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ANIMAL PRODUCTION

Intake, performance and ingestive behaviour in lambs finished in confinement with wet brewery residue used as roughage

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ABSTRACT: The present study evaluated the effect of increasing levels of wet brewery residue (WBR) as a source of roughage on nutrient intake, performance and ingestive behaviour in lambs finished in confinement. Thirty-two uncastrated male lambs were used, weaned at 50 days of age. The treatments comprised increasing levels of WBR as roughage in the diet: 31, 44, 57 and 70%, on a dry-matter. The concentrate consisted of disintegrated corn, soybean meal, calcitic limestone and mineral salt. There was a quadratic effect ($P \leq 0.05$) from the increasing levels of WBR on the intake of DM, OM, CP and TCH. The intake of EE, NDF and ADF increased linearly ($P \leq 0.01$), while TDN intake showed a linear reduction ($P < .0001$) for increases in the level of WBR. There was a quadratic effect ($P \leq 0.010$) on the average daily weight gain (ADG) from the addition of WBR to the diet. The time spent on feeding and rumination ($P \leq 0.05$), expressed in minutes, showed a linear increase. Feeding rate for DM showed decreasing linear behaviour ($P \leq 0.006$), while NDF rumination rate showed increasing linear behaviour ($P \leq 0.013$) due to the increased levels of WBR in the diet. There was a linear increase in the time spent on each feeding activity ($P \leq 0.007$) with the increase in WBR in the diet. Maximum weight gain is achieved when 46.9% WBR is used as a source of roughage in the diet, and this level can be recommended for terminating lambs in confinement.
Key words: agro-industrial by-products, sheep, weight gain.

Consumo, desempenho e comportamento ingestivo de cordeiros terminados em confinamento com resíduo úmido de cervejaria como volumoso

RESUMO: O objetivo do presente estudo foi avaliar o efeito de níveis crescentes de resíduo úmido de cervejaria (RUC) como fonte de volume sobre o consumo de nutrientes, desempenho e comportamento ingestivo de cordeiros terminados em confinamento. Foram utilizados 32 cordeiros machos não castrados, desmamados aos 50 dias de idade. Os tratamentos consistiram em níveis crescentes de RUC como volumoso na dieta: 31, 44, 57 e 70%, na matéria seca. O concentrado consistia em milho desintegrado, farelo de soja, calcário calcítico e sal mineral. Houve efeito quadrático ($P \leq 0,05$) dos níveis crescentes de RUC sobre o consumo de MS, MO, PB e CHT. O consumo de EE, FDN e FDA aumentou linearmente ($P < .0001$), enquanto o consumo de NDT apresentou redução linear ($P < .0001$) para aumentos no nível de WBR. Houve um efeito quadrático ($P \leq 0,010$) no ganho de peso médio diário (GMD) da adição de RUC à dieta. O tempo gasto com alimentação e ruminação ($P \leq 0,05$) e para mastigação total ($P \leq 0,003$), expresso em minutos, apresentou aumento linear. A taxa de alimentação para MS apresentou comportamento linear decrescente ($P \leq 0,006$), enquanto a taxa de ruminação da FDN apresentou comportamento linear crescente ($P \leq 0,013$) devido ao aumento dos níveis de RUC na dieta. Houve aumento linear no tempo gasto em cada atividade alimentar ($P \leq 0,007$) com o aumento da RUC na dieta. O ganho de peso máximo é alcançado quando 46,9% de RUC é usado como fonte de volumoso na dieta, e este nível pode ser recomendado para cordeiros terminados em confinamento.
Palavras-chave: ganho de peso, ovinos, subprodutos agroindustriais.

INTRODUCTION

Sheep farming focused on meat production is an activity currently enjoying high demand on the market, with good prices when the animals are sold. However, this practice still requires improvement in activities related to production efficiency, and that can meet the needs of the market in relation to the availability and quality of the final product offered to the consumer.

Due to these and other factors, such as a reduced profit margin and increased competition, among other economic aspects, there is a trend towards greater use of technologies aiming to intensify production, to make the production system more efficient during the finishing phase of the animals (SOUZA et al., 2014).

BARROSO et al. (2006) stated that the reduction in slaughter age, the greater health control and a supply of meat during the off-season are

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points that have resulted in an increase in the use of confinement for finishing sheep in recent years.

However, one of the major problems encountered in sheep confinement are the high production costs, especially regarding feed. As such, the use of low-cost diets has led to the search for cheaper ingredients (MENDES, 2006), such as agro-industrial by-products.

Among these by-products is wet brewery residue (WBR), which basically consists of malted barley husks, the main by-product of the brewing industry, and which is available all year round in large quantities and at low cost (MUSSATTO et al., 2006). These by – products have high nutritional values, such as high concen-trations of protein, fat and minerals (LIU, 2011). The wet brewery residue is rich in crude protein (CP) at an average of 25%, has high levels of crude fiber (FB) at an average of 20% and a total digestible nutrient (TND) index of 74%, comparable to other traditional foods (KLAGENBOECH et al., 2012).

According to FRASSON (2015), due to the great production potential, the use of WBR can be a productive alternative for finishing lambs in confinement, as it can reduce feeding costs, as well as maximize the animals performance. As described to LALHRIATPUII & PATRA (2022), brewery by-products can also provide extra nutritional values, such as probiotics (live yeast), prebiotics and postbiotics (for example, enzymes, polysaccharides and organic acids), functions, which may promote the activity of beneficial bacteria in the gut and improve the health of animals.

Knowledge about the ingestive behavior of animals that receive by-products as part of the diet will contribute to the elaboration of low-cost feeds, and elucidate the problems of quantifying ingredients for its construction (PEREIRA, 2018).

The wet brewery residue can be used as an exclusive source of roughage for ruminants, thus this research to evaluate the nutrient intake, performance and ingestive behavior of feedlot lambs using WBR as a source of roughage in the diet.

MATERIALS AND METHODS

Study location

The confinement phase of the present study was conducted at the Sheep Farming Laboratory, with the bromatological analysis carried out at the Food Science Laboratory and Ruminant Nutrition Laboratory, both at the Zootechnics Department of the Federal University of Santa Maria (UFSM), located in the physiographic region known as the Central Depression in southern Brazil (29°43′ S, 53°42′ W, at an altitude of 95 m).

Animals and experimental design

Thirty-two uncastrated male lambs from crossings between the Texel and Ile de France breeds were used, weaned at 50 days of age, properly dewormed and vaccinated against clostridial infection. After weaning, the lambs were confined in individual covered stalls, allowing 2 m² per animal, with slatted floors approximately 1.0 m above the ground, fitted with individual feeders and drinking fountains, where feed and water were provided. The treatments consisted of different levels of wet brewery residue (WBR) as the exclusive source of roughage in the diet (31, 44, 57 or 70%, on a dry-matter basis).

The start of the experimental period was preceded by a period of 14 days for the animals to adapt to the facilities, feeding and handling. During the adaptation phase, in order to prevent the occurrence of possible metabolic disturbances, Tifton-85 hay was used in the proportion of 5% of the total DM in the diet. The feeding trial began after the adaptation phase with WBR as the exclusive source of roughage, and continued until each animal reached the pre-established body weight of 34 kg, when they were stunned and slaughtered. The lambs were weighed at the start of the experimental phase and every 14 days, after fasting for 12 hours, to better monitor their performance, as the slaughter weight approach, the interval between weighings was reduced in order to identify the moment when the animals reached the pre-established slaughter weight. The body condition of the lambs before slaughter was also determined, through scores from 1 (very thin) to 5 (very fat), considering intermediate values in 0.5 increments, according to RUSSEL et al. (1969), in addition to conformation assessments and in vivo measurements as described by OSÓRIO et al. (1998).

A complete diet was offered *ad libitum*, consisting of wet brewery residue as roughage and a concentrate composed of disintegrated corn (*Zea mays* L.), soybean meal (*Glycine max* L.), calcitic limestone and common salt. The roughage to concentrate ratio varied according to the experimental diet. The diets were formulated to be isoproteic, as per the NRC (2007), and calculated to meet the requirements for a daily gain of 0.200 kg. The Ca to P ratio was pre-established at 2:1. When offering food to the animals, WBR and concentrate were initially weighed separately, always respecting the roughage:concentrate ratio, based on DM, according to the treatment. Afterwards, they were given to the animals in the form of a complete mixture. The wet brewery residue came from a brewing industry in Santa Maria, RS, and was conserved in the form of silage, in a trench silo throughout the confinement period. At the beginning of the experiment, a bromatological evaluation was made to adjust the diets, which presented 24.20% DM, 21.18% CP, 63.71% NDF and 66.12% TDN.

During the experiment, the animals were fed twice daily, once in the morning (08:00 hr) and once in the afternoon (17:00 hr), with the quantity offered being adjusted by the daily leftovers of 10% of the quantity offered the previous day so as to guarantee maximum voluntary intake by the animals.

Nutrient intake and chemical analysis

Samples of the supplied feed and leftovers were pre-dried in a forced ventilation oven at 55 °C for approximately 72 hours and then ground in a Wiley mill with a 1 mm sieve. To analyse the neutral detergent fibre, the samples were ground in a 2 mm sieve, as per SENGER et al. (2008). The samples were then stored in marked bottles. The dry matter (DM) content of the samples of feed and leftovers was determined by drying in an oven at 105 ºC for a minimum of 16 hours. The ash content (ASH) was determined by combustion at 600 °C for 4 hours (SILVA & QUEIROZ, 2002). The total nitrogen (N) content was determined by the Kjeldahl method (Method 984.13, AOAC, 1997), as modified by KOZLOSKI et al. (2003). The ether extract (EE) was determined as per SILVA & QUEIROZ (2002). To determine the concentration of neutral detergent fibre (NDF), the samples were packed in polyester bags (KOMAREK, 1993) and treated with neutral detergent solution in an autoclave at 110°C for 40 minutes (SENGER et al., 2008), while α-amylase was used for the samples of concentrate, (MERTENS, 2002). The levels of acid detergent fibre (ADF) and lignin (ADL) were determined as per AOAC Method 973.18 (1997). Total carbohydrates (TCH) were determined as per SNIFFEN et al. (1992), where TCH (%) = 100 - (%CP +%EE +%ASH). The values for total digestible nutrients (TDN) and metabolizable energy (ME) were obtained from tabulated values as per VALADARES FILHO et al. (2006). Table 1 shows the chemical-bromatological composition of the experimental diets on a dry-matter basis, with the proportion of ingredients.

Table 1 - Proportion of ingredients (% DM) and bromatological composition of the experimental diets.

	--------------------------------------Levels of wet brewery residue--			
	31%	44%	57%	70%
------------Proportion of ingredients (%DM)------------				
Brewery residue	31.0	44.0	57.0	70.0
Disintegrated corn	51.8	42.1	32.3	22.6
Soybean meal	14.0	10.5	7.05	3.57
Calcitic limestone	2.13	2.33	2.58	2.82
Salt	1.00	1.00	1.00	1.00
------------Bromatological composition (%DM)------------				
DM	68.4	60.2	51.9	43.7
OM	93.1	92.5	91.8	91.1
CP	18.8	18.8	18.8	18.8
EE	3.70	4.65	5.61	6.56
NDF	26.9	33.7	40.5	47.4
ADF	8.73	11.2	13.8	16.3
TCH	70.6	69.0	67.4	65.8
ADL	3.36	4.30	5.25	6.19
TDN	77.1	74.4	71.6	68.9
ME	3,04	2,98	2,93	2,87
ASH	6.88	7.50	8.17	8.82
Ca	0.86	0.94	1.04	1.14
P	0.43	0.47	0.52	0.57

Dry matter (DM); organic matter (OM); crude protein (CP); ether extract (EE); neutral detergent insoluble fibre (NDF); acid detergent insoluble fibre (ADF); total carbohydrates (TCH); acid detergent lignin (ADL); total digestible nutrients (TDN); metabolizable energy (ME); ashes (ASH); calcium (Ca) and phosphor (P).

Intake was determined from the difference between what was offered in the diet and the leftovers (on a dry-matter basis) to obtain the daily intake of dry matter, organic matter, crude protein, ether extract, neutral detergent fibre, acid detergent fibre, total carbohydrates and total digestible nutrients.

Behavioural parameters

During the period of confinement, the ingestive behaviour of the animals was observed over an uninterrupted period of 24 hours, starting at 08:00 hours and ending at 08 hours the following day. The observations were carried out every 10 minutes to evaluate the time spent on feeding, rumination, inactivity (idle), water intake and other pursuits (stereotyped behaviours, such as gnawing the facilities or drinking fountains, among others). The time spent standing or lying down was also established. In this way, the number and periods of feeding and rumination were determined for each animal. Night-time observations were made under artificial lighting.

The results for the characteristics of ingestive behaviour were obtained using a methodology described by CARVALHO et al. (2006), with the following equations:

FR_{DM} = CDM/TFD (Dry matter feeding rate = dry matter intake/ daily time spent on feeding);

FR_{NDF} = CNDF/TFD (Neutral detergent fibre feeding rate = dry matter intake/ daily time spent on feeding);

where FR_{DM} (g DM consumed/hr) and FR_{NDF} (g NDF consumed/hr) = feeding rate; CDM (g) = daily dry-matter intake; CNDF = daily NDF intake; TFD = daily time spent on feeding:

RRU_{MS} = CMS/TRU (Dry matter rumination rate = dry matter intake/ daily time spent on rumination);

RRU_{FDN} = CFDN/TRU (Neutral detergent fibre ruimination rate = dry matter intake/ daily time spent on rumination);

where RRU_{DM} (g DM consumed/hr) and RRU_{NDF} (g NDF consumed/hr) = rumination rate; TRU (hr/day) = rumination time.

Statistical analysis

Data were analyzed using the PROC GLM of the SAS INSTITUTE INC software (2016) version 3.6, according to the following statistical model:

$Yij = \mu + WBRi + eij$

With $eij \sim N(0, \sigma_e^2)$ where: Yij is the observed value of the dependent variable; μ is the overall mean; $WBRi$ is the fixed effect of the level of inclusion of wet brewery residue as roughage (i = 1 to 4); eij is the experimental error (j = 1 to 8); N indicates normal/Gaussian distribution; σ_e^2 is the variance associated with the experimental error. Treatment effects were broken down into orthogonal contrasts to assess effects: linear and quadratic. The most complex and significant model was presented to represent the relationship between dependent and independent variables. A significance level (α) of 0.05 was considered for all analyses.

RESULTS AND DISCUSSION

When assessing nutrient intake, expressed in kg/day, % live weight (LW) and in g/kg of $LW^{0.75}$ (Table 2), it was found that DM, OM, CP and TCH intake showed a quadratic effect ($P \leq 0.05$) from the levels of wet brewery residue used as a source of roughage in the diet. Whereas, EE, NDF and ADF intake showed a significant increasing linear effect ($P \leq 0.01$), and the TDN intake, an increasing linear effect ($P < .0001$).

DM intake showed quadratic behaviour ($P \leq 0.026$), and can be explained by the statement of MERTENS (1994), that when high quality diets with a low fibre content are offered, the animal consumes to meet its energy requirements, and intake is limited by the animal's genetic potential to use the absorbed energy (physiological regulation of intake). Conversely, increasing the proportion of wet brewery residue in the diet resulted in a reduction in intake. This can be explained by the increase in the NDF content of the diets promoting physical regulation of the intake. This result agrees with those obtained by BOVOLENTA et al. (1998) and KOZLOSKI et al. (2006).

In the present experiment, DM intake increased to a maximum of 1.54 kg/day for a level of 49.2% WBR as roughage in the diet. From that point on, intake decreased as a consequence of the increased NDF content of the diet (Table 1); and was therefore, influenced by the physical mechanism of regulation. This result disagreed with that obtained by CABRAL FILHO et al. (2007), who stated that the maximum level of added WBR in the diet is 33% of the DM, and from then on, the DM intake of the lambs is reduced. It should be noted that, at the lowest level of WBR in the diet (31%), the NDF content was 26.94%, with a possible limitation on intake, in addition to the physiological regulation, a result of the reduction in rumen pH although no animal behaviour relating to the occurrence of acidosis and no reduction in the daily meal frequency were seen, as assessed from the ingestive behaviour of the animals.

Another aspect to be discussed is the moisture content of the diets, since, according to

Table 2 - Mean intake values for different levels of wet brewery residue as a roughage in the diet.

	---------------------Levels of wet brewery residue[1]---------------------				SEM	------------Probabilities---------	
	31%	44%	57%	70%		Lin.	Qua.
---Kg/Day---							
CDM	1.40	1.47	1.39	1.22	0.011	0.015	0.026[1a]
COM	1.30	1.36	1.27	1.12	0.010	0.006	0.029[2a]
CCP	0.26	0.27	0.25	0.22	0,002	0,009	0,033[3a]
CEE	0.04	0.06	0.07	0.07	0,001	<.0001[4a]	0,007
CNDF	0.38	0.49	0.56	0.58	0,004	<.0001[5a]	0,009
CADF	0.12	0.16	0.19	0.19	0,001	<.0001[6a]	0,004
CTCH	0.99	1.02	0.94	0.81	0,008	0,001	0,031[7a]
CTDN	1.08	1.09	0.99	0.84	0,008	<.0001[8a]	0,033
---% LW---							
CDM	4.84	5.23	4.97	4.41	0,028	0,102	0,031[1b]
COM	4.51	4.83	4.56	4.03	0,026	0,051	0,033[2b]
CCP	0.90	0.96	0.92	0.81	0,005	0,062	0,034[3b]
CEE	0.16	0.23	0.26	0.27	0.019	<.0001[4b]	0.003
CNDF	1.31	1.77	2.01	2.09	0.018	<.0001[5b]	0.020
CADF	0.42	0.59	0.68	0.70	0.010	<.0001[6b]	0.010
CTCH	3.43	3.63	3.37	2.94	0.019	0.009	0.036[7b]
CTDN	3.74	3.89	3.56	3.04	0.032	0.002[8b]	0.036
---g/kg $LW^{0.75}$---							
CDM	112.1	120.1	114.0	101.2	0.093	0.070	0.022[1c]
COM	104.4	111.1	104.7	92.4	0.087	0.034	0.024[2c]
CCP	21.0	22.2	21.2	18.6	0.064	0.045	0.025[3c]
CEE	3.8	5.3	6.0	6.2	0.047	<.0001[4c]	0.005
CNDF	30.4	40.7	46.2	48.0	0.348	<.0001[5c]	0.012
CADF	9.8	13.5	15.6	16.2	0.120	<.0001[6c]	0.006
CTCH	79.5	83.6	77.3	67.5	0.069	0.006	0.026[7c]
CTDN	86.5	89.4	81.7	69.7	0.682	0.006[8c]	0.026

Dry matter (CDM); organic matter (COM); crude protein (CCP); ether extract (CEE); neutral detergent insoluble fibre (CNDF); acid detergent insoluble fibre (CADF); total carbohydrates (CTCH); and total digestible nutrients (CTDN).
[1] WBR = Level of brewery residue as roughage.

the NRC (2001), dry-matter intake has a negative relationship to diets that have a high moisture content. This system showed that diets with less than 50% DM can limit the voluntary intake of the animals. PENDINI & CARRIZO (2008) found that when the water content of the forage was greater than 50%, there was a reduction in CDM of 0.02% of the live weight for each 1% increase in the water content of the diet when using silages (fermented foods). According to SUAREZ (2014), an excess of water can reduce intake due to rumen fill. Diets with a higher level of WBR as roughage have an increased moisture content, where the level of 57% WBR is at the limit with 51.97% DM; the diet of 70% WBR is below the recommended level, with 43.74% DM, resulting in intake being expressed quadratically. The diet with the maximum level of WBR as a source of roughage had a high total NDF content of 47.40% and a low DM content of 43.74%, thereby showing bromatological characteristics that indicated a reduction in voluntary intake through both physical regulation and regulation due to excess moisture (Table 1).

EE, NDF and ADF intake showed increasing linear behaviour (P < .0001) for each form of expression. This behaviour occurred due to the increase in the percentage of EE, NDF and ADF in the diets containing higher levels of WBR (Table 1). Regarding EE intake, it is important to emphasise that values greater than 5% of this nutrient in the diet can have a negative effect on nutrient intake, whether through regulatory mechanisms that control feeding or by the limited ability of ruminants to oxidise fatty acids (PALMQUIST & MATTOS, 2006). The higher proportion of EE in the WBR in relation to the feed that made up the concentrated mixture, caused the concentration of this nutrient to increase in the total diet (Table 1) as the levels of WBR increased. Therefore, the treatments with 57 and 70% WBR showed EE levels slightly higher than those acceptable for feeding ruminants, which, together with the excess moisture and NDF, may have interfered to limit nutrition and reduce DM intake.

The results for OM and CP intake showed quadratic behaviour in kg/day, %LW and g/kg $LW^{0.75}$, as seen for DM intake, due to the similarity in concentration of this nutrient in the experimental diets, and also due to the diets being isoproteic. There was a significant quadratic effect ($P \leq 0.031$) for total carbohydrate intake similar to DM intake; the point of maximum TCH intake was achieved at a level of 43.3% WBR as roughage in the diet.

TDN intake was found to decrease linearly ($P < .0001$) as the levels of WBR increased. Despite the lowest intake being expressed at a level of 70% WBR in the experimental diets, with a value of 3.04%, it can be seen that the average intake among all the treatments under evaluation (Table 3) is higher than that indicated by the NRC (2007) of 1.95% LW for animals in this category, and for a daily gain of 0.200 g. This may be responsible for the satisfactory performance of the mean values for daily weight gain, which were greater than those indicated by the nutrient demand.

The daily weight gain was adjusted quadratically ($P \leq 0.010$) by the increase in wet brewery residue as a source of roughage in the diet (Table 3), similar to the order and results for dry matter intake. In the present study, the ADG reached its maximum point at a level of 46.9% WBR as roughage, with a value of 0.375 kg. From that level on, the ADG decreased, which can be explained by the differences in concentration of the fibrous fraction in the experimental diets, limiting intake (as discussed above) and animal performance; although, higher than the 0.200 kg daily gain recommended by the NRC (2007) for this category.

A similar result to that found in this study was obtained by GILAVERTE et al. (2011), who evaluated the effects of replacing corn with wet brewery residue on the performance of Santa Inês sheep. The authors reported that the addition of wet brewery residue to the diet in the proportion of 30.5% of the DM reduced DM intake ($P \leq 0.05$) by 54.2% in relation to the diet containing corn. This can be explained by the high moisture content of the diet containing wet brewery residue and the higher concentration of NDF leading to a physical limitation of DM intake, and resulting in a reduction in the average daily weight gain.

Also agreeing with the present study is the result obtained by FRASSON (2015), who evaluated different levels (0, 33, 66, and 100%) of wet brewery residue as a substitute for sorghum silage in Suffolk lambs finished in confinement with a roughage to concentrate ratio of 50:50. At a level of 50% WBR, the author found an ADG of 0.363 kg/day, a value close to the maximum value of 46.9% WBR and 0.375 kg/day ADG obtained in this study.

The initial live weight and the live weight at slaughter were expected to be similar since the animals were uniformly distributed in the treatments, were of the same genotype, sex and age, and were slaughtered at a predetermined weight of 34 kg LW in order to reach the desired physiological and tissue maturity.

Table 3 - Mean values for performance variables and in vivo evaluations of lambs. according to different levels of wet brewery residue as a roughage in the diet.

	----------------Levels of wet brewery residue[1]----------------				SEM	----------Probabilities----------	
	31%	44%	57%	70%		Lin.	Qua.
LWI (kg)	21.6	23.2	21.3	20.2	0.287	0.413	0.966
LWF (kg)	34.9	34.5	34.5	34.2	0.062	0.405	0.370
ADG (kg)	0.33	0.37	0.36	0.29	0.005	0.037	0.011[a]
DAYS	38.5	31.0	37.0	45.6	1.170	0.141	0.125
FC	3.87	4.08	3.89	4.27	0.062	0.313	0.468
CON (1-5)[2]	3.18	3.25	3.00	2.93	0.031	0.161	0.695
BCS (1-5)[3]	3.62	3.41	3.41	3.28	0.026	0.189	0.336

Initial live weight (LWI); final live weight (LWF); average daily weight gain (ADG); number of days to slaughter (DAYS); feed conversion (FC).

[1]WBR = Level of brewery residue as roughage.

[2]Conformation: 1 = extremely poor – 5 = excellent.

[3]Body condition score: 1 = extremely poor - 5 = excellent.

The similarity (P > 0.05) obtained for feed conversion should be noted, showing that irrespective of the level of WBR used as roughage the animals were similarly efficient in converting dry matter and ingested nutrients into live-weight gain. The mean value of 4.03:1 is considered satisfactory, and is close to that normally obtained for lambs in this category and finished in confinement.

Another important result to be emphasized is the body condition score of the lambs at the time of slaughter, which suffered no significant effect (P > 0.05) from the level of WBR in the diet. This demonstrates that all levels of WBR were efficient in relation to the degree of finishing of the animals, with the average value of 3.43 being in line with that desired by lamb abattoirs, which, seek a value of 3.5 as the ideal degree of finishing for lambs being slaughtered. However, due to the lower DM intake and lower ADG, these animals had more days in confined absolute values (Table 3) until they reached the slaughter weight and body condition score. Increasing the WBR content as a source of roughage in the diets afforded a linear increase ($P \leq 0.036$; $P \leq 0.011$) in the time spent on feeding, rumination and with a linear reduction ($P \leq 0.001$) in idle time (Table 4).

The high energy density of diets with lower levels of WBR (Table 1) led to a reduction in ingestion time, causing the animals to spend less time feeding during the day, possibly due to the physiological regulation of intake that occurs when diets with a low fibre content and high energy demand are used in ruminants. CARVALHO et al. (2006), analysing different sources of NDF for goats, reported that increased concentrate in the diet reduced ingestion time due to the high energy density of the diet, corroborating the result of the present study.

Conversely, according to MERTENS (1997), as the level of NDF in the diet increases, as occurred in the experimental diets with the increase in WBR, there is an increase in the time spent on ingestion, in order for the animal to meet its energy requirements. This confirmed the results of the present study and agreed with FIMBRES et al. (2002), who worked with increasing levels of hay (0, 10, 20 and 30% of the DM); and consequently, of NDF in sheep diets, and saw an increasing linear effect on ingestion, rumination and total chewing time.

The time spent on rumination was influenced by the increased fibre content of the diet, which showed a significant linear increase ($P \leq 0.011$) as the wet brewery residue and; consequently, the NDF content of the diet increased. According to DADO & ALLEN (1995), the number of rumination periods rises for increases in the amount of fibre, showing that greater processing of the rumen digesta is necessary to maximise digestive efficiency. As such, the increase in NDF leads to a rise in the daily rumination activities of the animal, aiming to process food more efficiently. In order to free up space at rumen level so that the animal ingests more food in an effort to meet its nutritional requirements.

At the lowest level of WBR in the diets (31%), rumination activities were effective, even showing an NDF content (26.94%) slightly below that stated by KOZLOSKI et al. (2006), who suggested, from a nutritional point of view, the addition around 30% NDF, which represents the most suitable level for formulating diets for confined lambs based on sorghum silage and concentrate. This result can be considered important nutritionally, characterizing the effectiveness of the WBR fibre, necessary for reducing the occurrence of metabolic disorders due to the lack of rumen buffers and the drop in rumen pH. In this context, SILVA et al. (2011) when evaluating the addition of different levels of WBR for goats as a

Table 4 - Mean values in min/day for ingestive behavior variables according to different levels of wet brewery residue as a roughage in the diet.

	--------------------Levels of wet brewery residue[1]--------------------				SEM	-------------Probabilities-------------	
	31%	44%	57%	70%		Lin.	Qua.
FEED	172.1	183.7	213.7	226.2	0.303	0.036[a]	0.987
RUM	427.1	458.7	515.6	499.3	0.345	0.011[b]	0.281
IDLE	767.8	721.2	624.3	663.1	0.386	0.001[c]	0.080
WTR	11.42	13.12	7.50	16.25	0.064	0.629	0.391
OTH	61.42	63.12	78.75	33.75	0.216	0.269	0.088
STND	408.5	426.2	440.6	426.8	0.362	0.532	0.507
LYDN	1031	1013	999.3	1013	0.362	0.532	0.507

Feeding (FEED); rumination (RUM); leisure (IDLE); water (WTR); other activities (OTH) and standing (STND) or lying down (LYDN).
[1]WBR = Level of brewery residue as roughage.

substitute for concentrate, concluded that WBR can be used as an effective source of fibre in the diet.

As described by MERTENS (1997), WBR has 8.3% physically effective fibre, twice as much as that of ground maize, thereby confirming the result of the present study, where there was an increase in rumination activity as WBR levels increased and concentrate levels were reduced in the experimental diets.

BURGER et al. (2000), working with Holstein calves, reported that the average time spent on rumination decreased linearly for increased levels of concentrate in the diets. The authors reported that rumination time was directly affected by the increase in NDF in the diet due to increases in the proportion of Coast-cross hay as roughage. The longer feeding and rumination times, resulted the idle time showing a linear reduction as a consequence of this increase in the total chewing time (feeding + rumination).

The amount of time spent on water and other activities over 24 hours was not significantly influenced (P > 0.05) by the increase in WBR levels in the experimental diets.

The time spent standing or lying down suffered no significant effect (P > 0.05) from the levels of wet brewery residue in the diets, with mean values of 425.57 and 1014.42 min/day respectively, as shown in table 4. Similar results were obtained by FRASSON et al. (2016), who evaluated the ingestive behaviour of lambs in confinement with WBR replacing sorghum silage, and found mean values of 438.13 min/day spent standing and 1001.87 min/day spent lying down.

For DM feed and rumination rate (Table 5), as there was an effect from the levels of WBR on the time spent on feeding and rumination in minutes per day, the expression of dry matter intake resulted in the lambs offered the highest level of WBR in the diet ingesting smaller amounts of DM for longer feeding times. This explains the reduction in feeding and rumination rate, expressed linearly in g DM ($P \leq 0.004$) per hour, i.e. the lambs spent more time on ingestion, or ruminating a smaller amount of ingested DM, causing a reduction in efficiency. These results agreed with studies by MIRON et al. (2004) and HUBNER et al. (2008).

However, NDF rumination rate showed the opposite behaviour to that of DM, since, as the WBR content of the diets increased, there was an increase in NDF intake, resulting in the lambs having a higher proportion of NDF to process per hour of rumination activity, making it more efficient. This corroborated the results of BURGER et al. (2000), who saw a linear increase in NDF rumination rate for the increased participation of roughage in the diets of Holstein calves.

According to SILVA (2007), this showed that even though the fibre particles of the WBR are tiny, they have a real influence on rumination, and are therefore, more effective than using only concentrate. This probably also contributed to the lower rate of passage of these diets compared to diets with a higher proportion of concentrate, with a negative effect on intake and animal performance expressed in the daily weight gain at the highest levels of WBR in the diets.

The number of feeding and rumination periods was not significantly influenced (P > 0.05) by the levels of WBR in the diets (Table 6), with mean values of 11.27 and 21.07 respectively, similar to results obtained by FRASSON et al. (2016), who, evaluating levels of WBR as a substitute for sorghum silage in confined lambs, found mean values of 9.14 and 22.66 respectively.

It can be seen that there was an increasing effect ($P \leq 0.007$) from the level of WBR on the minutes spent per feeding period. The lower energy density of the diet as the WBR levels increased (Table 1), caused the animals to take longer on each feeding activity, seeking to meet their energy requirements with a greater intake of this nutrient.

Table 5 - Mean values for ingestive rate for different levels of wet brewery residue as roughage in the diet.

	---------------------Levels of wet brewery residue[1]-------------------				SEM	-------------Probabilities------------	
	31%	44%	57%	70%		Lin.	Qua.
FR_{DM}	517.6	523.5	377.0	308.4	0.686	0.006[a]	0.341
FR_{NDF}	140.4	177.4	178.4	161.8	0.316	0.526	0.196
RRU_{DM}	201.9	197.2	164.4	147.7	0.169	0.004[b]	0.600
RRU_{NDF}	54.77	66.81	66.72	70.19	0.059	0.013[c]	0.273

Feeding rate (FR. g DM/h and g NDF/h) and rumination rate (RRU, g DM/h and g NDF / h).
[1]WBR = Level of brewery residue as roughage.

Table 6 - Mean values for ingestive frequency for different levels of wet brewery residue as roughage in the diet.

	-----------------------Levels of wet brewery residue[1]--------------------				SEM	----------------Probabilities--------------	
	31%	44%	57%	70%		Lin.	Qua.
No FEED	11.21	10.81	11.00	12.06	0.018	0.583	0.532
No RUM	20.92	20.62	20.68	22.06	0.012	0.291	0.264
min/FEED	15.43	17.37	19.69	19.19	0.016	0.007[a]	0.240
min/RUM	20.66	22.24	25.36	22.68	0.022	0.173	0.127

Meal frequency (No FEED); rumination frequency (No RUM) over 24 hours, time spent per feed (min/FEED) and time spent per rumination (min/RUM).
[1]WBR = Level of brewery residue as roughage.

CONCLUSION

Brewery residue can be used as an exclusive source of roughage in feeding confined sheep. However, the maximum weight gain is obtained when using 46.9% of wet brewery residue as a source of roughage in the diet, and this level can be recommended for finishing lambs in a confinement system.

The use of increasing levels of wet brewery residue (WBR) as roughage in the diet of confined lambs increases the neutral detergent fibre (NDF) content and reduces the levels of dry matter (DM) and energy, influencing the characteristics of ingestive behaviour and performance in the animals.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

The experiment was approved by the Ethics Committee on Animal Experimentation (CEEA) of the Universidade Federal de Santa Maria (approval No 8088120419), and all the procedures followed the recommendations for animal welfare and humane slaughter.

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