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ANIMAL PRODUCTION

Non-carcass components of confined lambs in feedlot using red propolis extract

Adriano Mendes Vasconcelos[1], Vitor Visintin Silva de Almeida[2], Aline Cardoso Oliveira[2], João Wilian Dias Silva[1], Tarcísio Paixão[1], Laize Vieira Santos[1], Ana Paula Gomes da Silva[1], Dorgival Morais de Lima Júnior[3*] and Robério Rodrigues Silva[1]

[1]Universidade Estadual do Sudoeste da Bahia, Itapetinga, Bahia, Brazil. [2]Universidade Federal de Alagoas, Arapiraca, Alagoas, Brazil. [3]Universidade Federal Rural do Semi-árido, Rua Francisco Mota, 59625-900, Mossoró, Rio Grande do Norte, Brazil. *Author for correspondence. E-mail: juniorzootec@yahoo.com.br

ABSTRACT. The objective of this work was to evaluate the non-carcass components of crossbred Santa Inês lambs finished in feedlot with the inclusion of different levels of red propolis extract (RPE). Thirty-five crossbred lambs were used with an average weight of 17.08 ± 2.36 kg and mean age of five months, distributed in a completely randomized design with five treatments and seven replications. The treatments evaluated were: 0; 7; 14 and 21 mL of extract/animal/day Before slaughter, each animal was individually weighed to obtain the body weight at slaughter (BWS). The weights and yields of non-carcass components were evaluated, weights and yields of regional dishes (*Buchada* and *Panelada*). The addition of different levels of red propolis extract (RPE) did not influence ($p > 0.05$) the weights and yields of non-carcass components, by-products and adipose deposits, to the weight and yield of regional dishes. The use of red propolis extract in diets up to the level studied (28 mL day^{-1}) did not change the characteristics evaluated.

Keywords: additive; adipose deposits; by-products slaughter; *Dalbergia ecastophyllum*.

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Introduction

The confinement of sheep has been encouraged, but to obtain gains that economically compensate this practice, the diet must contain adequate levels of protein and energy, with the maximization of the use of concentrates. With the intensification of carcass production, obviously, the quantities of non-carcass components will be increased, which should receive an adequate destination by the sheep meat industry or by other segments of the production chain. Of these components, for example, the skin has been widely used and valued, and, when properly processed and manufactured by the footwear and clothing industry, it has added values that far outweigh the price of the animal that originated it.

From another perspective, significant amounts of non-carcass components can be used for human consumption in typical dishes of regional cuisine, such as some organs and viscera. The use of these components in human food is reported in various parts of the tropics and subtropics (Cordeiro, Bezerra, & Madruga, 2022).

The visceral organ mass can influence an animal's feed efficiency and nutrient utilization by various body tissues. Knowing the variations of body organs can help to assess the effects of nutrition on growth and also optimize the use of various foods. These components can represent up to 40% of the live weight of sheep and goats, being influenced by genetics, age, live weight, sex, and especially food (Alkass, Yateem, Al-Sherwany, & Mustafa, 2023).

Therefore, the manipulation of the ruminal environment is carried out with the objective of increasing the efficiency of food degradation, reducing energy losses, which occur mainly in the processes of gas production and nitrogen recycling (Pimentel et al., 2022). In the pursuit of alternatives that promote the improvement and efficiency of the production system, compounds that control metabolism, increasing the efficiency of food use, have been studied in recent decades. These compounds are classified as additives and their addition to the animals' diet can provide increased productivity.

Among the additives released for use in ruminants in Brazil are buffers, ionophores, non-ionophore antibiotics, fibrolytic enzymes, yeasts, lipids and propolis (Jouany & Morgavi, 2007; Soltan & Patra, 2020).

However, the use of ionophores is banned in the European Union since January 1, 2006. Thus, red propolis has been studied as a natural alternative to ionophores commonly used in ruminant feed, as it has numerous active substances in its composition, especially flavonoids, which have bacteriostatic and bactericidal action, mainly against Gram-positive bacteria (Rufatto et al., 2017; Aldana-Mejía et al., 2021). The use of these compounds, which work by reducing the number of gram-positive bacteria (producers of methane and carbon dioxide) is beneficial, as it favors the growth of gram-negative producers of propionic acid, an organic acid with greater energy potential, generating productive gains (Stradiotti Junior et al., 2004). However, there are few results available on the use of red propolis extract for growing animals, especially non-carcass components weight.

Our hypothesis is that propolis extract improves non-carcass components weight. Therefore, the present study evaluated the effects of increasing levels of red propolis extract (RPE) on non-carcass components weight of confined lambs.

Material and methods

Experimental area, animals and facilities

All applicable institutional guidelines for the care and use of animals were followed, in accordance with Law No. 11.794, of October 8, 2008, of Decree No. 6.899, of July 15, 2009, and with the rules published by the National Control Council of Animal Experimentation (CONCEA) and was approved by the Ethics Committee on the use of animals at the Federal University of Alagoas (CEUA/UFAL).

The field experiment was conducted in the sheep farming sector, at the Federal University of Alagoas - UFAL, Campus de Arapiraca-AL, from September to November 2018. The experiment lasted 68 days, of which the first 10 days were used as an adaptation period. Thirty-five crossbred Santa Inês lambs with an average weight of 17.08 ± 2.36 kg and an average age of five months were used, distributed in a completely randomized design with five treatments and seven replications. The animals were randomly allocated in individual pens arranged in a covered area with a useful area of 2.25m^2 (1.5 x 1.5 m), with cemented floor, equipped with individual feeding and drinking troughs.

Strategies, diets and management

At the beginning of the adaptation period, the pens were enumerated, the animals identified with earrings, deverminated against ecto and endoparasites (CYDECTIN®) and vaccinated against clostridiosis (SINTOXAN®), and after drawing, they were distributed in treatments that consisted of different dosages of red propolis extract (RPE), as follows: Treatment 0 = no extract/animal/day; Treatment 7 = 7 mL of extract/animal/day; Treatment 14 = 14 mL of extract/animal/day; Treatment 21 = 21 mL of extract/animal/day; Treatment 28 = 28 mL of extract/animal/day.

The raw red propolis was purchased from a beekeeper located in the municipality of Santa Cruz de Cabrália, Bahia. To obtain the extract, 30 g of crushed, homogenized and mixed 100 mL of hydro-alcoholic solution (70%) were weighed, which remained at rest in a dark environment for a period of 10 days, with subsequent filtering on paper-filter, obtaining the stock solution, according to the methodology of Stradiotti Júnior et al. (2004).

The administration of the propolis extract to the animals was performed after feeding using a 10 milliliter (mL) continuous flow metering gun fitted with a metering nozzle, the administration of water being carried out to the animals in the treatment in order to standardize the management. The daily dosage was divided into two, half the dose at 9:00 am and the other half at 4:00 pm, orally, after feeding the diet.

The animals received food based on roughage and concentrate ad libitum divided into two daily meals 08:00 and 15:00, with 60% of the total in the morning and 40% in the afternoon in order to allow leftovers of 10% of what is provided. The animals' diet was the same for all treatments, consisting of roughage and concentrate in a 60:40 ratio, respectively (Table 1). The concentrate was formulated according to the National Research Council (NRC, 2007), for a daily gain of 250 g, in an isoprotein diet, formulated with corn, soybean meal and mineral mixture. As roughage source, Tifton grass hay was used and previously crushed.

The amount of feed offered and leftovers was recorded daily in a specific spreadsheet for each pen. The collections of leftovers were made at the end of each experimental period and stored in plastic bags previously identified and frozen at -10°C, to carry out the analysis of the chemical composition.

Before laboratory analyses, the samples were thawed at room temperature, dried in a ventilated oven at 65°C for 72 hours, and processed in knife mills, with a 1 millimeter mesh sieve (mm) and sequentially analyzed the composition of the ingredients of the diet according to the methodology of Detmann et al. (2012).

Table 1. Chemical and percent composition of ingredients in experimental diets.

Ingredients			(g kg^{-1})
Tifton 85 hay			600
Soybean meal			194
Corn			186
Mineral mix[1]			20
Total			1000
	Concentrate	Tifton 85 hay	Total diet
Dry matter[2]	880.4	846.4	860.0
Crude protein[3]	356.3	70.2	184.6
Ether extract[3]	33.1	14.7	22.0
Ash[3]	81.0	57.3	66.7
NDFap[3,4]	109.0	734.8	484.4
Acid detergent fiber[3]	62.5	436.0	286.6
Non-fibrous carbohydrates[3]	420.6	123.0	242.0
Total digestible nutrients[3]	724.9	632.5	669.4

[1]Mineral mix: Calcium 120 g; Phosphorus 87 g; Sodium 147 g; Sulfur 18 g; Cobalt 40 mg; Copper 590 mg; Iodine 80 mg; Chrome 20 mg; Manganese 1300 mg; Selenium 15 mg; Zinc 3800 mg; Iron 1800 mg; Molybdenum 10 mg; Fluorine (max) 870 mg. [2]g kg^{-1} fresh matter. [3]g kg^{-1} dry matter. [4]Neutral detergent fiber free from ashes and protein.

Morphometric measurements of non-carcass components

At the end of the experimental period, the animals were randomly distributed in a slaughter order and sent to the slaughterhouse, where they were kept at rest only on a water diet for 16 hours, in accordance with animal welfare standards. Before slaughter, each animal was individually weighed to obtain the body weight at slaughter (BWS), and subsequently stunned by cerebral concussion, followed by bleeding by scission of the jugular veins and carotid arteries.

The internal components of the pelvic, abdominal and thoracic cavities were extracted and their weights recorded. The gastrointestinal tract content was quantified by the difference between the full and empty gastrointestinal tract weights. The body weight at slaughter (BWS) subtracted from the gastrointestinal content corresponded to the empty body weight (EBW) (Cezar & Souza, 2007; Silva Sobrinho, 2001). The hot carcass weight (HCW) consisted of the bled, decapitated, skinned, eviscerated, amputated animal with kidneys and perirenal fat.

Non-constituent components of the carcass were considered: organs (heart, lungs, trachea, spleen, liver, kidneys, penis, testis, bladder, pancreas, diaphragm, tongue, and thymus), viscera (esophagus, rumen, reticulum, omasum, abomasum, small intestine and large intestine) and by-products (blood, skin, head, limb extremities and adipose deposits: omentum, mesentery, pelvic + renal and fat linked to the gastrointestinal treatment).

Statistical analysis

The data were evaluated using analysis of variance and regression. The statistical models were chosen according to the significance of the regression coefficients, using the t test at a 5% probability level, and determination (R^2) as a studied biological phenomenon. The statistical analyzes were performed using the Statistical and Genetic Analysis System (SAS), version 9.0 (SAS, 1999).

Results and discussion

The content of total flavonoids found in the extract used in the present study was 8.5 mg QE/g. There was no effect ($p > 0.05$) of the levels of red propolis extract (RPE) on the quantitative characteristics of the lambs carcass (Table 2).

Table 2. Weights and carcass yields of sheep fed increasing levels of red propolis extract (RPE).

	Red propolis extract levels (mL day^{-1})					Mean standard error	P-value	
	0	7	14	21	28		L	Q
Initial live weight (kg)	17.17	17.06	17.11	17.06	17	1.124	0.924	0.997
Body weight at slaughter (kg)	22.54	22.41	22.2	22.76	22.39	1.546	0.681	0.696
Gastrointestinal tract content (kg)	5.67	5.58	5.18	5.66	5.54	0.364	0.877	0.548
Hot carcass weight (kg)	9.56	9.51	9.24	10.07	9.88	0.726	0.606	0.769

The similarity in body weight at slaughter of animals with the use of RPE may have influenced the results observed in the evaluated characteristics, since the diet adopted was the same for all animals, adding only the different levels of propolis extract. The RPE used at these levels was not enough to modify the ruminal fermentation characteristics and induce better energy use. The body weight at slaughter had an average of 22.46 kg, below the 31 kg of live weight, recommended by Silva Sobrinho (2001) for slaughter. This low weight observed is associated with the small weight gain of the animals during the experiment, which led to a reflection on the hot carcass weight (HCW), with an average of 9.65 kg, lower than the minimum values of 14.3 and 13.8 kg recommended by Silva Sobrinho (2001) for characterization of good quality carcasses.

Costa et al. (2011) found that the carcass characteristics (EBW, HCW and CCW) in Santa Ines lambs increased linearly as the slaughter weight increased. These values were higher than those described by Sá, Siqueira, Sá, Roça, and Fernandes (2005), who report an average of 14 kg (HCW) in relation to the body weight at slaughter of 30 kg for the Santa Ines breed and higher than that of the present work. As there was no increase in slaughter weight in this work, these characteristics were not influenced by the diets either.

The addition of different levels of red propolis extract (RPE) did not influence ($p > 0.05$) the non-carcass components, except for penile weight and the relationship between total organ weight (TWO) and empty body weight (EBW) (Table 3).

Table 3. Organ weight and relationships with other body components of sheep fed increasing levels of red propolis extract (RPE).

	Red propolis extract levels (mL day^{-1})					Mean standard error	P-value	
	0	7	14	21	28		L	Q
Tongue	0.064	0.072	0.071	0.071	0.58	0.006	0.539	0.101
Trachea	0.09	0.08	0.084	0.085	0.104	0.007	0.143	0.053
Lungs	0.232	0.24	0.22	0.234	0.257	0.018	0.466	0.346
Heart	0.096	0.107	0.101	0.1	0.094	0.006	0.628	0.224
Diaphragm	0.098	0.091	0.087	0.097	0.11	0.008	0.278	0.086
Liver	0.331	0.314	0.34	0.331	0.355	0.021	0.333	0.544
Spleen	0.037	0.044	0.037	0.034	0.108	0.033	0.214	0.272
Pancreas	0.091	0.042	0.047	0.037	0.047	0.019	0.146	0.179
Testicles	0.183	0.139	0.129	0.151	0.187	0.031	0.83	0.109
Penis	0.094	0.084	0.087	0.077	0.12	0.011	0.228	0.037
Bladder	0.028	0.027	0.024	0.028	0.017	0.004	0.176	0.488
Kidneys	0.073	0.071	0.071	0.073	0.068	0.003	0.551	0.762
TWO[1]	1.377	1.287	1.265	1.297	1.505	0.109	0.448	0.124
TWO: BWS[2] (%)	6.067	5.728	5.758	5.681	6.374	0.263	0.501	0.057
TWO: EBW[3] (%)	8.124	7.628	7.576	7.581	8.346	0.324	0.703	0.042

[1]Total weight of organs (TWO); [2] Body weight at slaughter (BWS); [3]Empty body weight (EBW).

The non-alteration in the weights of the organs was possibly due to the average daily gain of the animals not differing from each other, which indicates that the animals had the same physiological behavior. The means of each component demonstrate that there was no significant change due to the different levels of RPE studied and the mean values of the organs were proportionally smaller than those reported by other authors as a result of the lower body weight at slaughter.

Studying different levels of concentrate in sheep feed Morada Nova, Medeiros et al., (2008) found no differences for total organ weight and its relationship with body weight at slaughter (6.13%) and empty body weight (7.36%), similar to the averages found in this study, such as TWO:BWS (5.92%) and TWO:EBW (7.85%). Silva et al. (2019) evaluating the influence of production systems on non-carcass yields of Dorper x Santa Inês crossbred lambs found significant differences for spleen weight (0.18 kg), heart (0.44 kg), liver (1.77 kg) and kidney + fat (1.21 kg), being higher than those found in the present study (0.05 kg spleen; 0.10 kg heart; and 0.34 kg liver). It is common for the weight of the liver and other primary organs in metabolism, such as the heart and lungs, to accompany the energy levels of the diet (Fontenele et al., 2010), and as there was no differentiation between the diets offered in this work, this led to no change in these organs, in addition to the weight at lower levels on average.

Carvalho, Brochier, and Pivato (2007) evaluated non-carcass components of feedlot Texel lambs and found spleen, liver and heart values, with averages, in percentage of slaughter weight, of 0.13; 1.75 and 0.10%, respectively. These values are different from those in the present study, which were 1.16% for the spleen, 1.48% for the liver and 0.4% for the heart, even with non-significant differences between the different levels of RPE. The same behavior was observed by Ítavo et al. (2009), where the body components were not influenced by the additives used in the diets.

The organs and viscera have different growth rates during the animal's life, when compared to other parts of the body, and can be influenced by the chemical composition of the diet, especially energy. In this sense, the high deposition of fat is not desirable because, in addition to increasing production costs, it depreciates the carcasses and generates greater amounts of internal fat that are not used for human consumption (Pompeu et al., 2013).

According to Péron et al. (1993) and Alves et al. (2003), unlike organs linked to food digestion and metabolism, the yields of vital organs such as the respiratory system, brain and heart are not influenced by the composition of the diet, as these organs have priority in the use of nutrients, maintaining their integrity regardless of the state nutritional status of animals. Normally, the weights of the non-carcass components develop in a similar way with the increase in the animal's body weight, but not in the same proportions, that is, there is a decrease in the percentages in relation to the animal's weight.

There was no significant effect ($p > 0.05$) of the levels of RPE on the characteristics of weights and proportions of the constituents of the gastrointestinal tract of lambs, expressed as percentage of body weight at slaughter and of the total gastrointestinal tract (Table 4).

Table 4. Viscera weight and relationships with other components of sheep fed with increasing levels of red propolis extract (RPE).

	Red propolis extract levels (mL day^{-1})					Mean standard error	P-value	
	0	7	14	21	28		L	Q
Esophagus	0.047	0.047	0.045	0.05	0.087	0.016	0.118	0.199
Rumen	0.478	0.472	0.441	0.511	0.472	0.034	0.805	0.784
Reticle	0.085	0.097	0.08	0.094	0.101	0.009	0.331	0.509
Omaso	0.065	0.072	0.071	0.072	0.075	0.005	0.235	0.772
Abomaso	0.102	0.108	0.11	0.111	0.128	0.01	0.116	0.569
Small intestine	0.507	0.602	0.468	0.482	0.502	0.033	0.228	0.982
Large intestine	0.258	0.232	0.277	0.277	0.267	0.027	0.482	0.901
TWV[1]	1.524	1.615	1.414	1.571	1.510	0.093	0.807	0.881
TWV: SBW[2] (%)	6.802	7.265	6.534	6.970	6.554	0.390	0.526	0.689
TWV: EBW[3] (%)	9.170	9.738	8.598	9.314	8.551	0.560	0.356	0.703

[1]Total weight of viscera (TWV); [2]Body weight at slaughter (BWS); [3]Empty body weight (EBW).

The evaluated animals were submitted to the same time of fasting and slaughtered when they reached approximately 22.46 kg of body weight, that is, they were given the same fasting conditions and the slaughter weight was pre-established equally for all animals, which justifies the non-alteration of these constituents.

Moreno, Sobrinho, Leão, Loureiro, and Perez (2010), evaluating the yield of non-carcass components of lambs fed with corn or sugarcane silage and two levels of concentrate, they found a difference ($p < 0.05$) only for the small intestine weight, which was influenced by the roughage:concentrate ratios and bulky type. Consequently, the proportion of small intestine was also influenced, as it was higher in the 40:60 ratio and when corn silage was used as roughage, 2.32 and 2.25%, respectively. The small intestine has a nutrient absorption function and its size is proportional to the animal's body size and type of food, especially in relation to the level of fiber in the diet. Furthermore, according to these authors, the presence of large amounts of nutrients from balanced diets promotes greater development of the intestines, as the nutrients that escape from ruminal fermentation induce the mitotic process of intestinal villi (Furlan, Macari, & Faria Filho, 2006).

The weights of by-products and adipose deposits (Table 5) were not influenced by the different levels of addition of red propolis extract (RPE).

The amount of blood eliminated during slaughter can inform about the bleeding efficiency, because, according to Forrest et al. (1979), even under efficient conditions, it is only possible to eliminate between 50 and 60% of the animal's total blood volume, so the rest is retained in organs vital organs. Values found in the literature vary widely, from values lower than 0.43 kg (Clementino et al., 2007) to higher values, such as 4.81 kg (Silva et al., 2019). The mean blood weight found falls within this range (0.93 kg), as, according to Pompeu et al. (2013) body weight at slaughter is positively correlated with blood weight and variable accordingly to it.

The skin corresponded to 1.64 kg of the lambs body weight, inferior only to the gastrointestinal tract content percentage. It is noteworthy that the skin and the contents of the gastrointestinal tract are the non-carcass components that contribute the highest percentage to the body weight at slaughter of sheep, and that can suffer great variations. In addition, the skin is the most important and most valued component, reaching between 10 and 20% of the value of the animal (Fraser & Stamp, 1989). According to Siqueira, Simões, and Fernandes (2001), the weight of the skin can vary according to the different densities and fiber diameters and the height of the locks, in the case of released animals, while the weight of the gastrointestinal content is influenced by the type of diet, its passage speed, times of fasting, among others.

Table 5. Weight of by-products and adipose deposits of sheep fed increasing levels of red propolis extract (RPE).

	Red propolis extract levels (mL day^{-1})					Mean standard error	P-value	
	0	7	14	21	28		L	Q
Blood	0.973	0.954	0.926	0.853	0.943	0.060	0.402	0.448
Skin	1.611	1.564	1.644	1.683	1.700	0.160	0.565	0.886
Paws	0.577	0.57	0.573	0.571	0.619	0.034	0.441	0.421
Head	1.327	1.340	1.339	1.329	1.413	0.073	0.994	0.627
TWB[1]	4.486	4.419	4.471	4.429	4.667	0.298	0.693	0.648
TWB: SBW[2] (%)	19.879	19.797	20.380	19.441	19.923	0.578	0.885	0.886
TWB: EBW[3] (%)	26.733	26.449	26.806	25.927	26.067	0.825	0.483	0.901
Omentum	0.134	0.103	0.111	0.109	0.131	0.026	0.997	0.328
Mesentery	0.126	0.13	0.114	0.119	0.136	0.01	0.791	0.238
Internal fat	0.049	0.036	0.036	0.053	0.049	0.009	0.561	0.328
Perirenal fat	0.100	0.081	0.083	0.096	0.110	0.015	0.482	0.186
TWAD[4]	0.404	0.34	0.333	0.361	0.414	0.052	0.805	0.18
TWAD: SBW (%)	1.734	1.484	1.456	1.596	1.769	0.168	0.738	0.118
TWAD: EBW (%)	2.313	1.969	1.914	2.131	2.313	0.211	0.809	0.105

[1]Total weight of by-products (TWB); [2]Body weight at slaughter (BWS); [3]Empty body weight (EBW); [4]Total weight of adipocyte deposits (TWAD).

For internal, omental and perineal fat, no increase in weight was observed in relation to the addition of increasing levels of propolis. All treatments received the same diet, which was probably why there was no difference in non-carcass components in all treatments studied.

Kozloski (2017) stated that the higher level of concentrate in the diet increases the concentration of propionic acid in the rumen and decreases the acetate: propionate ratio, resulting in greater availability of energy in the form of glucose, which favors lipogenesis and consequent deposition of fat visceral. However, it is important to emphasize that the accumulation of large amounts of internal fat is not desirable, as there is an increase in energy requirements for maintenance, due to the higher metabolic rate of the adipose tissue, and there is a waste of energy provided by the diet, since the internal fat is not used for human consumption.

Morsy et al. (2015) used red propolis extract as a natural alternative to monensin and observed an increase in total short-chain fatty acids compared to monensin and decreased protozoal count. In vivo, Lana et al. (2005; 2007) showed that propolis supplementation (up to 6 g $animal^{-1}$ day^{-1}) did not affect total and individual SCFA concentrations in dairy goats fed a diet of 67% corn silage and 33% concentrate. The propolis levels studied in this work were not enough to change the studied variables.

The weight and yield of loofah and pan was not influenced by different levels of addition of red propolis extract (RPE) added to the diet ($p > 0.05$) because all treatments received the same amount of energy and non-carcass components did not show a significant difference (Table 6).

Table 6. Weights and yields of regional dishes of sheep fed increasing levels of red propolis extract (RPE).

	Red propolis extract levels (mL day^{-1})					Mean standard error	P-value	
	0	7	14	21	28		L	Q
Buchada (kg)[1]	3.049	3.120	2.843	2.933	3.034	0.182	0.711	0.536
Buchada (%)	13.531	13.977	13.026	12.967	12.987	0.459	0.159	0.981
Panelada (kg)[2]	4.946	5.023	4.749	4.830	5.060	0.275	0.968	0.526
Panelada (%)	21.993	22.559	21..737	21.327	21.684	0.625	0.357	0.998

[1]Sum of weights of blood, liver, kidneys, lungs, spleen, tongue, heart, omentum, rumen-reticulum, omasum, small intestine; [2]*Buchada* + head + paws.

Clementino et al. (2007), when evaluating levels of concentrate in the diet of sheep, they obtained bushing weights of 3.36 kg and bushing yield of 15% and Pinto et al. (2011) observed bushing weight of 5.84 kg and yields of 17.70%, both higher than the values found in this work, probably due to the lower slaughter weights. Regarding the pan weight and its yield, the average values of 4.92 kg and 21.86%, respectively, were lower than the pan weights found by Clementino et al. (2007), where the weight of the pan was 5.81 kg and its yield was 24.06%.

Conclusion

Given the above, the use of red propolis extract (RPE) in diets of lambs in up to 28 mL/day did not influence the weights and yields of non-carcass components.

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