Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 **ISSN 1519 9940**
http://dx.doi.org/10.1590/S1519-9940200132019

Nutritional value of dehydrated maize straw ammoniated with urea

Valor nutricional da palha da espiga de milho desidratada amonizada com ureia

SOUSA, Giovanne Oliveira Costa[1] *; RODRIGUES, Rosane Cláudia[2]; LIMA, Juliana Rodrigues Lacerda[1]; LIMA, Noilson Monteles[1]; MIRANDA, Bruno Eduardo Caxias[3]; JESUS, Ana Paula Ribeiro[2]; PARENTE, Henrique Nunes[2]; COSTA, Clésio dos Santos[3]

[1]Discentes do Programa de Pós-Graduação em Ciência Animal da Universidade Federal do Maranhão/UFMA campus IV/CCAA. Chapadinha, Maranhão, Brasil.
[2]Docentes do Programa de Pós-Graduação em Ciência Animal da Universidade Federal do Maranhão/UFMA campus IV/CCAA. Chapadinha, Maranhão, Brasil.
3Discente do curso de Zootecnia da Universidade Federal do Maranhão/UFMA campus IV/CCAA. Chapadinha, Maranhão, Brasil.
[4]Discente do Programa de Doutorado Integrado em Zootecnia-PDIZ/UFPB/UFC/UFRPE.
*Endereço para correspondência: giovanneolivei78@gmail.com

SUMMARY

This study aimed to evaluate the chemical composition and in situ degradation dry matter of maize straw ammoniated with urea. This was a completely randomized design with five levels of ammoniation (0; 2; 4; 6 and 8% dry matter), with five repetitions. There was effect (P<0.05) of the ammoniation process on the retention of nitrogen in maize straw. For each 1% utilization of urea, we observed a reduction of 1.57% nitrogen retention. The dry matter content was not influenced (P>0.05) by the ammoniation; straw presented a mean value of 75%. In turn, the crude protein content increased (P<0.05) with ammoniation, increasing from 2.74% in the straw without treatment to 10 and 11% with the levels of 6 and 8% urea, respectively. For each 1% urea used, we found a reduction (P<0.05) of 0.65% in the neutral detergent fiber content of maize straw. The acid detergent fiber presented effect (P<0.05) in response to ammoniation. The technique provided a reduction of 0.69% acid detergent fiber for each 1% urea used. For dry matter degradation, we observed an increase in the soluble fraction up to the level of 6% urea. The ammoniation process favored the increase in the dry matter degradation rate of maize straw. It is recommended to conduct the ammoniation process in maize straw with 6% urea.

Key Words: ammoniation, effective degradability, chemical treatment, *Zea Mays* L

RESUMO

Objetivou-se avaliar a composição químico bromatológica e degradação *in situ* da matéria seca da palha de milho amonizada com ureia. Adotou-se delineamento inteiramente casualizado com cinco níveis de amonização (0; 2; 4; 6 e 8% da matéria seca), com cinco repetições. Verificou-se efeito (P<0,05) do processo de amonização sobre a retenção de nitrogênio na palha de milho. Para cada 1% de utilização da ureia foi observado redução de 1,57% de retenção de nitrogênio. O teor de matéria seca não foi influenciada (P>0,05) pelo processo de amonização, a palha apresentou valor médio de 75%. Já o teor de proteína bruta aumentou (P<0,05) com a amonização, elevando valores de 2,74% da palha sem tratamento para 10 e 11% com os níveis de 6 e 8% de ureia, respectivamente. Para cada 1% de ureia utilizado foi observado redução (P<0,05) de 0,65% no teor de fibra em detergente neutro da palha do milho.A fibra em detergente ácido apresentou efeito (P<0,05) em resposta à amonização. A técnica proporcionou

Received on: 08/04/2018. Accepted on: 05/02/2019

redução de 0,69% de fibra em detergente ácido para cada 1% de ureia utilizada. Para a degradação da matéria seca foi observado aumento na fração solúvel até o nível de 6% de ureia. O processo de amonização favoreceu o aumento na taxa de degradação da matéria seca da palha de milho. Recomenda-se que o processo de amonização na palha de milho seja realizado com níveis de 6% de ureia.
Palavras-Chave: amonização, degradabilidade efetiva, tratamento químico, *Zea Mays* L

Received on: 08/04/2018. Accepted on: 05/02/2019

INTRODUCTION

Brazil is one of the leading producers of cereals, among which the maize grain occupies a prominent position, reaching approximately 97.8 million tons in the 2016/2017 season (CONAB, 2017). However, this high production generates tons of residues, as the straw that covers the ear of maize. Improper disposal of these products can cause serious damage to the environment.

Most of the by-products of agribusiness has nutritional potential for feeding ruminants, but the degree of utilization of food will depend on the presence or not of anti qualitative factors (lignin, silica and phenolic compounds) and low values of nitrogen, mineral and energy available (PAIVA, 1992).

Maize straw because it is considered as lignocellulosic type presents great potential for handicrafts, in addition, it is used as bedding by broiler breeders. This product has already been used fresh by producers as feed for ruminants, however, there are few studies that emphasize its nutritional value for its recommendation (CASTRO FILHO et al., 2007).

Maize straw has great potential to be used in ruminant nutrition, with around 7.50% crude protein, on the other hand, it presents 72% neutral detergent fiber (CASTRO FILHO et al., 2007).However, the high content of fiber can be a complication in animal performance for being a limiting factor for consumption (VAN SOEST, 1994).It is worth mentioning that this composition can vary depending on the place and the hybrid used, considering that the composition suffers effects of climatic variations.

However, there are strategies that aim to increase the crude protein content of the material and reduce the fiber content, which consists of the use of ammoniation (PIRES et al., 2010). This technique reduces the content of neutral detergent fiber and elevates the content of non-protein nitrogen, thus improving the digestibility of the material (DAMASCENO et al., 1994; ZANINE et al., 2007). The principle of this technique is that when urea is diluted in water and applied to the material, it will form the ammonia gas, which will react with the material, directly on the bonds of hemicellulose and lignin, with this occurs the solubilization of hemicellulose (ROSA & FADEL, 2001). In this context, this study aimed to evaluate the chemical composition and parameters of in situ dry matter degradability of maize maize ammoniated with urea.

MATERIAL AND METHODS

The experiment was conducted in the Forage Crops Unit of the Center for Agricultural and Environmental Sciences,Universidade Federal do Maranhão, Chapadinha, state of Maranhão, Brazil (03°44’33’’ S, 43°21’21’’ W).

The maize straw used was the one that covered the ear, obtained in commercial points of the city during the first half of the year 2016. Then the material was taken for dehydration, with the aim of avoiding losses in the material. This was a completely randomized design with five levels of ammoniation (0; 2; 4; 6 and 8% dry matter), with five repetitions.

We used two kg maize straw per experimental unit, following the amount adopted by Gobbi et al. (2008) and Moreira Filho et al. (2013). The quantity of urea used was based on dry matter; each quantity was diluted in 90 mL water. The distribution of the

Received on: 08/04/2018. Accepted on: 05/02/2019

Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-9940200132019

solution of urea was performed with the aid of a watering can, sprinkling evenly on the material, and then it was packaged in polyethylene bags with a thickness of 200 microns, with capacity for 200 liters. The bags were sealed with adhesive tape to prevent volatilization of ammonia produced and then stored in a shed covered with ceramic tiles, for 30 days (ROSA et al., 2000). After, the bags were opened and remained open for 48 hours of aeration for elimination of excess ammonia.

Then,300 g samples were collected from each experimental unit, and pre-dried in a forced ventilation oven at 55°C for 72 hours for later analyses. After drying, the material was ground in a Wiley mill with 1-mm sieve for determination of the chemical composition of maize straw. Samples were analyzed for dry matter (method 930.15), crude protein (method 954.01), according to the procedures described in AOAC (1990).Analyses of lignin and ash were performed according to Detmann et al. (2012) (INCT-CA F-005/1 Method; INCT-CA M-001/1 Method, respectively); analyses of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were carried out according to the procedures proposed by Van Soest et al. (1991).

Data relating to nitrogen retention of the ammoniated material was calculated by equation proposed by Paiva (1992) and Campos (1994), however, modified for use with urea.

NR (%) = [(%NA - NB) * (%urea x 0.45)] x 100 eq (1)

Where:

NR (%) = nitrogen retention expressed in percentage of nitrogen added by ammoniation;

%NA = percentage of total nitrogen in ammoniated material;

%NB = percentage of total nitrogen in non-ammoniated material;

%urea = percentage of urea used as level;

0.45= percentage of nitrogen contained in the urea.

For the degradability test, another part of the sample was ground in a Wiley mill with 5-mm sieve. The experimental design was a completely randomized design with repeated measures in time, and the levels of ammoniation (0; 2; 4; 6 and 8% dry matter) and repeated measurements were the incubation times (0, 6; 24; 72 and 96 h), with four replications.

For evaluation of in situ dry matter degradation, it was used fistulated sheep with average body weight of 60 kg, fed diet with forage: concentrate ratio of 70:30. Ammoniated cord straw (4g) were placed in nylon bags with 12 x 8 cm and 50 µm porosity (NOCEK, 1988).The bags were inserted in the rumen in the times proposed and then removed simultaneously and then placed in bucket with cold water to stop the fermentation process.

For determination of the material disappearance at time zero (soluble fraction), bags were placed in a water bath at39ºC for one hour (MAKKAR, 1999).After, the material was placed with the one removed from the rumen and washed and then pre-dried in an oven at 55ºC.

The parameters of dry matter degradability (DMD) were estimated according to the model proposed by Ørskov & McDonald (1979), modified and simplified by Sampaio (1995): DP = Deg = $A\text{-}B*e^{(-ct)}$; where: A= maximum potential of degradability; B= potentially degradable fraction; c= rate of degradability of fraction b; t= time. The effective degradability (ED) of DM was estimated considering three ruminal

Received on: 08/04/2018. Accepted on: 05/02/2019

Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-9940200132019

passage rates of 2; 5 and 8% h^{-1}, using the equation described by Ørskov & McDonald (1979): ED = a+(b*c/c+k); where: a = soluble fraction; b = potentially degradable fraction; c = rate of degradability of fraction b; k = rate of passage.

The parameters a, b and c and the curves of in situ degradability were determined according to the method of Gauss-Newton, by PROC NLIN of SAS (2002).The regression analysis at 5% probability was used to explore the effects of adding urea using PROC REG in SAS (2002).

RESULTS AND DISCUSSION

The ammoniation process had no effect (P>0.05) on the dry matter content of maize straw (Table 1).This result is explained by the low amount of water added in the material before ammoniation, once it is necessary a moisture content between 30 to 40% for no impairment in the process (WILLIAMS et al., 1984). At the time water with urea was sprinkled on the maize straw, it was observed that the absorption of water by straw was not immediate. It is noteworthy that the maize straw was not ground, which may have limited hydration of the material.

Table 1. Chemical composition of the maizestraw ammoniated with urea levels.

Variable	Levels of urea (%)					Mean	s.e.m[3]	Equation	R^{2*}	Effect
	0	2	4	6	8					
DM[1]	76.14	75.03	76.30	76.13	74.14	75.55	0.426	y=76.00	-	0.4594
NR[2]	-	46.68	41.41	42.81	35.71	42.56	1.229	y=49.52-1.57x	0.80	0.0045
CP[2]	2.74	5.36	7.64	10.06	11.22	7.21	0.720	y=3.00+1.12x	0.9703	<0.0001
NDF[2]	80.82	76.25	76.17	75.92	74.42	76.72	0.489	y=79.34-0.65x	0.505	<0.0001
ADF[2]	45.92	45.51	42.23	42.19	40.59	43.29	0.470	y=46.09-0.699x	0.4533	<0.0001
Lignin[2]	4.48	5.21	3.89	4.68	4.03	4.46	0.185	y=4.74	-	0.2670
Ash[2]	2.21	3.22	2.99	3.26	2.88	2.92	0.139	y=2.66	-	0.2757

[1]Values on a natural matter basis; [2] Values based on a dry matter basis; Regression analysis at the level of 5% probability depending on the levels of urea. DM=dry matter; NR=nitrogen retention; CP=crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber. [3]standard error of the mean; *coefficient of determination.

Furthermore, the time of aeration used (48 hours) may have caused the dehydration process as reported by Pires et al. (1999). A high variation in dry matter content can result in nutrient losses; as the maize straw did not alter the content of dry matter, we can infer that there was no loss of dry matter with the ammoniation process, which may be associated with the absence of development of fungi or fermentation processes (PIRES et al., 1999).

There was effect (P<0.05) of the ammoniation process on nitrogen retention (NR) in the maize straw (Table 1). For each 1% utilization of urea we observed a reduction of 1.57% nitrogen retention; this behavior is caused when using high levels of urea, due to the process of volatilization, a part is lost (SAENGER et al., 1982; BEZERRA et al., 2014). With the use of 8% urea, nitrogen retention was 35%, there was a decrease of almost seven percentage points in relation to the material treated with 6%.

We can infer that using 8% urea in the ammoniation process is not so advantageous, since the variation in nitrogen retention when using 6% was

Received on: 08/04/2018. Accepted on: 05/02/2019

Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-9940200132019

very similar to the level of 4%, when compared with the drop observed in NR when using 8% urea. This reduction in NR may be related to losses by volatilization due to the time of aeration. In addition, the fact that the material had a moisture content of 24% at the time of the process required the addition of a few mL of water so that the material remained within the idea content to carry out the ammonization process which is 30 to 40%. Consequently, the amount of water may have been insufficient to fully dilute the urea when using the higher levels.

There was an increase (P<0.05) in crude protein content with the levels of urea tested (Table 1). An increasing linear behavior was observed, for each 1% urea, an increase of 1.12% crude protein was recorded. It is worth noting that this increase is due to the contribution of non-protein nitrogen from urea as observed by Silva et al. (2017), who evaluated the ammoniation of shell of pods of the lima bean. It can be observed at the level of 6% urea, the crude protein content was 10%, higher than the minimum required for the proper functioning of ruminal microorganisms and no impairment of fiber degradation and consequently formation of microbial protein (VAN SOEST, 1994; LAZZARINI et al., 2009).

It is noteworthy the use of 6% urea resulted in an increase of 24% compared to the protein content of the material treated with 4%. When using the level of 8% urea, no representative increase was observed when compared to the material treated with 6%, being registered an increase of 10% protein. This behavior was caused by the lower nitrogen retention verified with the highest level of urea.

Therefore, the use of 8% urea may not be as advantageous as the level of 6%, considering that there will be more expenses with urea. Another point that should be taken into account is that with these higher levels, there is a greater formation of ammonia and with this stronger odor in the moment of opening, so there may be the need for more time of aeration to eliminate the excess and does not impair animal consumption. However, this longer aeration time results in less retention of nitrogen.

The neutral detergent fiber (NDF) presented effect (P<0.05) according to the levels of ammoniation (Table 1). For each 1% urea used, a reduction of 0.65% in the NDF content of the maize straw was observed. The technique proved quite effective in reduction, which can be highlighted is that the straw treated with 2, 4, 6, and 8% had no substantial variation when compared to the material treated with the reduction observed with untreated straw. High content of NDF may affect animal consumption, with a view to cause effect of ruminal fill, thereby regulating the consumption through physical limitation (MERTENS, 1994). Morais et al. (2017) evaluated the process of ammoniation of elephant grass hay of low-quality and observed a reduction in the NDF content with increasing levels of urea.

Another point that should be emphasized is that the fiber is of extreme importance in ruminant nutrition, as it ensures good ruminal functioning. Nevertheless, it is worth pointing out that the process of ammoniation will not reduce all the fiber of the material. Lazzarini et al. (2009) stresses that the reduction of the indigestible neutral detergent fiber (iNDF) is a priority goal to maximize the intake of NDF of the diet.

Received on: 08/04/2018. Accepted on: 05/02/2019

Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-9940200132019

Therefore, we highlight that the ammoniation process may increase the fraction of degradable NDF.

The acid detergent fiber (ADF) presented effect ($P<0.05$) in response to ammoniation. The technique provided a reduction of 0.69% ADF for each 1% urea used (Table 1). The ADF is the parameter associated with the quality of the fiber, high levels provide a reduction in feed digestibility (VAN SOEST, 1994).

Lignin was not influenced ($P>0.05$) by the ammoniation process. This result is probably associated with the principle of the technique, considering that higher responses are observed in the NDF content, because there is greater solubilization of hemicellulose as described by Reis et al. (1990). Reddy & Yang (2009) observed a large amount of coarse residues in the material after the alkaline treatment because of the lignin content of maize straw. These authors emphasize that lignin solubilization requires the use of enzymatic extraction.

However, the process of ammoniation did not affect the lignin content, thus maize straw did not present very high values, on average values of 4.46%, similar to that observed by Castro Filho et al. (2007).

The material lignification compromises the quality of the feed for ruminants, with consequent reduction in digestibility and reduction of voluntary intake due to the longer time than the material will stay in the rumen, consequently there will be a reduction in animal performance (LAZZARINI et al., 2009). The ammoniation process did not affect ($P>0.05$) the ash content of the maize straw.

The soluble fraction of maize straw increased with the ammoniation process, being the highest value observed with the straw treated with 6% urea (19.23%) (Table 2). This result is associated with the greatest reduction of neutral detergent fiber (Table 1), since the ammonia in contact with the fiber resulted in greater solubilization of the fraction. Moreira Filho et al. (2013) assessed the plant maize straw ammoniated with 3% urea, and observed an increase in the soluble fraction when compared to untreated material. Ammoniation provides an increase in fractions A+B1 (non-fiber carbohydrates), which results in increased degradability of soluble compounds such as sugars and lower participation of fiber fractions (MORAIS et al., 2017).

Table 2. Parameters of rumen degradability (a, b and c), potential degradability (A) and effective degradability of dry matter of maize straw ammoniated with urea.

Levels of urea[1]	*a(%)*	*b(%)*	*c(%/h)*	A	R^2	Effective degradability (%)		
						2 %/h	5 %/h	8 %/h
0	14.20	38.91	0.89	53.11	95.21	26.21	20.10	18.11
2	16.19	55.40	1.24	71.59	98.10	37.39	27.20	23.62
4	17.27	55.84	1.20	73.11	90.62	38.21	28.08	24.55
6	19.23	46.28	1.64	65.51	89.25	40.08	30.66	27.10
8	18.04	56.09	1.17	74.13	97.70	38.74	28.68	25.20

Received on: 08/04/2018. Accepted on: 05/02/2019

[1]% dry matter; a = soluble fraction in water; b = fraction insoluble in water, more potentially degradable; c = rate of degradability of fraction b; R^2 = coefficient of determination, A = potential degradability

It was observed that the ammoniation technique has increased the rate of degradation (c), in relation to untreated straw (no ammoniation), providing an increase of 28.22, 25.83, 45.73, 23.93% for the levels of 2, 4, 6, and 8, respectively (Table 2); the application of 6% provides the best result. The potential degradability (A) increased with the application of the levels of urea, this is explained by the reduction in the fiber content of straw, ammonia can act as alkali and act on ester bonds and thus it will act on the of the fibers and disruption of hydrogen bonds, consequently there will be a greater microbial degradation of particles (PIRES et al., 2010).

Another point that can be highlighted is the increase in the nitrogen content in the material, once there is greater amount of non-protein nitrogen, which ensures the proper functioning of the ruminal microbiota and greater degradation of the fiber (LAZZARINI et al., 2009; GARCEZ et al., 2014). Considering that the largest amount of non-protein nitrogen provides a greater amount of nitrogen to ruminal bacteria (PEREIRA et al., 2010).

The levels of addition of urea resulted in an increase in the effective degradability (ED) in relation to untreated straw (no ammoniation) (Table 1), this because the material has a lower fiber content when ammoniated. It was observed that ED is reduced in all treatments when increasing the rate of passage, which can be explained by the fact that the faster the food pass through the rumen the smaller its use, considering that the time of action of microorganisms on the material will be reduced (RUSSEL & WILSON, 1996).

Maize straw presents great nutritional potential, and the ammoniation technique increases the protein content and decreases the fiber content. It is recommended to conduct the ammoniation process with 6% urea.

ACKNOWLEDGMENTS

À Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão (FAPEMA), pela bolsa de iniciação científica, a CAPES pelo financiamento da bolsa de estudo. Ao grupo de estudo e pesquisa FOPAMA pela ajuda na condução do experimento.

REFERENCES

AOAC ‘**Official methods of analysis of AOAC International**.’ 15th edn. (AOAC International: Arlington, VA), 1990.

BEZERRA, H. F.C.; SANTOS, E. M.; OLIVEIRA, J.S.; PINHO, R.M.A.; PERAZZO, A.F.; SILVA, A.P.G.; RAMOS, J.P.F.; PEREIRA, G.A. Fenos de capim-buffel amonizados com ureia. **Revista Brasileira de Saúde e Produção Animal**, v.15, n.3, p.561-569. 2014

CAMPOS, M.C.L. **Níveis de amônia anidra e períodos de amonização sobre a composição químico-bromatológica e degradabilidade dos fenos de alfafa (Medicago sativa L.) e coastcross (Cynodon dactylon (L.) Pers. cv coastcross) com alta umidade**. Viçosa, MG, UFV, 1994. 130p. Dissertação (Mestrado em

Received on: 08/04/2018. Accepted on: 05/02/2019

Rev. Bras. Saúde Prod. Anim., Salvador, v.20, 01 - 11, e0132019, 2019 **ISSN 1519 9940**
http://dx.doi.org/10.1590/S1519-9940200132019

Zootecnia) - Universidade Federal de Viçosa, 1994.

CASTRO FILHO, M. A., BARBOSA, M. A. A. D. F., OLIVEIRA, R. L., BAGALDO, A. R. Valor nutritivo da palha de milho verde para bovinos. **Revista Brasileira de Saúde e Produção Animal**, v. 8, n. 2, 2007.

CONAB **– Companhia Nacional de Abastecimento**. Acompanhamento da safra brasileira grãos, v. 4 Safra 2016/17 - Décimo levantamento, Brasília, p. 1-171, julho 2017.

DAMASCENO, J. C.; PRATES, E. R.; SILVA, C.S.; PIRES, F.F.; CURY, P.R. Efeito de níveis e formas de aplicação de uréia sobre a qualidade da palha de trigo. **Revista Unimar**, v.16, n.1, p.137-147, 1994.

DETMANN, E.; SOUZA, M.A.; VALADARES FILHO, S.C.; QUEIROZ, A.C.; BERCHIELLI, T.T.; SALIBA, E.O.S.; CABRAL, L.S.; PINA, D.S.; LADEIRA, M.M.; AZEVEDO, J.A.G. (Eds.) **Métodos para análise de alimentos**. Visconde do Rio Branco: Suprema, 2012. 214p.

GARCEZ, B.S.; ALVES, A.A.; OLIVEIRA, M.E.; PARENTE, H.N.; SANTANA, Y.A.G.; MOREIRA FILHO, M.A.; CÂMARA, C.S. Valor nutritivo do feno de folíolos de pindoba de babaçu submetido a tratamentos alcalinos. **Ciência Rural**, v.44, n.3, p.524-530, 2014.

GOBBI, K.F.; GARCIA, R.; VENTRELLA, M.C.; GARCEZ NETO, A.F.; PEREIRA, O.G. Leaf tissues degradation of signal grass hay pretreated with urea and submitted to in vitro digestion. **Revista Brasileira de Zootecnia**, v.37, n.5, p.802-809, 2008.

LAZZARINI, I.; DETMANN, E.; SAMPAIO, C.B.; PAULINO, M.F.; VALADARES FILHO, S.C.; SOUZA, M.A.; OLIVEIRA, F.A. Dinâmicas de trânsito e degradação da fibra em detergente neutro em bovinos alimentados com forragem tropical de baixa qualidade e compostos nitrogenados. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.61, 1232 p.635-647, 2009.

MAKKAR, H.P.S. Recommendation for quality control of in sacco nylon bag technique. In: First research coordination meeting of the fao/iaea coordinated research project food and agriculture organization of the united nations for use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree, Viena, 1999. **Proceedings...** Viena: FAO/IAEA, 1999.

MERTENS, D. R. **Regulation of forage intake**. In. Forage quality, evaluation, and utilization, n. forage quality, p. 450-493, 1994.

MORAIS, L. F. D., ALMEIDA, J. C. D. C., NEPOMUCENO, D. D. D., MORENZ, M. J. F., MELO, B. M. G. D.,; FREITAS, R. S. X. D. Milled legume grain as urease source for the ammonization of elephant grass hay. **Pesquisa Agropecuária Brasileira**, v. 52, n. 12, p. 1268-1275, 2017.

MOREIRA FILHO, M.A.; ALVES, A.A.; VALE, G.E.S.; MOREIRA, A.L.; ROGERIO, M.C.P. Valor nutritivo do feno de restolho da cultura do milho

Received on: 08/04/2018. Accepted on: 05/02/2019

amonizado com ureia. **Revista Ciência Agronômica**, v.44, n.4, p.893-901, 2013.

NOCEK, J.E. In situ and others methods to estimate ruminal protein and energy digestibility. **Journal of Dairy Science**, v.71, p.2051-2069, 1988.

ØRSKOV, E. R.; McDONALD, I. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. **Journal of Agricultural Science**, v. 92, n. 2, p. 499-503, 1979.

PAIVA, J.A.J. **Níveis de amônia anidra, períodos de amonização e de aeração sobre a composição químico-bromatológica e a degradabilidade “in situ” da palha de milho (Zea mays L.)**. Viçosa, MG, UFV, 1992. 162p. Tese (Doutorado em Zootecnia) - Universidade Federal de Viçosa, 1992.

PEREIRA, E.S.; PIMENTEL, P.G.; DUARTE, L.S.; MIZUBUTI, I.Y.; ARAUJO, G.G.L. de; CARNEIRO, M.S. de S.; REGADAS FILHO, J.G.L.; MAIA, I.S.G. Determinação das frações proteicas e de carboidratos e estimativa do valor energético de forrageiras e subprodutos da agroindústria produzidos no Nordeste Brasileiro. **Semina: Ciências Agrárias**, v.31, p.1079-1094, 2010.

PIRES, A.J.V.; CARVALHO, G.G.P.; RIBEIRO, L.S.O. Chemical treatment of roughage. **Revista Brasileira de Zootecnia**, v.39, p.192-203, 2010.

PIRES, A.J.V.; GARCIA, R.; CECON, P.R.; NEIVA, J.N.M.; SARMENTO, P. Amonização da quirera de milho com alta umidade. **Revista Brasileira de Zootecnia**, v.28, p.1186-1193, 1999.
REDDY, N.; YANG, Y. Properties and potential applications of natural cellulose fibers from the bark of cotton stalks. **Bioresource technology**, v. 100, n. 14, p. 3563-3569, 2009.

REIS, R.A., GARCIA, R., QUEIROZ, A.C., RODRIGUES, L.R.A., PEREIRA, J.R.A., RUGGIERI, A.C. Efeitos da aplicação de amônia anidra sobre a composição química e digestibilidade in vitro dos fenos de três gramíneas forrageiras de clima tropical. **Revista da Sociedade Brasileira de Zootecnia**, v. 19 n. 3 p. 219-224, 1990.

REDDY, N.; YANG, Y. Properties and potential applications of natural cellulose fibers from mizehusks. **Green Chemistry**, v. 7, n. 4, p. 190-195, 2005.

ROSA, B., FADEL, R. Uso de amônia anidra e de ureia para melhorar o valor alimentício de forragens conservadas. In: Simpósio Sobre Produção e Utilização de Forragens Conservadas, **Anais...** p.41 –63, 319p. 2001.

ROSA, B.; SOUZA, H.; RODRIGUEZ, K.F. Composição química do feno de Brachiaria brizantha cv. Marandu tratado com diferentes proporções de ureia e de água. **Ciência Animal Brasileira**, v.1, n.2, p.107-113, 2000.

RUSSELL, J.B.; WILSON, D.B. Why are ruminal cellulolytic bacteria unable to digest cellulose at low pH. **Journal of Dairy Science**, 79: 1503-1509, 1996.

SAENGER, P.F., LEMENAGER, R.P., HENDRIX, K.S. Anhydrous ammonia treatment of mize stover and its effects on digestibility, intake and performance

Received on: 08/04/2018. Accepted on: 05/02/2019

of beef cattle. **Journal Animal Science**. v. 54 n.2 p. 419-25, 1982.

SAMPAIO, I.B.M**. Métodos estatísticos aplicados à determinação de digestibilidade in situ**. In: TEIXEIRA, J.C. Digestibilidade em ruminantes. Lavras: UFLA, 1995. p.165-178 1995.

SILVA, R.N.P.; ALVES, A.A.; GARCEZ, B.S.; MOREIRA FILHO, M.A.; OLIVEIRA, M.E.; MOREIRA, A.L.; AZEVÊDO, D.M.M.R.; PARENTE, H.N. Degradabilidade ruminal de casca de vagem de feijão-fava (*Phaseolus lunatus* L.) amonizada com ureia. **Revista Brasileira de Saúde e Produção Animal**, v. 18, n. 1, p. 26-37, 2017.

Van SOEST, P.J.; ROBERTSON, J.B.; LEWIS, B.A. Methods for dietary fiber, neutral detergent fiber, and nonstarch 007.

polysaccharides in relation to animal nutrition. **Journal of Dairy Science**, v.74, n.10, p.3583-3597, 1991.

VAN SOEST, P.J. **Nutritional ecology of the ruminant**. New York: Mizeell University Press, 1994. 476p.

WILLIAMS, P.E.V., INNES, G.M., BREWER, A. Ammonia treatment of straw via the hydrolysis of urea. I. Effects of dry matter and urea concentrations on the rate of hydrolysis of urea. **Animal Feed Science and Technology**, v. 11 n. 2 p. 103-113, 1984.

ZANINE, A.M., SANTOS, E.M., FERREIRA, D.J., PEREIRA, O.G. Efeito dos níveis de ureia sobre o valor nutricional do feno de capim-Tanzânia. **Semina: Ciências Agrárias**, v.28, n.2, p.333-340, 2

Received on: 08/04/2018. Accepted on: 05/02/2019