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Effect of high-grain diet and residual frying oil on the quality of lamb meat

Efeito da dieta de alto grão e óleo residual de fritura na qualidade da carne de cordeiro

Efecto de la dieta rica en cereales y el aceite de fritura sobre la calidad de la carne de cordero

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Abstract

In addition to influencing performance, the use of new ingredients in the diet of production animals can influence meat quality. Were used 15 lambs, crossbred from Dorper x Santa Inês, divided into three experimental groups. Group 1 (Control) fed with Tifton hay and concentrate, in the proportion of 40:60; Group 2- animals fed a 100% high grain diet; Group 3- lambs fed with Tifton hay and concentrated with the inclusion of 6% residual frying oil. After 40 days of confinement, the animals were slaughtered and the Longissimus dorsi muscle was removed from the carcasses for analysis of meat quality attributes. There was no effect of the test diets ($P > 0.05$) on the physical parameters of the meat. The protein and lipid values were higher in the meat of the animals on the diet with residual oil. The moisture content of meat from animals on the high-grain diet showed higher values ($P < 0.05$) than that of other diets. This fact is attributed to the lower muscle development in animals on this diet, which may also have contributed to the levels of meat protein and lipids in this treatment. It was concluded that the diet with the inclusion of frying oil was the best among the test diets because it did not negatively impact the meat quality.

Keywords: Meat atributes; Confinement diets; Small ruminants; Nutritional profile of meat.

Resumo

Além de influenciar o desempenho, o uso de novos ingredientes na dieta de animais de produção pode influenciar na qualidade da carne. Neste estudo investiga-se os efeitos de dieta de alto grão e da inclusão de óleo de fritura residual na dieta sobre a qualidade da carne de cordeiro. Foram utilizados 15 cordeiros, mestiços de Dorper x Santa Inês, divididos em três grupos experimentais. Grupo 1 (Controle) alimentados com feno de Tifton e concentrado, na proporção de 40:60; Grupo 2- animais alimentados com dieta 100% alto grão; Grupo 3-

cordeiros alimentados com feno de Tifton e concentrado com inclusão de 6% de óleo residual de fritura. Após 40 dias de confinamento, os animais foram abatidos e retirado o músculo Longissimus dorsi das carcaças para análise dos atributos de qualidade da carne. Não houve efeito das dietas experimentais (P> 0,05) sobre os parâmetros físicos da carne. Os valores de proteínas e lipídios foram maiores na carne dos animais da dieta com óleo residual. O teor de umidade da carne dos animais com dieta rica em grãos apresentou valores superiores (P <0,05) do que nas demais dietas. Esse fato é atribuído ao menor desenvolvimento muscular nos animais desta dieta, o que também pode ter contribuído para os menores níveis de proteínas e lipídios da carne neste tratamento. Concluiu-se que a dieta com inclusão de óleo de fritura foi a melhor dentre as dietas teste, pois não impactou negativamente na qualidade da carne.

Palavras-chave: Atributos da carne; Dietas de confinamento; Pequenos ruminantes; Perfil nutricional da carne.

Resumen

Además de influir en el rendimiento, el uso de nuevos ingredientes en la dieta de los animales de producción puede influir en la calidad de la carne. Este estudio investiga los efectos de una dieta grano alto y la inclusión de aceite de freír residual en la dieta sobre la calidad de la carne de cordero. Se utilizaron quince corderos, cruzados de Dorper x Santa Inês, divididos en tres grupos experimentales. Grupo 1 (Control)- alimentado con heno de Tifton y concentrado, en la proporción de 40:60; Animales del grupo 2 alimentados con una dieta 100% grano alto; Grupo 3- Corderos alimentados con heno Tifton y concentrados con inclusión de 6% de aceite de fritura residual. Después de 40 días de confinamiento, los animales fueron sacrificados y el músculo Longissimus dorsi se extrajo de las canales para analizar los atributos de calidad de la carne. No hubo efecto de las dietas experimentales (P> 0.05) sobre los parámetros físicos de la carne. Los valores de proteínas y lípidos fueron mayores en la carne de animales en la dieta con aceite residual. El contenido de humedad de la carne de animales con una dieta alta en granos mostró valores más altos (P <0.05) que en otras dietas. Este hecho se atribuye al menor desarrollo muscular en los animales con esta dieta, lo que también puede haber contribuido a los niveles más bajos de proteínas y lípidos cárnicos en este tratamiento. Se concluyó que la dieta con la inclusión de aceite para freír fue la mejor entre las dietas de prueba, ya que no afectó negativamente la calidad de la carne.

Palabras clave: Atributos de la carne; Dietas de confinamiento; Pequeños rumiantes; Perfil nutricional de la carne.

1. Introduction

The demands of the modern market have brought new concerns to the food production sector. In addition to quality, consumers demand products that meet their nutritional needs (Barros et al., 2015). In this new perspective, the production of meat for commercialization with any species requires the knowledge of the implication of management, feeding and genetic improvement in characteristics, aiming to offer consumers a standardized product that meets their expectations (Cruz et al., 2016).

Therefore, in addition to determining the influence of diet on production characteristics, it is necessary to assess how new diets influence the physical attributes and nutritional composition of meat (Guerrero et al., 2013; Santos et al., 2015).

The general quality of sheep meat marketed in Brazil falls short of what consumers want, which according to Grandis et al. (2016) is because of the late slaughter of the animals, the result of poor planning and precarious production conditions, which can be bypassed with the implementation of the termination in confinement of the sheep, reducing the slaughter age and improving carcass standardization.

Aiming to minimize feeding costs in termination ins confinement, the use of by-products of the industry, as well as the use of diets that allow maximum efficiency in meat production and minimum cost of production within the systems gains relevance (Ortiz et al., 2005).

In this context, the use of diets exclusive of concentrated ingredients has been shown to be advantageous in sheep confinement by providing carcass finishing faster than the conventional system, by increasing weight gain rates and feed efficiency, reducing production costs (Haddad & Husein 2004; Vechiato & Ortolani 2008).

In addition, the use of diets with a high proportion of roughage requires that large areas of land dedicated to the production of this ingredient, thus reducing the areas destined for agriculture, beyond to the great demand for water that the production of roughages requires, scarce in periods of drought in some regions. In that context, Paniago (2014) emphasizes the use of high-grain diets in sheep farming as an alternative to barriers at production of roughage.

Another alternative that is promising for reducing production costs in confinement is the inclusion of, or partial replacement of conventional ingredients with, by-products from the industry, such as residual vegetable oil from frying, an alternative source of lipids in the diet.

Peixoto et al. (2017) quote two advantages of using residual oil is the reduction of

harmful effects to the environment when the oil is disposed of incorrectly and the improvement of the efficiency of feed conversion, by decreasing the requirement for consumption of dry matter for body weight gain, because of its lipid content.

Therefore, the objective of this study was to evaluate the effects of the high-grain diet (HG) and the inclusion of 6% residual frying oil (RFO) in the diet on the meat quality of lambs.

2. Methodology

The use of animals and the experimental procedures were approved by the Ethics Committee on the Use of Animals, of the Federal Rural University of the Semi-Árido (Protocol No. 23091.014462 / 2018-50).

The experiment was carried out at the Lagoa de Pau property, Governador Dix-Sept Rosado (05° 27' South, 37° 3' West, 50 m altitude), Rio Grande do Norte, Brazil.

Fifteen male lambs, uncastrated, crossbred from Dorper x Santa Inês, six months of age, with initial weight of 23.1 ± 1.9 kg, were distributed in a completely randomized design (CRD), with three treatments and five repetitions, housed in collective bays (total area 17 m²), one per treatment, equipped with a linear feeder (0.30 m/animal), drinking fountains and salt shakers.

The treatments were as follows: Control Diet (CT) - Tifton hay + concentrate; High-Grain Diet (HG) - Diet of high-grain; Diet with Residual Frying Oil (RFO) - Tifton hay + concentrate + 6% residual frying oil.

The roughage used was Tifton hay (Cynodon sp.) at a proportion of 60% of DM for the control treatments (CT) and with residual frying oil (RFO). The corn and soybean meal of the concentrate of diet RFO was substituted in 6% for the residual frying oil. The treatment high-grain (HG) it consisted exclusively of commercial diet of high-grain used in sheep termination.

The CT and RFO diets were balanced according to the recommendations of the NRC (2007) to gain 200g daily (Table 1).

Table 1. Ingredients and bromatological composition of experimental diets.

	Diets		
Ingredients[1]	**CT**	**HG**	**RFO**
Hay	40.0	-	37.5
Corn	36.2	60	34.0
Soybean meal	22.0	-	20.7
Soy husk	-	25	-
Cotton Pie	-	10	-
Uréia	-	1	-
Mineral and vitamin core	1.8	4	1.8
Residual frying oil	0.0	-	6.0
Bromatological composition			
Dry matter[2]	89.42	86.34	89.46
Organic matter[1]	94.04	95.29	93.68
Mineral matter[1]	5.96	4.71	6.32
Crude protein[1]	20.91	16.95	19.25
Ether extract[1]	3.30	3.15	4.16
Neutral detergent fiber[1]	33.56	24.79	34.14
Acid detergent fiber[1]	13.89	13.26	13.73
Hemicellulose[1]	19.67	11.53	27.66
Lignin[1]	1.69	0.19	1.59
Cellulose[1]	12.20	13.07	10.93
Total carbohydrates[1]	69.83	75.19	70.27
Nonfibrous carbohydrate[1]	36.28	50.40	36.13
Total digestible nutrients[1]	71.22	71.49	71.29

[1] % of dry matter; [2] in %.
Source: Authors.

Ten days were used to adapt the animals to the experimental diets, followed by 40 days of data collection. To adapt the animals to the HG diet, a protocol suggested by the manufacturer was followed, with increasing replacement of roughage by the high-grain diet until the total removal of roughage from the diet was attained.

The diets were offered ad libitum to the animals daily at 8 AM and at 4 PM, except for the high-grain diet, which had a limited supply of 3.5% of live weight, according to the manufacturer's recommendation. The quantities offered in the diets were adjusted daily by the offer-leftover method, allowing a maximum of 10% of the leftover in the trough.

At the end of the experimental period, the animals were subjected to 12 hours of solid fasting, and then slaughtered in a slaughterhouse under municipal inspection in the city of Mossoró-RN. The animals were stunned by the non-penetrative percussive concussion method, followed by bleeding, with cutting of the carotid and jugular, according to the requirements of the Ministry of Agriculture (Riispoa 1997).

After identification, the carcasses were kept in a cold chamber with plastic protection and hung by the tarsometatarsal joint on individual hooks for 24 hours at an average temperature of 4 ± 0.5 ºC, to establish rigor mortis. For the physical–chemical analysis of the meat, the Longissimus dorsi muscle was removed from the loin and ribs of each carcass, packed in an identified bag and transported in a thermal box with ice to the Federal Rural University of the Semi-Arid (UFERSA), where analysis was performed.

The physical analysis of the meat was carried out at the Laboratory of Instrumental and Sensory Analysis (LANIS) of UFERSA, evaluating the following parameters: pH, color, weight loss on cooking (WLC), shear force (SF) and water-holding capacity (WHC).

To measure the value of the hydrogen potential (pH) of the samples, a digital pH meter, Hanna brand, was used, coupled to a penetration electrode, checking the pH in three different points of the meat.

Color was evaluated using the Konica Minolta colorimeter, CM-700d/600d (CIE System L*a*b*), measuring the coordinates L*: luminosity (black–white), a*: red content (green–red) and b*: yellow (blue–yellow) at three different meat locations.

To measure WLC, for each sample three portions of meat of similar dimensions were weighed, wrapped in aluminum foil and transferred to the grill. Upon reaching the internal temperature of 75 °C measured with a thermometer, the samples were removed from the grill, and after cooling to room temperature, the aluminum foil was removed from the samples, followed by weighing to obtain the results, which were calculated as the difference of weight of samples before and after cooking and expressed as a percentage weight loss.

To determine the SF, the same WLC samples were used, using a texturometer (Texture Analyzer TA-XT-125), coupled to the Warner–Bratzler device (HDP/WBV) operating at a speed of 20 m/s, with 1.0 cm edge samples. SF values are expressed in kilogram force (kgf)

For the WHC, the difference between the initial and final weights of three 0.5 g meat cubes per sample, placed on filter paper and between two acrylic plates subjected to a pressure of 5 kg for five minutes, was determined. This method is based on the methodology performed by Sanfelice et al. (2010).

The chemical composition of the meat was determined at UFERSA Animal Nutrition Analysis Laboratory (LANA). The moisture, mineral matter and crude protein content determinations followed the methodology described by AOAC (2016), and to quantify the lipid content, the Folch et al. (1956) method was used.

All analyses were performed in triplicate. The data were subjected to analysis of variance, and the means were compared by Tukey's test, with a probability of 5% statistical significance ($P < 0.05$), using the SISVAR software, version 5.6 (Ferreira, 2008).

3. Results and Discussion

Regarding the physical parameters of the meat (Table 2), no difference was detected ($P > 0.05$) between treatments.

Table 2. Physical characteristics of meat from lambs finished with a high-grain diet and diet with the inclusion of residual frying oil.

	Diets				
Variables	**CT**	**HG**	**RFO**	**SEM**	**p-value**
pH	5.70	5.80	5.75	0.05	0.5120
L*	66.78	67.98	66.80	0.38	0.0773
a*	5.66	6.54	6.08	0.29	0.1544
b*	9.70	10.38	9.76	0.26	0.1682
WLC	55.96	55.78	54.68	1.35	0.3639
SF	4.46	4.20	4.86	0.45	0.1719
WHC	65.40	67.60	70.60	3.01	0.4936

L*: luminosity; a*: green–red coordinate; b*: blue–yellow coordinate; WHC: water-holding capacity (%); WLC: weight loss on cooking (%); SF: shear force (kgf). SEM: standard error of the mean.
Source: Authors.

The pH of the meat is related to the sensory quality, considering that the pH drop of meat is influenced by the amount of glycogen reserves moments before the slaughter of the

animals, so under abnormal conditions of slaughter the meat can undergo significant changes, resulting in PSE meat (pale, soft and exudative) or HFD meat (hard, firm and dry), as highlighted by Silva et al. (2008). In relation to pH, the values found in this work are in accordance with the reference values for the specie, between 5.5 and 5.8 (Silva Sobrinho et al., 2005), indicating the normal muscle acidification process.

pH values similar to those in this study were reported by Gasparini et al. (2020) evaluating the effect of using oil and sunflower seed in the diet of crossbred lambs from Santa Inês × Dorper on meat quality.

For the color parameter, the values of L*, a* and b* were similar ($P > 0.05$) between treatments. The color of the meat is conditioned by the concentration and structure of the myoglobin, which in turn is influenced by the species, sex, and age of the animal, meat cut, temperature and postmortem pH (Mancini & Hunt 2005); the concentration of myoglobin can also be altered by incorrect handling of the carcass in the slaughter process, exposing the meat to the action of aerobic bacteria, decreasing the amount of available oxygen and subsequent formation of metmyoglobin and browning of the meat (Silva et al., 2008).

The absence of differences between the diets for WHC can be explained by the similarity of the pH values between the treatments, given that the pH value is highly correlated with the water-holding capacity (Zeola et al., 2007).

The influence exerted by pH on the water-holding capacity also explains the similar values for weight loss on cooking, as this is highly correlated with the water-holding capacity. In this context, according to Rubiano et al. (2009), the values for WHC and WLC are inversely proportional; that is, as the WLC decreases, the WHC increases.

Used to evaluate the tenderness of the meat, averages for shear force (SF) for the treatments did not differ among themselves ($P > 0.05$). Boleman et al. (1997) classify meat according to the texture, as very tender (SF between 2.3 and 3.6 kgf), moderately tender (SF between 4.1 and 5.4 kgf) and slightly tender (SF between 5.9 and 7.2 kgf). Considering the average SF values (4.50 kgf), in this study the meat can be considered as moderately tender.

Knowing that the meat's color, tenderness, and water-holding capacity are influenced directly, and the weight loss cooking is influenced indirectly, by the pH of the meat (Hopkins & Fogarty 1998), one can conclude that, by not influencing the final pH, diets did not alter the qualitative characteristics of the meat.

The values of moisture, mineral matter, crude protein and lipids from lamb meat fed an HG diet and a diet with the inclusion of RFO are shown in Table 3.

Table 3. Nutrition composition of meat from lambs fed with high-grain diet and diet with the inclusion of residual frying oil.

Variables (%)	Diets			SEM	p-value
	CT	HG	RFO		
Moisture	73.58c	74.84a	73.84b	0.03	<0.0001
Mineral matter	1.61	1.96	1.71	0.05	0.0890
Crude protein	18.17a	16.37b	18.18a	0.36	0.0058
Lipid	1.95a	0.50b	2.63a	0.15	0.0002

SEM: standard error of the mean. Means followed by different letters on the same line differ from each other statistically, according to Tukey's test ($P < 0.05$).
Source: Authors.

According to data available in the literature, the average composition of sheep meat is 75% moisture, 1.1% mineral matter, 19% crude protein and 4% lipid (Zeola et al., 2004). The values of moisture, mineral matter and crude protein found in this work are close to those; therefore, these parameters were not negatively influenced by the test diets.

There was an effect ($P < 0.05$) of diets on moisture, with a higher average in meat from animals in the HG treatment. This result can be attributed to the lower muscle development observed in animals fed this diet, as it is known that a greater amount of water in the muscle is associated with less muscle tissue (Grandis et al., 2016). The moisture content of meat is closely related to juiciness, texture, color and flavor (Cruz et al., 2016), which can significantly influence consumer choice.

In a literature review, Gois et al. (2016) highlighted among the factors that influence the lipid composition of the meat, the chemical composition of the diet. So the higher content of lipids in the meat of animals fed with a diet containing residual oil may be associated with the lipid increase in this diet by including the frying oil. Likewise, according to the same author, the lower protein content of the diet may influence the amount of protein in the meat, thus explaining the results regarding the crude protein of the meat of animals fed the HG diet, considering the lower protein content in this diet.

The effect exerted by the HG diet on the lipid and protein amounts in the meat may be related both to the chemical composition of the diet and to the greater amount of water in the muscle, as according to Berchielli et al. (2006), low water content in the muscle is associated with greater deposition of fat, because of the higher energy density of lipids when compared to protein.

The use of the HG diet decreased the values of crude protein and lipids in the meat. The inclusion of 6% RFO in the lambs' diet did not alter the physical and chemical characteristics of the meat, making its use viable in termination systems.

4. Final Considerations

The use of the high grain diet decreased the values of crude protein and lipids in the meat. The inclusion of 6% of residual frying oil in the lambs diet did not alter the physical and chemical characteristics of the meat, making its use viable in the finishing systems.

It is worth mentioning that the results presented here refer to the meat quality of only one genetic group of sheep. At this point, it is important that future studies aim to evaluate the influence of high grain diet, as well as the use of residual frying oil on the qualitative parameters of the meat of lamb from different regions, aiming to disseminate the use of these ingredients in the production of beef sheep.

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