

Muscularity and Leg Tissue Composition of Lambs Fed with Hydrolyzed Sugarcane

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Abstract—This study aimed to evaluate the muscularity and tissue composition of 24 legs of Ile de France lambs. They were fed with diets containing “in nature” or hydrolyzed sugarcane with 0.6% of calcium oxide in aerobic and anaerobic environments. Animals entered the trial at 15 and were slaughtered at 32 kg of body weight. The leg tissue composition, as well as muscularity (0.47), muscle:bone (6.66) and muscle:fat (4.25) were not affected ($P>0.05$) by treatments. The proportions found were: 67.62% for muscle, 17.52% for bone and 10.15% for fat. In relation to lambs fed with “in nature” sugarcane, hydrolyzed sugarcane with calcium oxide in aerobic and anaerobic environments did not affect muscularity and leg tissue composition of lambs.

Keywords—calcium oxide, feedlot, *Saccharum officinarum*

I. INTRODUCTION

THE use of specialized breeds for meat production has great potential for weight gain in less time and with better yield and grade of the carcasses [1]. The use of methods that assess the carcasses and allow to predict their quality, composition, muscle, bone and fat, as well as cut yields is essential [2]. A very accurate method to determine the tissue composition of the carcass is the dissection of some commercial cuts, such as leg, shoulder and loin. The method consists in the separation of the muscle, bone and fat, but the dissection of the whole carcass is only justified in some cases once it is a laborious and time consuming procedure.

According to [3], the dissection of the leg or shoulder is more common due to their high correlation with carcass tissue composition and together constitute over 50% of the lamb carcass. The proportion of muscle in the carcass can also be estimated by the muscularity of the leg, which considers the average depth of a group of muscles surrounding the femur in relation to the length of this bone [4].

The amount of muscle in the carcass is the most important component to the consumer market. Fat amount is the second most important and it varies according to the preference of each region. Therefore, the consumer market seeks a carcass that provides maximum deposition of muscle and enough fat to provide satisfactory organoleptic characteristics to whom tastes it [5]. Currently, is not enough to produce greater quantities of meat cheaply, the consumer market increasingly requires uniformity and quality of carcass cuts, and it is needed studies about factors that influence tissue composition of carcass cuts to provide good quality [6].

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Ruminants diet is composed of concentrate and roughage. Concentrates are responsible for higher costs, meanwhile roughage have more affordable prices [7].

Thus, the use of sugarcane as roughage is feasible because it is a tropical grass. It presents a high potential for production of dry matter and energy per unit of area. Provides in one cut 15 to 20 tons of natural matter per hectare, besides maintains its productivity during dry periods of the year, when there is shortage of forage. However, it has limitations such as low crude protein (2 to 4%), high levels of non-degradable fibers, slowly ruminal degradation fibers and low content of minerals, especially phosphorus, sulfur, zinc and manganese.

Diets containing sugarcane need to be corrected with protein and mineral supplements of good quality [2]. Alkaline hydrolysis has been used in order to reduce fiber levels and increase the consumption by ruminants. It also enables its storage for few days while minimizing costs with work hours. Calcium oxide is a mineral product with better economic value, easy and efficient acquisition and storage because it fixes the calcium content of sugarcane with low risk of contamination [8].

The application of calcium oxide in the sugarcane raises the pH and after aerobic exposure decreases it. This occurs linearly, but it is not interesting, because the drop in pH occurs by action of microorganisms. They consume the soluble carbohydrates and cause acidification of sugarcane, thus the aerobic stability of sugarcane decreases [9]. In the sugarcane hydrolysis in anaerobic environment, i.e., without the exposure of oxygen, theoretically, in the course of time pH gradually decreases less than aerobic hydrolysis exposure, this may result in a less favorable environment for development of aerobic microorganisms, such as yeasts.

This study aimed to evaluate the muscularity index, tissue composition, muscle:bone ratio and muscle:fat ratio from legs of Ile de France lambs fed with “in nature” or hydrolyzed sugarcane with 0.6% of calcium oxide.

II. MATERIAL AND METHODS

The study was conducted at the Faculdade de Ciências Agrárias e Veterinárias - FCAV / Unesp, Jaboticabal, São Paulo. It was used 24 uncastrated lambs Ile de France, animals entered the trial at 15 and were slaughtered at 32 kg of body weight. The treatments were IN: “in nature” sugarcane + concentrate; AER: hydrolyzed sugarcane with 0.6% calcium oxide (CaO) in aerobic environment + concentrate and ANA: hydrolyzed sugarcane with 0.6% with 0.6% CaO + concentrate, providing a completely randomized design with 8 replicates per treatment. Feedlot lambs were raised individually in approximately 1.0m² with slatted and suspended floor, equipped with individual feeders and water drinkers installed in covered sheds, with diets contend 21% crude protein (CP), allowing 10% of leavings.

The variety of sugarcane used was IAC 86-2480 and the concentrate consisted of ground corn, soybean bran, urea, sodium chloride, calcium carbonate, dicalcium phosphate and vitamin and mineral supplements, making isoproteic (21% CP) and isoenergetic diets (2.6 Mcal of metabolizable energy/kg of DM), according to [10]. The diet with roughage:concentrate ratio of 50:50, was offered *ad libitum* at 8:00 and 17:00 o'clock.

At 32 kg of body weight, lambs were weighed and fasted of solid diet for 16 hours, being numbed by electronarcosis and then slaughtered by electro-section of the jugular veins and carotid arteries. After evisceration, carcasses were weighed and transferred to cold storage at 6°C for 24 hours, hanging by the gastrocnemius tendons, on appropriated hooks and spaced 17 cm. After weighing, carcasses were split longitudinally and sectioned into five anatomic regions: neck, shoulder, ribs, loin and leg, according to the methodology adapted from [11]. Left legs were identified, stored in plastic bags and frozen at -18°C to subsequent dissection of all legs. The defrosting of the leg was held in the refrigerator at 10°C for 20 hours for subsequent individual weighing.

It was performed cleaning of legs, before the dissection, where all the extra tissue, associated fat, channels of fat, other soft tissues medial to the pelvic bone and the caudal vertebrae, except for the first two were removed. Distal end of the tibia bone were also removed, leaving the gastrocnemius tendon loose, and then it was made cleaning above the sacral vertebrae, removing the fold of the flank muscles, fat in the pelvic canal and the tarsometatarsal joint [7].

The clean legs were weighed and the dissection started with the help of a scalpel and a knife to determine the composition of tissues: subcutaneous fat (external fat located directly beneath the skin), intermuscular fat (fat beneath the deep fascia, associated with muscles), muscles (total muscle dissected after the complete removal of all attached subcutaneous and intermuscular fat) and bones (total of bones dissected after the complete removal of all muscles and attached intermuscular and subcutaneous fat), which were weighed individually to be expressed in percentage and in relation of the leg weight, as cited by [12].

The five muscles lining the femur, *Biceps femoris*, *Semitendinosus*, *Adductor*, *Semimembranosus* and *Quadriceps femoris* were removed and weighed separately to determine the muscularity index of the leg (1). The others that did not directly involve the femur were removed and weighed together to determine the percentage of total muscle. The bones were weighed together and then the femur was weighed individually, and its length measured with the aid of tape-measure, after being put in a compartment of attachment, allowing the measure to be made in its entire length, from the great caudal part of the trochanter to the femoral trochlea. The methodology used for dissection of the legs was proposed by [13]. The muscularity index of the leg was calculated according to [4]:

$$IM = \sqrt{\frac{PM5/CF}{CF}} \quad (1)$$

Here IM = muscularity index; PM5 = weight (g) of the five muscles lining the femur (*Biceps femoris*, *Semitendinosus*, *Adductor*, *Semimembranosus* and *Quadriceps femoris*) and CF = length (cm) of the femur.

The experiment was a completely randomized design with three treatments and eight replicates. Data were subjected to analysis of variance and the means compared by Tukey test at 5% significance, using the Computational Program [14] to perform the statistical analysis.

III. RESULTS AND DISCUSSION

It is shown in Table I the muscularity index, the tissue composition, muscle:bone ratio and muscle:fat ratio of the legs of Ile de France lambs fed with "in nature" or hydrolyzed sugarcane with 0.6% of calcium oxide in aerobic and anaerobic environments. The proportions of muscle, bone and total fat found in this study were 67.62, 17.52 and 10.15%, respectively. Reference [2] reported lower muscle yield (63.00%), similar bone yield (17.4%) and higher for total fat (16.04%). This experiment, compared to the authors aforementioned found for muscle:bone ratio a value of 3.62, this was lower than 6.66 that was found in the present study. The muscle:fat ratio of 4.08 found by [2] was similar to 4.25 obtained in this study. According to [15] to assess the muscularity and the tissue composition in the lamb leg of different genotypes and slaughter ages presented a muscle:bone ratio value of 6.69, which was similar to our study. While [16] to assess tissue composition and leg muscularity of lambs fed with sunflower seeds and vitamin E, obtained superior muscle:bone ratio (7.04). The muscle:bone ratio provides the muscle index of the carcass [17], however this relationship may result from lighter bones, not necessarily from greater amount of muscle. The obtained femur length and weight were 16.17 cm and 130 g, [2] found 15.82 cm and 135 g. These femur measures may explain the lower value obtained by these authors for the muscle:bone ratio, compared with the results of this study. The length of the femur was lower, but the weight increased, indicating heavy bone. Reference [16] found 16 cm and 130 g for femur length and weight, respectively. The weight of the muscles (*Biceps femoris*, *Semitendinosus*, *Adductor*, *semimembranosus*, *Quadriceps femoris*) found in the present study was 0.984 kg, whereas for [15]-[2]-[16] were 1.100, 0.902 and 0.880 kg, respectively. In this work, the muscularity index was 0.47, confirming the values reported by [15]-[7]-[2]-[16] which respectively obtained values of 0.45, 0.40, 0.48 and 0.47. The muscularity of carcass is defined as the thickness of muscle in relation to the dimensions of the skeleton [18].

IV. CONCLUSION

In relation to lambs fed with "in nature" sugarcane, hydrolyzed sugarcane with calcium oxide in aerobic and anaerobic environments did not affect muscularity and leg tissue composition of lambs.

TABLE I
MUSCULARITY INDEX AND LEG TISSUE COMPOSITION OF LAMBS FED WITH "IN NATURE" OR HYDROLYZED SUGARCANE

Variable	Treatment ¹			Pr > F	CV ² (%)
	IN	AER	ANA		
Weight of the leg (kg)	2.07	2.10	2.10	0.84	4.80
Total muscle (%)	68.03	68.03	66.86	0.62	3.78
Leg muscle:					
Weight of five muscles (kg)	0.74	0.83	0.84		
<i>Biceps femoris</i> (kg)	0.16	0.17	0.17	0.49	8.94
<i>Semitendinosus</i> (kg)	0.08	0.08	0.08	0.63	11.93
<i>Semimembranosus</i> (kg)	0.19	0.20	0.21	0.33	8.85
<i>Adductor</i> (kg)	0.08	0.09	0.09	0.90	16.09
<i>Quadriceps femoris</i> (kg)	0.23	0.29	0.29	0.19	9.92
Total fat (%)	9.44	9.59	11.35	0.24	21.99
Subcutaneous fat (%)	5.39	5.93	6.43	0.59	30.23
Intermuscular fat (%)	4.05	3.66	4.92	0.15	28.00
Total bone (%)	17.55	17.59	17.44	0.94	5.03
Weight of the femur (kg)	0.13	0.13	0.12	0.43	11.38
Length of the femur (cm)	16.06	16.43	16.00	0.22	2.93
Others ³ (%)	2.69	2.70	2.13	0.19	24.90
Muscle:bone ratio	6.83	6.36	6.83	0.69	17.04
Muscle:fat ratio	4.71	4.46	3.64	0.28	29.46
Muscularity index	0.54	0.43	0.45	0.17	21.28

¹ IN="in nature" sugarcane + concentrate; AER=hydrolyzed sugarcane with 0.6% CaO in aerobic environment + concentrate; ANA=hydrolyzed sugarcane with 0.6% CaO in anaerobic environment. ² Coefficient of variation. ³ Nerve, connective tissue, blood vessels, cartilage.

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