	0.003	0.001	0.181
Carcass conformation (score) [3]	4.0	4.6	4.8	0.31	0.218	0.096	0.662
Carcass fatness (score) [4]	2.8	4.0	3.4	0.31	0.059	0.038	0.204

SEM, Standard Error Mean, Contrast: C1) RGH vs. FSM and SBM; C2) FSM vs. SBM
[2]Kidney fat, fat present in kidney, scale: 1, 2, 3 and 4
[3]Carcass conformation: scale 1-5; 3.0 normal; 4.0, good; 5.0, very good.
[4]Carcass fatness: scale 1-5; 1, normal; 2, lean; 3, moderately fatty; 4, fatty; 5 very fatty

Carcass yield was lower than Bores et al. [19] (47%) and Gutiérrez et al. [20] in Suffolk x Pelibuey lambs (44%) fed with diets based on cereals supplementation, even though this animals were slaughtered at a lower weight (35 kg LW). Louvandini et al. [21] find a similar carcass yield to the present study, in Santa Ines lambs, at slaughter weight of 20 kg and carcass length of 60 cm. Fahmy et al. [22] obtain carcass yields of 40%, in Suffolk lambs, slaughtered at 43 kg LW, whereas Borton et al. [23], slaughtering lambs at 48 kg LW, obtain heavier carcasses (25.6 kg) and carcass yield similar to the present study. This allows to suppose that even if the carcass yields of the lambs are similar among treatments, the lambs are slaughtered at different ages and weights, in function of the breed and country of origin [24]. Carcass yield in grazing animals did not show differences (*P*=.25) between treatments, similar to Carrasco et al. [25]. Fat content has beneficial effects on the taste: Osorío and Osorío [26] found that higher levels of fat in adult animals is not desirable for sale-related aspects due to their poor consistency; in the present study it was observed that the animals presented a fatty shape which ranged from good for RGH to very good when the animals were supplemented with FSM and SBM, showing a tendency (*P*=.096) in C1. Fatty coverage varied (*P*=.059) from moderately fatty for RGH to fatty for FSM treatment.

3.2 Sensory Characteristics and Chemical Composition

Diets did not influence on the shear force, (P=.1; Table 4),similar results was reported by Greiner and Duckett [27], who found that a shear force between 3.5 – 4.0, probably because the lambs were growing, and this promotes the synthesis of protein and makes the meat have a high production of it, with the subsequent formation of collagen, contrary to our results Hatfield et al. [28] found that the shear force is higher for lambs finished with grazing comparing them to those finished with cereals supplementation.

Sensory characteristics of the lamb meat (Table 4) were not different among treatments (*P*>.05), except for juiciness (*P*=.003), being increased in SBM vs. RGH (P=.002); general acceptance was increased for C1 (*P*=.045). There were no differences (*P*=.47 and .53, respectively) for moisture and protein content in lamb meat (Table 4), on the contrary fat content was increased (*P*=.001) for FSM compared with RGH and SBM diets. Fahmy et al. [22] found similar results in juiciness and tenderness in Suffolk lambs supplemented with FSM and SBM without difference among them; which may be related to the shear force that did not show differences between treatments.

Similar to the present study, Sañudo et al. [29], observed an increase in juiciness of lambs supplemented with FSM and SBM than RGH. Rhee et al. [30] found an increased in juiciness scores for animals reared indoors, showing the importance of feeding and production system on some lamb meat sensory characteristics [6]. These results could be related with the perception of “wateriness” in the mouth, apparent after initial chewing of meat from the animals. This may depend more concentration of soluble collagen, rather than on increased unsaturated fat content and their subsequent impression of increased sustained juiciness, derived from high-energy diets [31,32] or age. Thus, in the present study, grazing lambs supplemented with RGH showed the lowest juiciness ratings compared with SBM diets.

Diet supplementations had no effect (*P* = .39) on the meat aroma, contrary to other authors [10,24,33–35]. Aroma is probably linked to the different sorts of lamb and the cooking method [36], which may influence, according to the cultural preferences of the region and the sort of alimentation received by animals (grazing vs. supplementation), as well as the age and deposition of fat [37]. Borton et al. [23] and Priolo et al. [8] found that the taste was more intense in the meat from supplement-fed lambs than those fed on prairies; nonetheless, other studies did not found differences [7,9,22], as in our case.

Increased the palatability (general acceptance) was a wider acceptance to meat from SBM and FSM supplements (*P*=.0451) in relation to those fed on a grazing system supplemented with RGH, which is linked to juiciness while cooking (Table 4) and was something that may justify this preference. Feeding systems can affect the weight at slaughtering and fat condition, thereby the intensity of the taste of lamb meat [38]. Even between lambs slaughtered at similar ages, Rousset-Akrim et al. [9] did not find significant differences between lambs fed on grass and those on grains, in lambs from 71 to 101 days of age. On the contrary, Sañudo et al. [24] find differences in the preference for the meat of lambs fed on cereals or prairies, in function of the country of origin.

Table 4. Shear force (kg/cm^2), sensory characteristics (1-5 scale) and chemical composition (g/100 g wet tissue) of lamb meat grazing supplemented with rye grass hay (RGH), fish meal (FSM) and soy bean meal (SBM)

Characteristic	Treatments				P- value		
	RGH	FSM	SBM	SEM	Tx	C1	C2
Shear force[1]	3.27	3.17	3.21	0.2529	0.9549	0.787	0.891
Sensory characteristics							
Flavor intensity	3.96	3.96	4.22	0.449	0.464	0.531	0.282
Juiciness	3.53^b	4.00^{ab}	4.37^a	1.266	0.003	0.002	0.120
Tenderness	4.10	4.33	4.35	0.421	0.453	0.211	0.914
Aroma	3.75	3.82	4.03	0.451	0.397	0.342	0.326
Overall acceptability	3.86	4.05	4.27	0.620	0.066	0.045	0.221
Chemical composition (g/100 g wet tissue)							
Moisture	68.3	65.0	63.8	1.14	0.473	0.246	0.749
Protein	29.3	31.6	33.5	2.48	0.534	0.447	0.416
Fat content	2.38^b	3.37^a	2.66^b	0.11	0.001	0.167	0.001

Values in files with different letters are significantly different (P < .05)
SEM, Standard Error Mean.
Contrast: C1) RGH vs. FSM and SBM; C2) FSM vs. SBM

The lower content of energy and protein present in grass-based diets, compared to those based on cereals, allows the animals fed on grass to be older than those fed on cereals at the same weight at slaughtering. In our case, lambs fed with RGH supplementation took 15 days longer to reach 50 kg. At commercial weights, there seem to be other more important factors than age in the perception of lamb meat taste; it may be the sort of alimentation, preparation of meat, consumption habits and the customs of the region [24].

Moisture content of meat was similar to that found by Louvandini et al. [21] (67% DM); protein content was higher (60.5 g/100 g) in relation to our study, probably due to its expressed as fresh matter. Fat content was lower in relation to Louvandini et al. [21] (18.2 g /100g), these differences may be due to several factors, among them, the age of animals, therefore the amount of fat and the technique used for determination. Borton et al. [23,39] observed that at a heavier weight at slaughtering turned into 50-80% fatter in the leg, loin, rib, and chump; this might explain why in this study we have lower amount of fat in the leg of the animals.

4. CONCLUSION

The use of feed supplementation with diets containing soya bean meal or fish meal in grazing lambs, did not affect directly the carcass conformation and the sensory characteristics of the meat, juiciness of the meat showed a variation regarding the type of food supplementation used, without affect the tenderness, flavor and aroma in the meat. Meat fat content was higher in animals feed with fishmeal diets.

ETHICAL APPROVAL

All authors hereby declare that "principles of laboratory animal care" (nih publication no. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee". The management of the lambs and all procedures in the present study were performed according to the animal experimental guidelines of the University Autonomous of the State of Mexico.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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