Pesq. Vet. Bras. 37(2):171-178, fevereiro 2017
DOI: 10.1590/S0100-736X2017000200012

Intake and digestibility in sheep fed on marandu grass silages added with dehydrated barley[1]

Daniele J. Ferreira[2]*, Anderson M. Zanine[2], Rogério P. Lana[3], Alexandre L. Souza[4], Marinaldo D. Ribeiro[2], Fagton M. Negrão[4], Guilherme R. Alves[4] and Wanderson J.R. Castro[4]

ABSTRACT.- Ferreira D.J., Zanine A.M., Lana R.P., Souza A.L., Ribeiro M.D., Negrão F.M., Alves G.R. & Castro W.J.R. 2017. **Intake and digestibility in sheep fed on marandu grass silages added with dehydrated barley.** *Pesquisa Veterinária Brasileira 37(2):171-178.* Departamento de Zootecnia, Centro de Ciências Agrárias e Ambiental, Universidade Federal do Maranhão, BR-222 Km 4 s/n, Boa Vista, Chapadinha, MA 65500-000, Brazil. E-mail: dany_dosanjos@yahoo.com.br

The objective was to evaluate the intake and the apparent digestibility in sheep fed on marandu grass silages added with dehydrated barley. Twenty crossbred Santa Inês lambs were used, with a mean initial weight of 30±4.5 kg and mean age of 14±2 months. The experimental sheep were distributed into a completely randomized design and lining, with five treatments and four repetitions, with treatments levels of inclusion of 0, 10, 20, 30 and 40% natural matter of naturally dehydrated brewery residue for 36 hours to the marandu grass silage to feed the sheep. The evaluation period lasted 21 days, 15 for adaptation to the diets and 7 days for data collection. The data was submitted to analysis of variance, and when significant ($P<0.05$) the treatment means were analysed by regression. The inclusion of dehydrated barley to silage showed a linear increase in water intake ($P<0.05$), increased by 0.02% per unit of dehydrated barley. A quadratic effect was observed for the levels of dehydrated barley on the dry matter intake (DM), estimating a maximum consumption of 2.86% DM for silages containing 17.8% dehydrated barley. The crude protein intake (CP) behaved quadratically, with the maximum value estimated of 0.29% CP at a level of 22.5% dehydrated barley. Ether extract (EE) intake also exhibited quadratic behaviour ($P<0.05$), with the maximum value estimated of 0.2% EE at a level of 28.25% dehydrated barley. The regression study showed quadratic behaviour; with the maximum estimated value of neutral detergent fibre was 2.33% at a level of 34.58% dehydrated barley. No statistical significance was found for the intake of acid detergent fibre or organic matter ($P>0.05$). It was concluded that the addition of levels of 20 to 30% of dehydrated barley to silage resulted in a positive response for the dry matter intake, crude protein, Ether extract and neutral detergent fibre.

INDEX TERMS: Digestibility, sheep, marandu grass silages, dehydrated barley, feed, digestion, intake, nutritive value.

RESUMO.- [**Ingestão e digestibilidade de ovinos alimentados com silagens de capim-marandu aditivadas com resíduo de cervejaria desidratado.**] Objetivou-se avaliar o consumo e a digestibilidade aparente de ovinos alimentados com silagens de capim marandu aditivadas com resíduo de cervejaria desidratado. Foram utilizados 20 ovinos mestiços de Santa Inês machos inteiros, com peso médio inicial de 30±4.5 kg e média de 14±2meses de idade. O delineamento experimental foi o inteiramente casualizado, com cinco tratamentos e quatro repetições, sendo os trata-

[1] Received on June 10, 2015.
Accepted for publication on June 25, 2016.

[2] Departamento de Zootecnia, Centro de Ciências Agrárias e Ambiental, Universidade Federal do Maranhão (UFMA), BR-222 Km 4 s/n, Boa Vista, Chapadinha, MA 65500-000, Brazil. *Corresponding author: dany_dosanjos@yahoo.com.br

[3] Departamento de Zootecnia, Universidade Federal de Viçosa (UFV), Av. Peter Henry Rolfs s/n, Campus Universitário, Viçosa, MG 36570-900, Brazil.

[4] Departamento de Ciência Animal, Faculdade de Medicina Veterinária, Agronomia e Zootecnia, Universidade Federal de Mato Grosso (UFMT), Av. Fernando Correa da Costa 2.367, Cuiabá, MT 78060-900, Brazil.

mentos níveis de inclusão de 0, 10, 20, 30 e 40% da matéria natural de resíduo de cervejaria desidratado naturalmente por 36 horas à silagem de capim-marandu. O período de avaliação teve duração de 21 dias, sendo 15 para adaptação às dietas e seis para as coletas. Os dados foram submetidas à análise de variância, e quando significativo, as médias dos tratamentos à análise de regressão. A inclusão do resíduo de cervejaria desidratado promoveu aumento linear (P<0,05) no consumo de água, que aumentou em 0,02 ponto percentual a cada unidade de resíduo adicionada. Observou-se efeito quadrático (P<0,05) nos níveis de resíduo de cervejaria desidratado sobre o consumo de matéria seca, estimando-se consumo máximo de 2,86% peso vivo (PV) para silagens contendo 17,8% de resíduo de cervejaria. O consumo de proteína bruta apresentou comportamento quadrático, de modo que o valor máximo foi estimado em 0,29%PV de proteína bruta para o nível de 22,5% de resíduo de cervejaria desidratado. Para o consumo de extrato etéreo, houve comportamento quadrático (P<0,05), em que o valor máximo foi estimado em 0,2%PV de extrato etéreo para o nível de 28,25% de resíduo de cervejaria desidratado. O estudo de regressão mostrou comportamento quadrático (P<0,05) para o consumo de fibra em detergente neutro, em que o valor máximo foi estimado em 2,33% PV de fibra em detergente neutro para o nível de 34,58% de resíduo de cervejaria desidratado. Para os consumos de fibra em detergente ácido e matéria orgânica, não foi observada significância estatística (P>0,05). Conclui-se que silagens aditivada com níveis de 20 a 30% de resíduo de cervejaria desidratado, promoveram respostas positivas aos consumos de matéria seca, proteína bruta, extrato etéreo e fibra em detergente neutro.

TERMOS DE INDEXAÇÃO: Digestibilidade, ovinos, silagens de capim-marandu, resíduo de cervejaria, alimento, consumo, digestão, valor nutritivo.

INTRODUCTION

The seasonality of forage production has been responsible, among other factors, for the reduction in productivity of herds, which in conjunction with the frequent variation in prices of cereal grains and protein supplements used in animal feeding have aroused an interest in the use of alternate feeding strategies.

The substitution of traditional corn and sorghum silages by the grass in ruminant nutrition has greatly interested farm technicians and ranchers, in order to minimise the costs of production because of the increased productivity per unit of tropical grass area, particularly during the period of increased supply (Santos 2007).

Tropical forage grasses, following Bergamaschine et al. (2006), do not show adequate levels of dry matter, soluble carbohydrate or buffering capacity to provide for an efficient fermentative process. This situation has been modified through the use of techniques such as a mixture of appropriate products to the ensiled mass (additives). Bernardes et al. (2005) observed that the aerobic deterioration in tropical grass silages is principally characterised by aerobic bacteria rather than fungi or yeast, showing a greater level of humidity, reduced acidity and decreased supply of available nutrients to the ensiled mass.

In this context, agroindustrial residue can be important in ruminant nutrition, primarily in situations of low forage availability.

Residue from the brewing industry has been used in research in substitution of bulk feed (Alves et al. 2002, Correia et al. 2002, Lallo et al. 2003) and cereal grains and can possibly be used as an additive to tropical grass silage production (Oliveira Filho et al. 2002). The wet brewery residue in dried form (dehydrated barley) was studied by Rogers et al. (1986) and Bovolenta et al. (1998), who reported that this food has greater levels of non-degradable protein in the rumen.

Rogers et al. (1986) worked with heifers fed with wet dehydrated barley and compared with those fed on dry dehydrated barley, observing greater digestibility and nitrogen retention in heifers fed with wet dehydrated barley and suggested that this effect was associated with the increased nitrogen availability in this residue. Following this, Bovolenta et al. (1998) observed a linear increasing effect of the total digestibility coefficient of the dry matter, organic matter, crude protein, ether extract and neutral detergent fibre in lambs. Increasing levels of dry dehydrated barley in the ration however led to the reduction in dry matter intake.

In accordance with Brochier & Carvalho (2008), the utilisation of wet dehydrated barley in terminal feedlot lambs had great potential, and could lead to a significant reduction in feed costs and at the same time limit the occurrence of the environmental impact arising from the brewing industry without reducing production rates.

Considering this aspect and the necessity of further studies, the objective of this present study was to evaluate the effect of ensiling Marandu grass with the addition of dehydrated barley an the intake and apparent digestibility in sheep.

MATERIALS AND METHODS

The experiment was conducted in the forage crops sector experimental area in the Department of Animal Science, Federal University of Mato Grosso Rodonópolis at geographical coordinates 16°28' S and 50°34' W.

The climate is of Aw tropical type by Köppen classification, with well-defined wet and dry seasons; hot and humid summers and cold and dry winters. The mean annual temperature is 27.5°C, oscillating between respective minimum and maximum means of 17°C and 38°C. The mean relative humidity of the air is 60% and the mean annual precipitation is 1240mm.

The researched forage species was *Brachiaria brizantha* cv. Marandu. For the conduction of the experiment, uniformization harvest of the forage was performed in January 2011, with tractor attached harvester, to a height of approximately 5cm of the ground. In the same day a maintenance fertilization was performed with 60 kg of nitrogen and potassium, in the form of urea and potassium chloride, respectively, and, after 60 days, the forage harvest was performed for the silage process, adding brewery residue levels desitratado was mixed with grass.

Following that, the storage in silos was performed, with 200 liters of capacity; the silo was opened after 45 days.

The experimental lining was entirely random, with five treatments and four repetitions, being the treatments levels of inclusion of 0, 10, 20, 30 and 40% natural matter of naturally dehydrated brewery residue for 36 hours to the marandu grass silage to feed the sheep.

Twenty crossbred Santa Inês lambs were used, with a mean initial weight of 30±4.5 kg and mean age of 14±2 months. The animals were housed in individual pens of $1.5m^2$ area on a masonry floor and provided with a ration trough, salt trough and individual drinkers. At the commencement of the experiment, the animals were wormed, weighed and identified with plates affixed to the pens, then distributed according to the treatments. At the conclusion of the experimental period, the animals were weighed again. To collect faeces, nappies adapted to sheep were used.

The evaluation period had a total duration of 21 days, with 15 days for adaptation to the diets and seven for data collection. In the first phase, feed was provided *ad libitum* and intake measured daily, with the greatest mean intake occurring on the third day of adaptation taken as a basis for providing during the collection phase. The silage was provided daily at 8:30 and 16:30 hours, for the duration of the experimental period. In addition to silage, the sheep were offered mineral salt supplement *ad libitum*, with its composition shown in Table 1.

Water intake was determined for five days of the experimental period, twice per day at the hour nearest to the ration provision (at 9:00 and 17:00h). The water was provided in plastic buckets with an 8 L capacity. intake was calculated by the weight difference of buckets before and after intake. The buckets were always washed on supply and at the same time distributed by the installing two water buckets and weighing to measure the water loss by evaporation (Souza et al. 2010).

The quantity of silage provided to each animal in the collection phase was 10% greater than the mean intake observed in the preliminary phase, in order to enable leftovers. The intake of silage was measured daily by measuring the weight difference between the feed offered and the leftover feed. Composite samples of provided and leftover feed was later placed in plastic wrap, identified and stored in a freezer for laboratory analyses.

The total faecal collection was made daily, at 7:00 and 16:00 hours, with quantity of faecal extraction per animal registered to compute the daily production. After the homogenisation of material, an equivalent quantity of 5-10% was taken daily to make a composite sample per animal. The faecal samples were stored in plastic bags in a freezer. After the conclusion of the experiment, the samples were thawed to ambient temperature, pre-dried and stored for analyses. The apparent digestibility was obtained by the difference between the nutrient concentrations of the ingested material and of the faeces.

When the silos opened, subsamples were collected of approximately 25g for pH analysis, to which were added 100mL water and, after a two hour rest, the pH assessment was performed using a potentiometer. To another 25g subsample were added 200mL of a H_2SO_4 solution, 0,2 N, remaining at rest for 48 hours, for, then, be filtered in a Whatman 54 type filter. This filtered byproduct was stored in a refrigerator for further n-ammoniacal analysis (Bolsen et al. 1992).

The buffering capacity was expressed with equivalent alkali milligram required to change pH from 4.0 to 6.0 by 100g dry matter, after correction for the titration value of 250mL water (Table 3); 15 to 20g of fresh material were weighted, performing the maceration in a blender with 250mL distilled water. The macerated was titrated, firstly, for 3.0 pH with HCl 0.1N to release bicarbonates and CO_2 and, then, titrated for 6.0 pH with NaOH 0.1N. The buffering power analysis was determined in frozen samples, according to the technique described by Playne & McDonald (1996).

The soluble carbohydrates were determined following the method described by Bailey (1981), modified by Valadares Filho (1997). This method's principle consists in the extraction of the carbohydrates with alcohol solution ate 80%, in the reaction with acid solution prepared with anthrone and in the following reading in spectrophotometer using the glucose solution for the standard curve preparation (Table 3).

Collection samples of the silage were dried in a forced air oven at 65°C for 48 hours, and then ground in a Wiley mill, equipped with sieve mesh of 1mm, according to the recommendations of the NRC (2001).

The dry matter in vitro digestibility (DIVDM) was determined according to Tilley & Terry (1963), by weighing of 0.5g of sample pre-dried in previously dried and calibrated centrifuge tubes. To the tubes were added 40mL of McDougall solution (artificial saliva) and 10mL innocuous rumen of animals kept in marandu grass grazing areas with mineral salt in the through. The tubes were sealed with rubber corks containing bunsen valves (immediately after CO_2 passage) and incubated for 48 hours in controlled temperature greenhouse, being agitated at least three to four times during fermentation. The second phase occurred after supernatant centrifugation and discard. A pepsin solution (1:10.000) was added (50mL) at 0.2% in each tube, agitating them and placing them in greenhouses at 39°C for more 48 hours. After tubes washing, drying and weighing, the calculations were performed according to the following:

$$\text{DIVDM} = \frac{100 \text{ x g MS in sample - (residual MS g - white MS g)}}{\text{Sample MS g}}$$

Samples were stored in polyethylene containers for analysis of crude protein (CP), ether extract (EE), dry matter (DM), mineral matter (MM) and organic matter (OM) according to methodology described by (AOAC 2005); neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose (HEM), according to methodology described by (Van Soest et al. 1991) (Tables 2 and 3).

The total digestible nutrient (TDN) values were estimated according to Van Soest (1994), by the equation: TDN (%) = Deg + (1.25 *EE) – MM, where Deg = degradability, 1.25 = correction

Table 1. Composition and proportion of mineral salt ingredients

Mineral	Level
Phosphorus	80g
Calcium	177g
Sulfur	20g
Sodium	40mg
Copper	550mg
Iodine	60mg
Selenium	15mg
Manganese	1200mg
Zinc	3000mg
Fluorine (Max)	800mg

Table 2. Content of dry matter, crude protein, neutral detergent fiber, acid detergent fiber (ADF), hemicellulose (HEM), ether extract (EE) and In vitro dry matter digestibility of marandu grass silages added with dehydrated barley

Additive	DM[a]	CP[b]	EE[c]	NDF[d]	ADF[e]	HEM[f]	IVDMD[g]
DB[h]	89.96	24.31	6.52	60.75	30.09	30.66	64.35

[a] Dry matter (DM), [b] crude protein (CP), [c] ether extract (EE), [d] neutral detergent fibre (NDF), [e] acid detergent fibre (ADF), [f] hemicellulose, [g] dry matter in vitro digestibility (DIVDM); [h] dehydrated barley (DB).

factor, EE = ether extract and MM = mineral matter. The content of neutral detergent fiber was determined according to Van Soest et al. (1991).

The forage value index (FVI) was obtained by the following equations described by Teixeira & Andrade (2001):

Equation I
DMI (% live weight) = 120/% NDF of forage DM

Equation II
DDM (%) = 88.9 – 0.779 x % ADF of forage

Equation III
FVI = (DMI x DMD)/1.29
Where DMI = dry matter intake and DDM = digestible dry matter

The intake and apparent digestibility data obtained were statistically analysed, with the choice of models based on the significance of regression parameters tested by the t-test ($P<0.05$), while the coefficient of determination values were made using the program SAS (2000).

RESULTS AND DISCUSSION

The inclusion of dehydrated barley to silage resulted in a linear increase in water intake of 0.02% per unit of added grain ($P<0.05$, Fig.1). This result can be explained in view of the increased proportion of dry matter by the inclusion of dehydrated barley in the silage, as can be seen by the 19.77% difference between the control treatment and the highest level of inclusion (40%) (Table 4).

Table 3. Chemical composition, pH and N-NH3 of Marandu grass silage added by different levels of dehydrated barley

Variable	Levels of brewer's grain (%)				
	0	10	20	30	40
pH	4.28	4.19	4.13	4.12	4.09
N-NH3 (%TN)	7.61	7.03	6.45	5.89	5.29
Dry Matter[a]	24.13	27.91	31.02	39.5	43.9
Nitrogen[b]	1.15	1.80	2.02	2.16	2.35
soluble carbohydrates[b]	4.06	4.09	4.12	4.15	4.19
Ether extract	3.52	5.08	5.19	5.29	5.42
Total digestible nutrient[b]	33.27	39.06	44.85	50.60	56.40
Neutral detergent fiber[b]	73.63	64.06	61.25	61.60	60.50
Acid detergent fiber[b]	29.45	30.28	30.96	32.30	32.80
Hemicellulose	44.18	33.78	30.29	29.30	26.00
Lignin[b]	6.89	6.48	6.40	6.32	6.18
Minerals[b]	6.31	7.13	7.02	6.52	6.55
In Vitro Dry Matter Digestibility[b]	60.93	64.37	65.10	65.60	66.10

[a] Percentagen, [b] Percentage of dry matter.

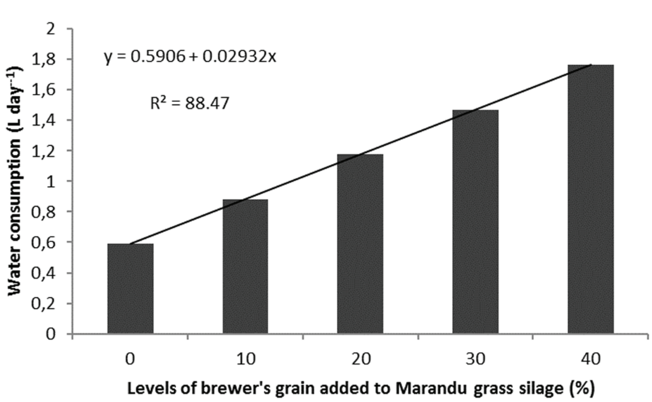

Fig.1. Water intake (L day^{-1}) of sheep fed on Marandu grass ensiled with levels of dehydrated barley.

When comparing the control animals with those of the highest level of dehydrated barley, the animals had a 300% greater demand for water when dehydrated barley was added. Souza et al. (2010) evaluated the water intake of sheep and goats fed on hay and/or maniçoba silage and found that for the animals that received the conserved maniçoba silage, 66% of the water intake came originally from the feed. Conversely, the animals that received hay had 94% of their total water intake obtained by drinking. This result corroborates with that of the present experiment, in that the increase in dry matter levels increases the sheep's water demand.

According to the NRC (2007), the water intake by goats is less than that consumed by sheep, which could relate to the greater efficiency in water use by goats. In addition, it is worth mentioning that taking into account the sheep's water demand as 0.800 kg per day (NRC 2007), the animals reached and exceeded this demand, in the view that the water level from food was not considered.

The increased water intake most likely was a result of increased dry matter intake and crude protein. Following the NRC (1985), voluntary water intake by sheep is related to the dry matter intake, crude protein and mineral salt in diets. According to Berchielli et al. (2006), ruminant water intake is influenced by the intake of crude protein, resulting in an increased water demand due to the heat increment from the digestive process of protein. This corroborates with the greater levels of crude protein in silage with dehydrated barley added (Table 4).

The levels of dehydrated barley added to ensiled Marandu grass influenced the dry matter intake, crude protein, ether extract and neutral detergent fibre ($P<0.05$), but did not influence the values of acid detergent fibre and organic matter (Table 4).

A quadratic effect was observed for the levels of dehydrated barley on the dry matter intake, with the maximum intake estimated at 2.86% of the dry matter volume when 17.8% dehydrated barley was added, allowing compliance with the requirements nutritional sheep established by NRC (2007) (Table 4). A similar behaviour was observed for the consumption expressed in relation to metabolic weight. Ribeiro et al. (2008) estimated dry matter intaketo vary between 1.74 and 2.59% live weight for Tanzania grass silages on increase of 0 to 30% wheat bran. The initial increase in dry dry matter intake in the present study can be explained in part by the increase in dry matter content of the silage. On addition of dehydrated barley to 90% dry matter in the silage (Table 4), part of the grass humidity was absorbed by the grain, thus increasing the fermentation quality, with mean pH and ammoniacal N of 4.13 and 6.16, respectively (Table 3).

One indication of this improvement was the observation of appropriate colouration and pleasant odour in the silage containing dehydrated barley, which was related to a good fermentation process, despite the control silage also showing good fermentation because the control silage was approximately 25% dry matter, with McDonald (1981) recommending mean levels of 30-35% dry matter. Following McDonald (1981), silages with butyric acid as their primary fermentation product generally exhibited low animal intake as a function of the elevated concentrations of butyric acid and ammoniacal nitrogen.

According to Silva et al. (2011), the utilisation of agricultural byproducts requires special attention, primarily in respect to stimulation of ruminal function, therefore alternative sources of dietary fibre deserve special attention particularly because the grinding process can reduce particle size and result in decreased physical effectiveness and occasional metabolic alterations. Despite 40% dehydrated barley composed in a higher percentage of grass silage, the reduced particles could increase intake by increasing intake and stimulating an increased rumen passage rate, although this was not observed. According to Cabezas et al. (1978), the decrease in intake observed y addition of agricultural residues can be associated with the low acceptability and/or adverse effects on the animals' metabolism and digestion.

In this context, the dry matter intake is a more important aspect to be considered in the formulation of ruminant diets because of its close relationship with reproductive and productive performance of the animals. DM intake predicts the nutrient intake, with several factors influencing the animal's ability to consume food inherent to the animal itself, the food, the environment and the management conditions.

Thecrude protein intake showed quadratic behaviour, so that the maximum value was estimated at 0.29% crude protein increase at a level of 22.5% dehydrated barley addition. Considering the crude protein intake is expressed in g/kg live weight $(LW)^{0.75}$/day, the maximum value was estimated at 6.78 g/kg $LW^{0.75}$/day of crude protein for the level of 30.7% dehydrated barley (Table 4). The increase of crude protein intake is related to the increase in CP level of Marandu grass silages with the inclusion of dehydrated barley.

Neiva et al. (2006) evaluated the inclusion of passionfruit byproduct on elephant grass silage and found an increase in CP of 0.20 g kg^{-1} $LW^{0.75}$ for each 1% of byproduct. In the case of Neiva et al. (2006) study, beyond the increase of CP level in the silages, there was an increase in DM consumption which permitted the animals greater levels of intake.

For the ether extract intake , quadratic behaviour was also observed (P<0.05), where the maximum value was estimated at 0.2% ether extract increase at a level of 28.25%

Table 4. Mean daily dry matter intake, crude protein, ether extract, neutral detergent fibre, acid detergent fibre and organic matter, and the respective regression equations and coefficients of variation of Marandu grass ensiled with levels of dehydrated barley

Variable	Level of dehydrated barley added to silage (%)					Regression equation	CV (%)g	R2 (%)[h]
	0	10	20	30	40			
	Mean daily intake (% LW)							
DM[a]	2.39	2.81	2.87	2.73	2.4	Y = 2.55 + 0.0356X - 0.001X2	7.65	89
CP[b]	0.137	0.227	0.277	0.295	0.305	Y = 0.141 + 0.009X - 0.0001X2	5.82	88.95
EE[c]	0.052	0.117	0.152	0.155	0.162	Y = 0.057 + 0.005X - 0.00007X2	7.21	87.21
NDF[d]	0.787	1.03	1.342	1.535	1.705	Y = 0.774 + 0.030X - 0.0001X2	7.27	89.63
ADF[e]	0.455	0.689	0.898	1.256	1.325	Y = 0.924	-	NS
OM[f]	1.169	1.422	1.627	1.977	1.995	Y = 1.638	-	NS
	Mean daily intake (g kg-1 LW0.75 day-1)							
DM[a]	53.8	67.13	63.96	57.64	54.32	Y = 56.11 + 0.917X - 0.0255X2	4.55	69.04
CP[b]	3.85	5.38	6.12	6.53	6.6	Y = 3.91 + 0.157X - 0.0022X2	4.43	89.5
EE[c]	1.17	7.71	9.65	10.23	11.22	Y = 1.69 + 0.582X - 0.0089X2	6.94	86.07
NDF[d]	22.58	26.26	30.80	34.21	36.42	Y = 22.40 + 0.476X - 0.0030X2	3.11	89.77
ADF[e]	15.55	17.85	22.56	27.89	27.93	Y = 22.35	-	NS
OM[f]	30.46	34.51	40.28	53.76	50.85	Y = 41.974	-	NS

NS = Not significant (P>0.05 by t-test), LW = live weight. [a] Dry matter intake (DM), [b] crude protein intake (CP), [c] ether extract intake (EE), [d] neutral detergent fibre intake (NDF), [e] acid detergent fibre intake (ADF), [f] organic matter intake (OM), [g] coefficients of variation (CV), [h] regression equations (R^2).

Table 5. Apparent digestibility of dry matter, crude protein, ether extract, neutral detergent fibre, acid detergent fibre and organic matter, and the respective regression equations (R^2) and coefficients of variation (CV) of Marandu grass ensiled with levels of brewer's grain

Variable	Level of dehydrated barley added to silage (%)					Regression equation	CV (%)g	R2 (%)[h]
	0	10	20	30	40			
DM[a]	55.01	61.55	63.89	64.42	64.23	Y = 55.39 + 0.6486X - 0.0109X2	6.34	65.82
CP[b]	57.99	62.55	64.86	64.86	64.79	Y = 58.27 + 0.5094X - 0.0088X2	1.69	79.70
EE[c]	48.39	55.62	58.46	60.51	61.04	Y = 48.73 + 0.7073X - 0.0101X2	4.62	78.08
NDF[d]	58.50	62.30	63.36	65.92	67.31	Y = 58.82 + 0.222X	2.27	88.96
ADF[e]	48.15	55.13	56.32	57.38	58.33	Y = 55.06	-	NS
OM[f]	47.56	51.29	54.33	57.58	55.68	Y = 53.33	-	NS

NS = Not significant (P>0.05 by t-test). [a] Dry matter intake (DM), [b] crude protein intake (CP), [c] ether extract intake (EE), [d] neutral detergent fibre intake (NDF), [e] acid detergent fibre intake (ADF), [f] organic matter intake (OM), [g] coefficients of variation (CV), [h] regression equations (R^2).

dehydrated barley addition. Similar behaviour was observed for the ether extract intake in relation to metabolic weight (Table 4). The elevation of ether extract intake occurred due to the elevation of nutrient levels in the silages when dehydrated barley was added, with the Marandu grass silage without grain addition had an ether extract level of 0.052%.

The regression study showed quadratic behaviour for the neutral detergent fibre intake (P<0.05), where the maximum value was estimated at 2.33% NDF increase at a level of 34.58% dehydrated barley addition. Similar behaviour was observed for the neutral detergent fibre intake in relation to metabolic weight (Table 4). This behaviour is determined by a compensation mechanism of animals to meet their nutritional necessities by eating a greater amount of food. Neiva et al. (2006) evaluated the addition of concentrated corn gluten meal in Tifton grass hay based diets for Santa Inês sheep, obtaining a mean neutral detergent fibre intake of 3.0% LW, superior to that registered by this research.

For the neutral detergent fibre intake and organic matter, no significant statistical difference was observed (P<0.05), with mean values of 0.92 and 1.63% LW and of 22.35 and 41.97g kg^{-1} $LW^{0.75}$ per day, respectively (Table 4).

The dry matter digestibility showed a significant quadratic effect, with the maximum value estimated at 65.03% at a level of 29.75% dehydrated barley addition (Table 5). Behavior similar to dry matter intake, that is, values up to 30% dehydrated barley addition in silage improves silage fermentation profile and its nutritional value, however, above these values occurs reduction in the intake and digestibility, possibly the low acceptability by animals (Ferreira et al. 2016).

It is also worth mentioning that the IVDMD of this estimated maximum value was superior by 10% compared to the silage without additive. Cabral Filho et al. (2007) evaluated the inclusion of 0.33 and 67% of fermented dehydrated barley in sheep rations containing Tifton grass hay and observed no effect in total digestibility coefficients of DM and NDF (P>0.05), although observed an increase in the total digestibility coefficient of CP, a fact attributed to the greater values of energy and protein in dehydrated barley compared to hay.Concomitantly, the protein digestibility was influenced by the addition of dehydrated barley in ensiled Marandu grass in quadratic form (P<0.05; Table 5), with the maximum value estimated at 65.54% at the inclusion of 28.94% dehydrated barley addition to the ensiled grass. Note that the quadratic effect of the inclusion of the dehydrated barley on the Marandu grass silage on the crude protein digestibility may be related to the quality of this protein in this by-product. Hence the type of processing or additives used in the fermentation process in the brewing industry may affect the quality of the final product, since variations in temperature and humidity can lead to the formation of insoluble complexes between nitrogen and starch, who present chemical characteristics similar to lignin, making it indigestible by animal (Ferreira et al. 2016). Should be taken in consideration the maximum level of 30% inclusion of dehydrated barley on the ensiling process.The ether extract digestibility was significant also (P<0.05), showing a quadratic effect and a maximum value of 65.03% at the inclusion of 29.75% dehydrated barley addition (Table 5). This upward trend might be a consequence of the increased digestibility of DM. According Castro et al. (2016) increase in digestibility of EE may be assigned the biosynthesis of non-lipid components.

A linear increase was observed for the regression equation of the NDF digestibility (P<0.05; Table 5). An increase of 0.22% of NDF digestibility was observed for each 1% inclusion of dehydrated barley to silage, with the maximum level of dehydrated barley inclusion (40%) resulting in a maximum estimated value of 67.7%. As a result, the sheep fed the 40% treated silage digested 18.97% more NDF than

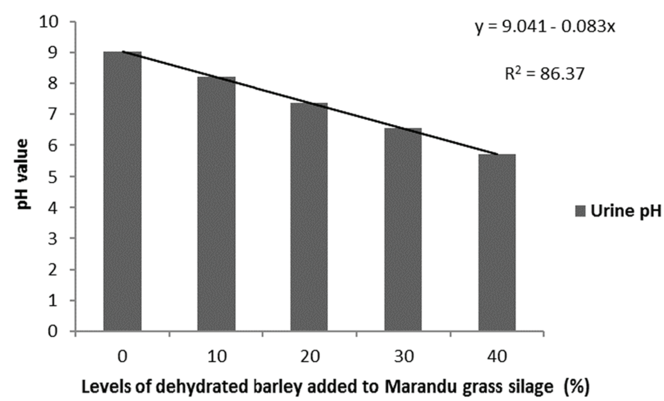

Fig.2. Sheep urine pH values for sheep fed on Marandu grass ensiled with levels of dehydrated barley.

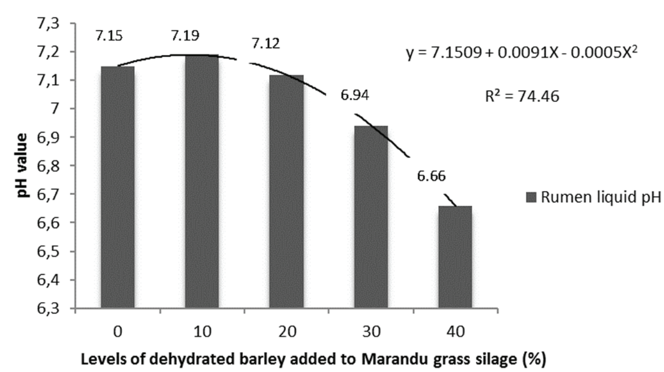

Fig.3. Rumen liquid pH values of sheep fed on Marandu grass ensiled with levels of dehydrated barley.

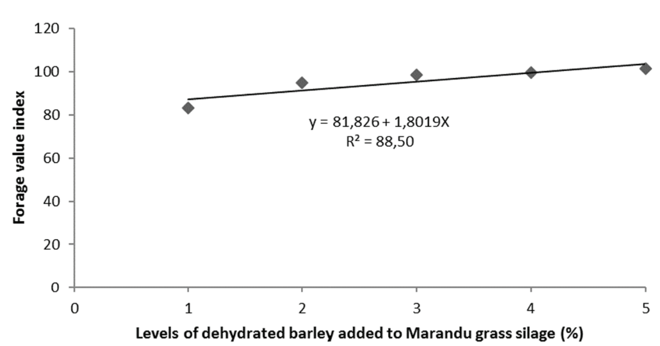

Fig.4. Forage value index (FVI) of Marandu grass ensiled with levels of dehydrated barley.

those fed the control silage (58.82%). This result can be explained by the longer period of retention of the feed in the rumen of the sheep fed the diets containing higher levels of the residue, possibly resulting from the increased fiber content.The ADF and organic matter digestibility's were not significant, with their mean values being 55.06 and 53.33, respectively (P>0.05, Table 5). Same behavior registered for the AFD digestibility and organic matter. Despite the best fiber values and organic matter in relation to control silage, inclusion levels did not change the other silages.

It was observed that the regression equation related to the pH of the sheep urine, verifying a linear decrease (P<0.05) with a reduction of 0.083% at a level of 1% dehydrated barley added to the Marandu grass silage (Fig.2). Based on the control silage, the pH value decreased from 9.04 to 5.71 when 40% dehydrated barley (maximum) was added.

The ruminal liquid pH values showed quadratic performance when dehydrated barley was added to Marandu grass silage (P<0,05), with the maximum value measured at 9.1 at a level of 7.10% dehydrated barley addition (Fig.3).

Rumen pH is a factor that can affect rumen fermentation; when below 6.2 it may depress the increase in ruminal microorganisms, primarily cellulolytic and methanogenic bacteria. The concentrate to bulk ratio can affect the efficiency and microbial production due to the effects on the availability of substrate, passage rate and ruminal pH (Russell et al. 1992). According to Rode et al. (1985), the microbial efficiency was greatest when the bulk to concentrate ratio was 80:20 (alfalfa hay:corn and soybean meal), but the microbial production was greatest in diets that contained higher proportions of concentrate (38:62).

The rapid digestion of starch can lower the ruminal pH drastically, causing digestive problems and reducing milk ether extract. Due to these factors, the diets must contain adequate fibre for possible use of significant quantities of barley. In this sense, Kennelly et al. (2001) found that the substitution of corn with barley in lactating cow diets resulted in a drop in rumen pH, reduction of fibre digestion and DMI and depression of milk ether extract. Given that the lowest pH values of this study are above 6.2, this effect was not observed for sheep.

According to Knowlton et al. (1998), the reduction in DMI due to decreased rumen pH, reduces the fibre digestibility and may increase the fibre retention time in the rumen, limiting feed intake associated with rumen fill.

The addition of dehydrated barley proportions linearly increased the forage value index (FVI) of the Marandu grass silage (Fig.4). The FVI is an important parameter in silage quality evaluation because it takes DM digestibility and intake into account, factors that can limit animal performance. Consequently, the FVI of tropical grasses proposed by Teixeira & Andrade (2001) can be utilised as comparative parameters between tropical forages, determining the equivalent grade. This index is divided into six grades, from FVI >122, considered superior, to grade 1 (<51), that includes the forages of inferior quality.

The lowest FVI value (81.82) found in the silage without dehydrated barley addition fits as a grade 4 classified forage as described by Teixeira & Andrade (2001), the same degree as elephant grass (*Pennisetum purpureum*) *in natura*, which is broadly used in ruminant nutrition. The high FVI value was associated with the cutting age of the forage (50 days post-regrowth), which probably caused a higher leaf to stem ratio, more with DM levels close to 25% and pH close to 4.2 (Table 5), the minimum prerogatives highlighted by McDonald et al. (1991) for good silage quality. Lopes et al. (2011) recorded that the low actuation of the extracellular matrix in converting parenchymal cells (rich in soluble carbohydrates) in sclerenchyma (constitute of NDF and ADF fractions), led to the reduction of NDF and ADF levels in the ensiled material, with these fractions having an inverse relationship with FVI.

A higher forage value index was obtained with the addition of 40% dehydrated barley to ensiled Marandu grass (154.18); this was comparable to alfalfa (lucerne) *in natura,* since both are classified as superior grade by the classification of Teixeira & Andrade (2001). The expressive FVI increase from the addition of dehydrated barley is explained by the fact that this grain has greater fibre quality, because these fractions are inversely related to FVI. Another factor to be taken into consideration is that the addition of dehydrated barley increased the dry matter, and by this likely favoured better fermentation of ensiled material and thus reduce the losses caused by effluent formation. These results were similar to those of Ribeiro et al. (2008), who observed FVI values of 76 and 141 in a study of Tanzania grass silage with levels of 0, 8, 16, 24 and 34% wheat bran.

CONCLUSIONS

Diets containing levels of 20 to 30% dehydrated barley in Marandu grass silage positively influenced the dry matter intake, crude protein, ether extract and neutral detergent fibre, but did not influence the values of acid detergent fibre or organic matter.

The inclusion of dehydrated barley also resulted in an increase in water intake.

Acknowledgements.- National Council for Scientific and Technological Development and Foundation for research Support of the State of Mato Grosso and Fundação de Amparo à Pesquisa e Desenvolvimento Científico do Maranhão - FAPEMA.

REFERENCES

Alves G.R., Fontes C.A.A. & Ribeiro E.G. 2002. Influência do nível de matéria seca, e de uréia sobre a qualidade de silagens contendo polpa de abacaxi, em misturas com bagaço de cana ou feno de Coast cross. Anais 39ª Reunião Anual da Sociedade Brasileira de Zootecnia, Recife. 4p.

AOAC 2005. Official Methods of Analysis of the Association of Official Analytical Chemists. 18th ed. Gaithersburg, MD, USA.

Bailey R.W. 1981. Quantitative studies of ruminant digestion. II. Loss of ingested plant carbohydrates from the reticulerumen. J. Agricult. Res. 10(1):15-32.

Berchielli T.T., Rodriguez N.M. & Osório Neto E. 2006. Nutrição de Ruminantes. Funep, Jaboticabal. 583p.

Bergamaschine A.F., Passipiéri M. & Veriano Filho W.V. 2006. Qualidade e valor nutritivo de silagens de capim-marandu (*B. brizantha* cv. Marandu) produzidas com aditivos ou forragem emurchecida. Revta Bras. Zootec. 35(4)1454-1462.

Bernardes T.F., Reis R.A. & Moreira A.L. 2005. Fermentative and microbiological profile of Marandu-grass ensiled with citrus pulp pellets. Scient. Agricult. 62(9):214-220.

Bovolenta S., Piasentier E. & Peresson C. 1998. The utilization of diets containing increasing levels of dried brewers' grains by growing lambs. Anim. Sci. 66(9):689-695.

Bolsen K.K., Gadeken D. & Flachowsky O. 1992. Effect of silage additives on the microbial succession and fermentation process of alfalfa and corn silages. J. Dairy Sci. 75(11):3066-3083.

Brochier M.A. & Carvalho S. 2008. Consumo, ganho de peso e análise econômica da terminação de cordeiros em confinamento com dietas contendo diferentes proporções de resíduo úmido de cervejaria Arq. Bras. Med. Vet. Zootec. 60(5):1205-1212.

Cabezas M.T., Flores A. & Egaña J.I. 1978. Uso de pulpa de café en la alimentación de ruminantes, p.45-67. In: Braham J.E. & Bressani R. (Eds), Pulpa de café. Instituto de Nutrición de Centro América y Panamá, Bogotá.

Cabral Filho S.L.S., Bueno I.C.S. & Abdalla A.L. 2007. Substituição do feno de Tifton pelo resíduo de cervejaria úmido em dietas de ovinos em mantença. Ciênc. Anim. Bras. 8(12):65-73.

Castro J.R.C., Zanine A.M., Lana R.P., Souza A.L., Negrão F.M. & Geron L.J.V. 2016. Inclusion of different levels of common-bean residue in sheep diets on nutrient intake and digestibility. Semina, Ciênc. Agrárias 37(1): 369-380.

Correia M.X.C., Costa R.G. & Silva J.H.V. 2002. Desempenho de caprinos alimentados com níveis crescentes de resíduo agroindustrial de abacaxi em substituição ao feno de capim coast cross. Anais 39ª Reunião Anual da Sociedade Brasileira de Zootecnia, Recife, PE. 4p.

Ferreira D.J.F., Zanine A.M., Lana R.P., Souza A.L., Negrão F.M., Geron L.J.V., Parente H.N. & Dantas C.C. 2016. Kinetic parameters of ruminal degradation of Marandu grass silage supplemented with brewer's grain. Cient. Invest. Agricult. 43(1):135-142.

Kennelly J., Okine E., Khorazani R. & Corbett R. 2001. Barley grain for dairy cattle. J. Dairy Sci. 82(11):2486-2496.

Knowlton K.F., Glenn B.P. & Erdman R.A. 1998. Performance, ruminal fermentation, and site of starch digestion in early lactation cows fed corn grain harvested and processed differently. J. Dairy Sci. 81(7):1972-1984.

Lallo F.H., Prado I.N. & Nascimento W.G. 2003. Níveis de substituição da silagem de milho pela silagem de subproduto industrial de abacaxi sobre a degradabilidade ruminal em bovinos confinados. Rev. Bras. Zootec. 32(3):719-726.

Lopes M.N., Cândido M.J.D., Pompeu C.F.F. & Lopes J.W.B. 2011. Componentes estruturais do resíduo pós-corte em capim-massai. Revta Ciên. Agron. 42(2):518-525.

McDonald P. 1981. The Biochemistry of Silage. John Wiley and Sons, Chichester. 218p.

McDonald P., Henderson A.R. & Heron S.J. 1991. The biochemistry of Silage. 2nd ed. Chalcombe Publications, Marlow. 340p.

NRC 1985. Ruminant Nitrogen Usage. National Research Council, National Academy Press, Washington, DC. 138p.

NRC 2001. Nutrients Requirements of Dairy Cattle. 7th ed. National Research Council, Washington, DC. 381p.

NRC 2007. Nutrient Requirements of Small Ruminants. National Research Council, National Academy Press, Washington, DC. 362p.

Neiva J.N.M., Nunes F.C.S. & Cândido M.J.D. 2006. Valor nutritivo de silagens de capim-elefante enriquecidas com subproduto do processamento do maracujá. Revta Bras. Zootec. 35(4):843-1849.

Oliveira Filho G.S., Neiva J.N.M. & Pimentel J.C.M. 2002. Avaliação do valor nutritivo de silagens de capim elefante (*Pennisetum purpureum*) com diferentes níveis de subproduto de pseudofruto do abacaxi (*Ananas comosus*). 39ª Reunião Anual da Sociedade Brasileira de Zootecnia, Recife, PE. 4p.

Ribeiro J.L., Nussio L.G., Mourão G.B., MarI L.J., Zopollatto M. & Paziani S.F. 2008. Valor nutritivo de silagens de capim-marandu submetidas aos efeitos de umidade, inoculação bacteriana e estação do ano. Revta Bras. Zootec. 37(7):1176-1184.

Rode L.M., Weakley D.C. & Satter L.D. 1985. Effect of forage amount and particle size in diets of lactating dairy cows on site of digestion and microbial synthesis. Can. J. Anim. Sci. 65(1):101-111.

Rogers J.A., Conrad H.R. & Dehority B.A. 1986. Microbial numbers, rumen fermentation and nitrogen utilization of steers fed wet or dried brewers' grains. J. Dairy Sci. 69(13):745-753.

Russell J.R., Irlbeck N.A., Hallauer A.R. & Buxton D.R. 1992. Nutritive value and ensiling characteristics of maize herbage as influenced by agronomic factors. Anim. Feed Sci. Technol. 38(6):11-24.

Santos E.M. 2007. Populações microbianas e perfil fermentativo em silagens de capins tropicais e desempenho de bovinos de corte alimentados com dietas contendo silagens se capim-mombaça. Tese de Doutorado em Zootecnia, Universidade Federal de Viçosa, Viçosa, MG. 154p.

SAS 2000. User's Guide: basic and statistic. SAS, Cary. 1686p.

Silva V.L., Rogério M.C.P. & Alves A.A. 2011. Comportamento ingestivo de cordeiros alimentados com dietas contendo a inclusão de farelo de castanha de caju. Revta FZVA Univ. Católica Rio Grande do Sul, Uruguaiana, 18(1):165-181.

Souza E.J.O., Guim A., Batista A.M.V. & Albuquerque D.B. 2010. Comportamento ingestivo e ingestão de água em caprinos e ovinos alimentados com feno e silagem de Maniçoba. Revta Bras. Saúde Prod. Anim. 11(4):1056-1067.

Teixeira J.C. & Andrade G.A. 2001. Carboidratos na alimentação de ruminantes. II Simpósio de Forragicultura e Pastagens, Lavras. Editora UFLA, p.165-210.

Tilley J.M.A. & Terry R.A. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassl. Soc. 18(3):104-111.

Valadares Filho S.C. 1997. Digestibilidade aparente e locais de digetão da matéria seca, energia e carboidratos de feno de soja perene. Tese de Doutorado em Zootecnia, Escola de Veterinária, Universidade Federal de Minas Gerais, Belo Horizonte. 88p.

Van Soest P.J. 1994. Nutritional Ecology of the Ruminant. 2nd ed. Cornell University Press, Ithaca. 476p.

Van Soest P.J., Robertson J.B. & Lewis B.A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74(10):3583-3597.