Bonagurio Gallo, Sarita; Arrigoni, Mario de Beni; da Silva C. Lemos, Ana Lúcia; Harada Haguiwara, Márcia Mayumi; Alves Bezerra, Helena Viel
Influence of lamb finishing system on animal performance and meat quality
Acta Scientiarum. Animal Sciences, vol. 41, e44742, 2019
Editora da Universidade Estadual de Maringá - EDUEM

DOI: https://doi.org/10.4025/actascianimsci.v41i1.44742

Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v41i1.44742

ANIMAL PRODUCTION

Influence of lamb finishing system on animal performance and meat quality

Sarita Bonagurio Gallo[1*], Mario de Beni Arrigoni[2], Ana Lúcia da Silva C. Lemos[3], Márcia Mayumi Harada Haguiwara[3] and Helena Viel Alves Bezerra[1]

[1]Departamento de Zootecnia, Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo, Avenida Duque de Caxias Norte, 225, 1365-900, Pirassununga, São Paulo, Brazil. [2]Faculdade de Medicina Veterinária e Zootecnia, Universidade Estadual Paulista "Júlio de Mesquita Filho", Botucatu, São Paulo, Brazil. [3]Centro de Tecnologia da Carne, Instituto de Tecnologia de Alimentos, Campinas, São Paulo, Brazil. *Author for correpondense. e-mail: saritabgallo@usp.br

ABSTRACT. This study aimed to assess the influence of lamb finishing systems on zootechnical performance, as well as on carcass and meat quality. The experiment was conducted at the APTA's experimental farm. Thirty-three lambs were used – both sexes, initial age of 90 ± 3 days, Texel with Santa Inês, each animal being one experimental unit, with 6 males and 5 females per treatment. Treatments consisted of: lambs finished on pasture, in semi-feedlot or in feedlot. The lambs were slaughtered with average live weight of 35 kg. Weight gain and carcass measures were taken by ultrasound. After slaughter, carcass conformation and yield, pH, temperature, color, water retention capacity and tenderness were measured. Animals finished on pasture had lower weight gain, were slaughtered at an older age, with lighter carcass weight, smaller loin area, lower shank compactness index, besides lighter shoulder and shank weights, compared to the other production systems ($p < 0.05$). There was no difference between the semi-feedlot and the feedlot systems for the assessed characteristics. In conclusion, production systems affect animal performance, as well as carcass and meat quality, especially when it comes to important production aspects, such as slaughter age and yield of premium cuts.

Keywords: carcass conformation; carcass cut; feedlot; meat quality; pasture; sheep.

Received on September 25, 2018.
Accepted on October 25, 2018.

Introduction

Lamb meat presents beneficial properties for human nutrition, is a source of proteins and essential amino acids, and has low concentration of lipids and saturated fat (Alves, Osório, Fernandes, Ricardo, & Cunha, 2014). In addition, its flavor, color and smell are more accepted by consumers compared to those of older animals. For these reasons, farmers seek to finish young ovines, with a short life between birth and slaughter compared to other ruminants. Thus, producers need to properly plan and execute their production system. In order to help producers in their decision-making, studies on production systems are necessary, taking into account different breeds, nutrition and climate (Macedo, Siqueira, & Martins, 2000a; Osório et al., 2012).

There are different raising systems for lamb finishing in Brazil, with the most common ones being: animals raised on pasture only, on pasture with supplementation, and in feedlot. Pasture lamb finishing usually happens at properties with forage availability and quality compatible with the lamb's requirement. A negative point is forage seasonality over the year and sanitary problems such as helminthiasis. Feedlot is used to optimize soil utilization and finish lambs more quickly but draws attention to production costs and sanitary issues like eimeriids and urolithiasis. In semi-feedlot system, the animal stays on the pasture and is given food supplementation. The latter is used when there is available forage and has helminths as point of attention.

The implications of production systems on performance, meat quality and economical aspects have been investigated by different researchers (Macedo et al., 2000a; Poli et al., 2008; Salgado et al., 2018), but it is still a point of discussion among scientists, producers and the meat industry. In this way, the objective of this study was to compare the influence of different lamb finishing systems on performance, as well as carcass and meat quality.

Material and methods

The experiment was run at the APTA's Regional Center of Northwestern São Paulo in the city of Votuporanga, state of São Paulo – Brazil. The city is located at coordinates 20º 25' 13" south latitude, 49° 58′ 42″ west longitude, at a height of 499 m, and has dry tropical climate.

The lambs had an average weight of 3.6 kg at birth and were weaned with an average live weight of 18 kg at 90 days, when the lamb finishing phase began (experiment start). Thirty-three mixed lambs were used – Texel with Santa Inês – males and females randomly distributed into three treatments, in which different finishing systems were compared: pasture, semi-feedlot and feedlot. Each treatment counted with six males and five males, and each animal was taken as one experimental unit. The experiment was considered completed when the average live weight of the lambs reached 35 kg, after which they were slaughtered.

Animals finished on pasture stayed in the finishing phase for four months, and there was difference as to forage bromatological composition over this period; Table 1 displays the average for the period only. Forage consisted of *Panicum Maximum* cv. Aruana and access to mineral salt. Salt consumption was unlimited, with average daily consumption of 10 grams. The composition of the mineral, as per the manufacturer's specification, was: Calcium (min) 145 g kg^{-1}, Calcium (max) 160 g kg^{-1}, Phosphorus (min) 85 g kg^{-1}, Sodium (min) 135 g kg^{-1}, Magnesium (min) 10 g kg^{-1}, Sulfur (min) 18 g kg^{-1}, Iodine (min) 80 mg kg^{-1}, Manganese (min) 1400 mg kg^{-1}, Molybdenum (min) 150 mg kg^{-1}, Selenium (min) 25 mg kg^{-1}, Cobalt (min) 60 mg kg^{-1}, Zinc (min) 4000 mg kg^{-1}, Fluorine (max) 850 mg kg^{-1}.

Forage availability was *ad libitum* for animals raised on pasture, for minimum consumption of 3% of the live weight in dry matter. Forage amount was measured every 15 days with a ruler and the square of $1m^2$. Semi-feedlot lambs stayed on an Aruana grass pasture, supplemented with concentrate at 2% of their live weight.

Feedlot lambs were provided a diet composed of 20% of roughage and 80% of concentrate, with consumption adjusted *ad libitum*. The roughage source used in the diets of the feedlot animals was cut Tifton hay cut. The animals were fed twice a day; the offer level was adjusted to 20% of leftovers in order to keep *ad libitum* consumption; offers and leftovers were daily weighted to calculate dry matter consumption.

The diet was formulated so as to have a high protein level in order to meet the demand of animals still growing. The energy level did not surpass 3% of ethereal extract so that there was no supplementation nutritional difference between production systems. Samples of the food provided and the leftover were analyzed, every 15 days, to quantify dry matter, crude protein Association Official Analytical Chemist (AOAC, 2005), ADF and NDF (Van Soest, Robertson, & Lewis, 1991).

Endoparasitic infection was controlled by means of the Famacha method, in accordance with methodology proposed by Cintra, Ollhoff, and Sotomaior (2018), every 28 days, the animals' conjunctiva color was checked, comparing it with a graphic scale that sets five categories. Only those that presented problems were dewormed.

Table 1. Bromatological composition of foods and total feed used in lamb finishing in three different finishing systems.

Composition (%)	Aruana Pasture	Concentrate Semi	Tifton Hay	Concentrate Feedlot
Dry Matter (DM)	30.69	89.27	90.66	90.27
Crude Protein (DM%)	7.09	22.52	15.65	19.04
Ethereal Extract (DM%)	1.76	2.80	2.01	3.38
NDF (DM%)	77.13	11.90	72.30	11.70
ADF (DM%)	43.89	6.37	41.00	6.10
Ashes (DM%)	9.96	6.28	7.37	4.58
Calcium (DM%)	0.47	0.82	0.40	0.58
Phosphorus (DM%)	0.27	0.42	0.30	0.33
Total Feed		Semi-feedlot		Feedlot
Dry Matter (%)		90.00		90.35
Crude Protein (DM%)		18.91		18.30
Ethereal Extract (DM%)		2.38		3.09
NDF (DM%)		43.65		24.37
ADF (DM%)		34.11		13.40
Ashes (DM%)		6.78		5.15
Calcium (DM%)		0.59		0.54
Phosphorus (DM%)		0.33		0.30

ADF- acid detergent fiber; NDF- neutral detergent fiber.

The lambs were weighed at birth, every 14 days, and, when close to the slaughter weight, they were then weighed every 7 days, without prior fasting. Thus, it was possible to calculate the daily average weight gain from birth to weaning (WGBW) and the average daily weight gain from weaning to slaughter (WGWS)

Upon reaching the average live weight of 35 kg (slaughter weight) for the treatment – both males and female – the carcass was analyzed by ultrasound, through device PIEMEDICAL Scanner 200 VET, in real time, with a 3.5 MHz transducer and an 18 cm acoustic guide. For reading, shearing and cleaning were done first in the area between the 12th and the 13th ribs on the animal's left side. The transducer was placed in a perpendicular way in relation to the length of muscle *Longissimus dorsi*. With the image, it was possible to read the loin eye area (LEA) and the subcutaneous fat thickness (SFT). This measurement allowed comparing values measured *in vivo* with measures obtained in the carcass and assessing the use of ultrasound as prediction instrument.

The experiment was finalized when the average weight of the animals per treatment reached 35 kg of live weight. The lambs' finishing period was 173 days for pasture animals, 60 days for semi-feedlot and 69 days for feedlot. After a solid fast of 16 hours, the animals were transported to Nhandeara Slaughterhouse, located in the municipality of Nhandeara, São Paulo, 35 km far from the city of Votuporanga, SP, in a sheep-specific truck. Slaughtering was done with federal inspection, that is, in compliance with humanitarian procedures, as required by the Brazilian legislation. First, the animals were numbed through stunning by penetrating captive bolt, and, immediately after, bloodletting was performed from the section of their necks' great vessels. Subsequently, skinning, evisceration and carcass cleaning were carried out, following normal procedures used by the industry.

The carcasses were identified and weighed individually for determination of hot carcass weight (HCW) and hot carcass yield (HCY). After 24 hours of refrigeration at an average temperature of 5°C, the carcass was again weighed to obtain the cold carcass weight (CCW). The carcasses were cut in half and weighed, and the commercial cuts were separated: neck, arms (front and back), shoulder, rack, loin, breast-flank, and shank. Cut yields were calculated in relation to the weight of the cold half carcass.

The pH and temperature of muscle *Longissimus* in the area between the 12th and the 13th ribs were determined 45 minutes and 24h after slaughter, using a digital portable pH meter, model HI 99163 (Hanna Instruments, São Paulo, Brazil). Then, the loin area (LEA, cm^2) was defined by dividing muscle *Longissimus dorsi*, after a cross-sectional cut between the 12th and the 13th ribs, outlining it on tracing paper for later measurement with planimeter (Menezes et al., 2015). Subcutaneous fat thickness was measured in the same region (SFT, mm) of the loin, with the aid of a pachymeter

The following carcass measures were taken in accordance with methodology described by Cezar and Sousa (2007): degree of fat, conformation, inner and outer leg length, rump and thorax width, in addition to carcass and leg compactness index.

The half carcass was divided into commercial cuts. The *longissumus* was boned, packed in aluminum foil and cooled at 4°C; meat samples were taken to the Food Technology Institute at the Meat Technology Center for other analyses.

Meat color was assessed 25 minutes after the *longissimus* was cut into 2.5 cm-thick steaks, considering the CIE L*, a*, b* system (Comission International de l'Eclairage [CIE], 1986). Measures were taken using a portable spectrophotometer, model CM2500d (Konica Minolta Brasil, São Paulo, Brazil).

To determine cooking loss (CL) and shear force (SF), the methodology proposed by the American Meat Science Association (AMSA, 2012) was adopted. After color determination, the samples were weighed individually for initial weight determination. Then, a thermometer was inserted in the geometric center of each one of the samples, and the latter were put in an industrial electric oven at 170°C until reaching internal temperature of 40°C, after which they were turned and stayed there until reaching an internal temperature of 71°C. Subsequently, the samples stayed at room temperature (22°C) until cooling down, and were then weighed again. Afterwards, 4 to 6 cylinders were taken from each sample, parallel to the fibers, and were sheared using the Warner – Brazier device for shear force determination.

A fully randomized design was employed, in factorial arrangement, corresponding to 3 finishing systems (pasture, feedlot and semi-feedlot) and 2 sexes (female and male), and interaction between factors. All data were analyzed by analysis of variance through procedure MIXED of software Statistical Analysis System (SAS, 2013). For meat pH and temperature values, plots subdivided in time were used. Mean comparisons were done by Tukey's test, with statistical probability of up to 5%.

Results and discussion

The feedlot lambs' average diet consumption (roughage plus concentrate) based on dry matter was 0.90 kg animal^{-1} day^{-1}, and the semi-feedlot lambs' average concentrate consumption was 0.76 kg animal^{-1} day^{-1}. Feedlot and semi-feedlot animals reached slaughter weight 108 days sooner compared to pasture-finished lambs (Table 2). This happened due to lower ingestion of crude protein and energy, and higher fiber ingestion. These results reinforce the importance of pasture supplementation in case of insufficient quantity or quality to meet the nutritional requirements of the animal, especially if the production goal is to slaughter young animals.

Hot and cold carcass weights were similar among lambs finished in feedlot and semi-feedlot, and the lowest values of these variables were found for animals finished on pasture. There was no significant difference between treatments for carcass yield.

Daily weight gain from weaning to slaughter of lambs finished in feedlot and semi-feedlot, for both males and females, was higher compared to lambs finished on pasture. The females' absolute weight gain values were lower in relation to that of males, only in semi-feedlot.

The slaughter age of lambs finished in feedlot and semi-feedlot in this experiment corroborates with the first two slaughter ages of feedlot Santa Inês lambs studied by Queiroz et al. (2015), which were 145, 156 and 190 days, with live weight of 27.14, 33.84 and 34.85 kg, respecitvely. This indicates that the weight gain verified in this experiment fits the breed standards used, which are breedings that allow for higher meat production, muscle development and carcass conformation, being of great importance and capable of raising productivity in a shorter period of time.

As for carcass conformation characteristics, there was no influence from the different finishing types for most studied aspects, with the exception of carcass compactness index (CCI), which was lower for pasture-finished lambs compared to the other systems (Table 3).

With conformation, it is possible to assess the muscle development of the carcass. In most countries involved in sheep carcass trading, conformation is adopted as evaluation criteria, with carcasses of superior conformation being more valued (Macedo, Siqueira, Martins, & Macedo, 2000b).

Table 2. Performance and carcass data of lambs (males and females) in three finishing systems

	Pasture	Semi-feedlot	Feedlot	SEM	P
SA[1] (days)	263 B	150 A	159 A	9.0600	*
WGBW[2] (kg day^{-1})	0,159	0.170	0.185	0.0070	NS
WGWS[3] Female (kg day^{-})	0.100 a B	0.211 b A	0.236 a A	0.0140	*
WGWS Male (kg day^{-})	0.133 a B	0.318 a A	0.288 a A	0.0150	*
Farm weight (kg)	35	36	35	0.2545	NS
Slaughter weight (kg)	32	34	34	0.2125	NS
HCW[4] (kg)	15.00 B	17.26 A	17.23 A	0.1839	*
CCW[5] (kg)	14.90 B	17.14 A	17.04 A	0.1775	*
CY[6] (%)	45	50	45	0.0032	NS

[1]Slaughter age; [2] weight gain from birth to weaning; [3] weight gain from weaning to slaughter; [4] hot carcass weight; [5] cold carcass weight; [6] carcass yield. SEM – standard error of the mean; P – statistical probability; NS – non-significant; * significant at p < 0.05. A,B indicate different means in the row by t test (p < 0.05). a,b indicates different means in the column by t test (p < 0.05)

Table 3. Carcass conformation measures of lambs (males and females) in three different finishing systems.

	Pasture	Semi-feedlot	Feedlot	SEM	P
DF[1] (1 - 5)	2.50	2.77	2.75	0.0309	NS
DC[2] (1 - 5)	2.18	2.91	2.70	0.0629	NS
CIL[3] (cm)	54.00	54.50	54.41	0.3329	NS
CEL[4] (cm)	63.00	60.00	60.58	0.4390	NS
LL[5] (cm)	39.75	40.16	38.75	0.3235	NS
RW[6] (cm)	18.62	19.35	18.92	0.1600	NS
TW[7] (cm)	21.47	20.94	19.85	0.2708	NS
TP[8] (cm)	26.47	26.79	27.12	0.1463	NS
CCI[9] (kg/cm)	0.26 B	0.31 A	0.30 A	0.0039	*
LCI[10] (kg/cm)	0.46	0.48	0.48	0.0066	NS

[1]Degree of fat; [2] degree of conformation; [3] carcass internal length; [4] carcass external length; [5] leg length; [6] rump width; [7] thorax width; [8] thorax perimeters; [9] carcass compactness index; [10] leg compactness index. SEM – standard error of the mean; P – statistical probability; NS – non-significant; * significant at p < 0.05. A,B means followed by different letters indicate statistical difference by t test (p < 0.05).

CCI is an indicative of the correlation between carcass weight and length and assesses the amount of tissue deposited per unit of length. This index is an indirect measure of conformation and is used to assess muscle production in animals with similar live weight (Simela, Ndlovu, & Sibanda, 1999). Factors such as breed and live weight at slaughter may influence the CCI; a higher index is likely to be found in cutting breeds, since muscle development is higher (Sañudo et al., 2006). This explains why animals finished in pasture system have lower CCIs, which is also corroborated by abovementioned studies. Cartaxo et al. (2009), studying Santa Inês lambs in feedlot, slaughtered at an age of around 150 days and with live weight of 26 kg, found a lower CCI (0.24) than that of the three finishing systems of this study. A similar CCI (0.23) was found for crossbred Texel x Esguerra lambs slaughtered with an average live weight of 25.9 kg (Blasco, Campo, Balado, & Sañudo, 2016).

The lambs raised on pasture presented smaller half carcass, shoulder and rack cuts than the others. However, as for cut percentage, there was no statistical difference ($p > 0.05$, Table 4).

According to Huidobro and Cañeque (1993), cuts that compose the carcass have different economical values, and their proportion is an important index for assessment of carcass commercial quality. The main commercial cuts of sheep carcass are shoulder, shank, loin and rack. In the present study, there was no difference in cut proportion between the three different finishing systems, but half carcass, shoulder and rack weights were higher for lambs finished in feedlot and semi-feedlot compared to lambs finished on pasture. This result corroborates with the lower indexes presented by pasture-finished animals. Grandis et al. (2016) found similar commercial cut proportions compared to those of this study. Mcmanus et al. (2013) observed that Santa-Inês lambs had an average half carcass weight of 7.09 kg, similar to that of lambs finished on pasture, and inferior to that of the other systems in this study.

Tissue composition varies by genotype, sex, diet, and slaughter weight and age (Grandis et al., 2016). The basic tissues that make up the carcass (muscle, bone and fat) are fundamental to determine the value of the carcass and its cuts (Osório et al., 2012). The finishing system did not influence the proportions of muscle, bone, fat and others. Nevertheless, loin muscle and fat proportion were influenced by sex; females presented lower muscle proportions and higher fat proportions in relation to males (Table 5).

Table 4. Weights of commercial carcass cuts of lambs (males and females) in three different finishing systems

Cuts, weight (kg)	Pasture	Semi-feedlot	Feedlot	SEM	P
½ carcass weight	6.95 B	8.20 A	7.93 A	0.0909	*
Neck	0.93	1.12	1.01	0.0216	NS
Shoulder	1.06 B	1.27 A	1.27 A	0.0167	*
Rack	1.17 B	1.41 A	1.41 A	0.0218	*
Loin	0.48	0.65	0.60	0.0133	NS
Breast-flank	1.51	1.75	1.29	0.0384	NS
Shank	1.92	2.27	2.15	0.0269	NS
Front arm	0.30	0.33	0.30	0.0054	NS
Back arm	0.37	0.42	0.37	0.0098	NS
Cuts, proportion (%)	Pasture	Semi-feedlot	Feedlot		
Neck	15.21	13.55	12.39	0.1985	NS
Shoulder	15.29	15.63	16.00	0.1454	NS
Rack	16.91	17.26	17.69	0.2058	NS
Loin	7.00	7.95	7.61	0.1631	NS
Breast	21.81	21.26	21.22	0.1929	NS
Shank	27.69	27.26	26.90	0.2343	NS
Front arm	4.33	4.12	3.75	0.0055	NS
Back arm	5.39	5,14	4,74	0.0899	NS

SEM – standard error of the mean; P – statistical probability; NS – non-significant; * significant at $p < 0.05$. A,B means followed by different letters indicate statistical difference by t test ($p < 0.05$).

Table 5. Mean values for proportions of muscle, bone, fat and others of the *L. dorsi* of lambs (males and females) in three different finishing systems.

L. dorsi	Pasture	Semi-feedlot	Feedlot	SEM	P
Muscle (%)	57.66	57.24	57.88	0.0072	NS
Bone (%)	20.60	21.00	19.00	0.0038	NS
Fat (%)	19.07	19.00	19.40	0.0045	NS
Others (%)	2.67	2.76	2.92	0.0011	NS
	Female		Male		
Muscle %	55.23 B		60.02 A	0.1020	*
Fat (%)	22.58 A		16.59 B	0.4079	*

SEM – standard error of the mean; P – statistical probability; NS – non-significant; * significant at $p < 0.05$. A,B means followed by different letters in the row indicate statistical difference by t test ($p < 0.05$).

Queiroz et al. (2015) found a muscle, bone and fat proportion of 55.9, 20.9 and 23.6, respectively, in male, uncastrated Santa Inês lambs slaughtered with a 3mm SFT. It is worth highlighting that the lambs were fed a high-concentrate diet, which favors a higher fat deposition in the carcass.

Initial and final pH values stood around 6.80 and 5.50 on average, respectively (Table 6). Initial and final temperature ranged from 34 to 9°C, respectively. The finishing system and sex did not influence pH values and temperature. pH is the main indicator of the final quality of the meat, as it has a significant influence on quality parameters. For sheep, when measuring the pH of a recently-slaughtered animal's carcass, the value should be around 7.0 to 7.3. Found pH24 values vary between 5.5 and 5.8, which are influenced by several factors, such the animal's sex, slaughter age, production system, genetics and pre-slaughter management (Zimerman, Grigioni, Taddeo, & Domingo, 2011), indicating that the pH values in this study are normal, and the meat did not present quality issues.

Lambs finished in feedlot presented lower SF values, with a meat tender than the others, followed by semi-feedlot and pasture lambs. There was no significant difference between treatments or sex for CWL (Table 6).

It is possible to observe that the LEA of animals finished on pasture was inferior to that of animals finished in the other systems (Table 6). The correlation between measures obtained by ultrasound and in the carcass for SFT was 0.71, and 0.81 for LEA, values considered high, corroborating with the use of *in vivo* analyses for carcass prediction. LEA measurement is important to predict carcass yield because this index correlates with carcass meat percentage, and subcutaneous fat thickness measure, assessed in muscle *Longissimus dorsi*, highly correlates with carcass fat composition (Cartaxo & Sousa, 2008).

Queiroz et al. (2015) found higher UFT and SFT values (2.97 mm and 3.02 mm, respectively) in Santa Inês lambs finished in feedlot and slaughtered upon reaching the average live weight of 33 kg, with average age of 155 days. Grandis et al. (2016), assessing male, uncastrated Santa Inês lambs fed different amounts of soybean cake, observed average mean value for LEA of 14.60 cm^2, and 2.53 mm for SFT. The different results for SFT may derive from the difference between diet composition, slaughter weights and genetic groups.

Males presented higher L* and b* values compared to females, regardless of finishing system. Moreover, within each sex, that is, among males or females, animals finished in feedlot presented higher L* and b* values, followed by semi-feedlot and pasture. Females showed higher a* values compared to males, regardless of finishing system (Table 7).

Factors such as genetics, production system, nutrition, age and final meat pH may influence L*, a* and b* values. These values may change as slaughter weight increases, due to muscle development, as it raises the amount of myoglobin, and fat deposition is evidenced, consequently decreasing the amount of water in the muscle. As a result, there are lower L* values, which represent luminous intensity. Although slaughter weight was the same for both sexes, males were slaughtered more heavier and were more muscular than the females (Table 6), which may have interfered with the meat color assessment.

Table 6. Quality parameters of lamb meat (males and females) in three different finishing systems

Parameters	Pasture	Semi–feedlot	Feedlot	SEM	P
pH 15 min	6.90	7.12	6.92	0.0312	NS
Temp 15 min	32.60	36.33	32.42	0.4448	NS
pH 24h	5.40	5.45	5.54	0.0143	NS
Temperature 24h	11.35	11.90	10.91	0.3011	NS
CWL (%)	31.94	29.81	28.66	0.1345	NS
SF (kg)	5.06 C	4.97 B	3.55 A	0.1560	*
UFT (mm)	1.10	1.30	1.60	0.0386	NS
ULEA (cm^2)	9.00 B	15.44 A	13.65 A	0.0294	*
SFT (mm)	1.05	1.25	1.57	0.0976	NS
LEA (cm^2)	10.90 B	15.40 A	14.00 A	0.0389	*

pH 15 minutes and 24 hours after slaughter; Temp – temperature 15 minutes and 24 hours after slaughter; CWL – cooking weight loss; SF – shear force; UFT – ultrasound fat thickness; ULEA – ultrasound loin eye area; SFT – subcutaneous fat thickness; LEA – loin eye area. SEM – standard error of the mean; P – statistical probability; NS – non-significant; * significant at $p < 0,05$.

Table 7. Color parameters (L*, a, b) of lamb meats (males and females) in three different finishing systems.

Parameters	Pasture	Semi – feedlot	Feedlot	P
L*				
Female	25.51±0.42 Bb	26.08±0.52 Bab	27.00±0.55 Bb	*
Male	29.55 ±0.28 Aa	30.21±0.46 Aa	31.68±0.46 Ab	*
a*				
Female	14.00 ±0.20 Bb	15.17 ±0.25 Ba	14.91 ±0.26 Ba	*
Male	13.14 ±0.13 Aa	13.16 ±0.22 Aa	12.24 ±0.22 Ab	*
b*				
Female	6.60 ±0.20 Ba	8.34 ±0.22 Bb	8.90 ±0.28 Bb	*
Male	9.00 ±0.23 Aa	9.39 ±0.14 Aab	9.85±0.23 Ab	*

L* - luminosity level; a* - red level; b* - yellow level; SEM – standard error of the mean; P statistical probability; NS – non-significant; * significant at $p < 0.05$. Capital letters distinguish means in the column, and lower-case letters distinguish means in the row, by t test.

Conclusion

In conclusion, production system affects animal performance, as well as carcass and meat quality, especially as to important production aspects such as slaughter age and premium cuts. Nutritional supplementation is important to produce a higher-quality meat.

Acknowledgements

The authors thank FAPESP for funding project 05/55805-7.

References

Alves, L. G. C., Osório, J. C. S., Fernandes, A. R. M., Ricardo, H. A., & Cunha, C. M. (2014). Produção de carne ovina com foco no consumidor. *Enciclopédia Biosfera, Centro Científico Conhecer-Goiânia, 10*(18), 2399-2415.

American Meat Science Association [AMSA]. (2012). *Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Meat*. Chicago, IL: AMSA.

Association Official Analytical Chemist [AOAC]. (2005). *Official Methods of Analysis* (18th ed.). Gaitherburg, MD: AOAC International.

Blasco, M., Campo, M. M., Balado, J., & Sañudo, C. (2016). Influencia del cruce industrial en los rendimientos productivos y la calidad dela canal de corderos de la raza ovina Segureña. *Archivos de Zootecnia, 65* (251), 421-424.

Cartaxo, F. Q., & Sousa, W. H. (2008). Correlações entre as características obtidas in vivo por ultra-som e as obtidas na carcaça de cordeiros terminados em confinamento. *Revista Brasileira de Zootecnia, 37*(8), 1490-1495.

Cartaxo, F. Q., Cezar, M. F., Sousa, W. H., Gonzaga Neto, S., Pereira Filho, J. M., & Cunha, M. G. G. (2009). Características quantitativas da carcaça de cordeiros terminados em confinamento e abatidos em diferentes condições corporais. *Revista Brasileira de Zootecnia, 38*(4), 697-704. doi: 10.1590/51516-35982009000400016.

Cezar, M., & Sousa, W. (2007). *Carcaças ovinas e caprinas: obtenção, avaliação e classificação*. Uberaba, MG: Editora Agropecuária Tropical.

Cintra, M. C. R., Ollhoff, R. D., & Sotomaior, C. S. (2018). Sensitivity and specificity of the FAMACHA© system in growing lambs. *Veterinary Parasitology, 251*, 106-111. doi: 10.1016/j.vetpar.2012.06.006.

Comission International de l'Eclairage [CIE]. (1986). *Industrial Colour-Difference Evaluation.* Viena, AT: CIE.

Grandis, F. A., Ribeiro, E. L. A., Mizubuti, I. Y., Bumbieris Junior, V. H., Prado, O. P. P., & Pinto, A. P. (2016). Características de carcaça e qualidade da carne de cordeiros alimentados com diferentes teores de torta de soja em substituição ao farelo de soja. *Ciência Animal Brasileira, 17*(3), 327-341.

Huidobro, F. R., & Cañeque, V. (1993). Producción de carne em corderos de raza Manchega. II. Conformación y estado de engrasamiento de la canal y proporción de piezas en distintos tipos comerciales. *Investigación Agraria. Producción y Sanidad Animal, 8*(3), 233-234.

Macedo, F. A. F., Siqueira, E. R., & Martins, E. N. (2000a). Análise econômica da produção de carne de cordeiros sob dois sistemas de terminação: pastagem e confinamento. *Ciência Rural, 30*(4), 677-680.

Macedo, F. A. F., Siqueira, E. R., Martins, E. N., & Macedo, R. M. G. (2000b). Qualidade de carcaças de cordeiros Corriedale, Bergamácia x Corriedale e Hampshire Down x Corriedale, terminados em pastagem e confinamento. *Revista Brasileira de Zootecnia, 29*, 1520-1527. doi: 10.1590/S1516-35982006000700025.

Mcmanus, C., Paim, T. P., Louvandini, H., Dallago, B. S. L., Dias, L. T., & Teixeira, R. A. (2013). Avaliação ultrasonográfica da qualidade de carcaça de ovinos Santa Inês. *Ciência Animal Brasileira, 14*(1), 8-16. doi: 10.5216/cab.v14i1.12336.

Menezes, M. C., Brito, P. D., Lima, T. d. S., Magalhães, J. M., Albuquerque, J. F. G., & Freitas, C. I. A. (2015). Comparative evaluation of methods for obtaining the measure of loin-eye area in sheep (*Ovis aries* L.). *Ciência Veterinária nos Trópicos, 18*(2), 205-208.

Osório, J.C.S., Osório, M.T.M., Vargas Júnior, F.M., Fernandes, A.R.M., Seno, L. O., Ricardo, H.A., ... & Orrico Junior, M.A.P. (2012). Critérios para abate do animal e a qualidade da carne. *Revista Agrarian*, 5, 433-443.

Poli, C. H. E. C., Monteiro, A. L. G., Barros, C. S., Moraes, A., Fernandes, M. A. M., & Piazzetta, H. v. L. (2008). Produção de ovinos de corte em quatro sistemas de produção. *Revista Brasileira de Zootecnia, 37*(4), 666-673.

Queiroz, L. O., Santos, G. R. A., Macedo, F. d. A. F., Mora, N. H. A. P., Torres, M. G., Santana, T. E. Z., & Macedo, F. G. (2015). Características quantitativas da carcaça de cordeiros Santa Inês, abatidos com diferentes espessuras de gordura subcutânea. *Revista Brasileira de Saúde e Produção Animal, 16*(3), 712-722. doi: 10.1590/S1519-99402015000300021.

Salgado, J. A., Molento, M. B., Sotomaior, C. S., Dias, L. T., Castro, L. L. D., Faisca, L. D., & Monteiro, A. L. G. (2018). Endoparasite and nutritional status of Suffolk lambs in seven production systems. *Animal Production Science, 58*(9), 1667-1676. doi: 10.1071/AN16437.

Sañudo, A. (2006). Calidad de la canal y de la carne en los ovinos: factores que la determinan. *Revista Argentina de Producción Animal, 26* (2), 155-167.

Simela, L., Ndlovu, L. R., & Sibanda, L. M. (1999). Carcass characteristics of the marketed Matebele goat from south-western Zimbabwe. *Small Ruminant Research, 32*(2), 173-179.

Statistical Analysis System [SAS]. (2013). *SAS/STAT User guide, Version 9.4.* Cary, NC: SAS Institute Inc.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74*(10), 3583-3597. doi: 10.3168/jds.S0022-0302(91)78551-2.

Zimerman, M., Grigioni, G., Taddeo, H., & Domingo, E. (2011). Physiological stress responses and meat quality traits of kids subjected to different pre-slaughter stressors. *Small Ruminant Research, 100*(2–3), 137-142. doi: /10.1016/j.smallrumres.2011.06.011.