Drying methods and chemical quality of forages evaluated by near infrared spectroscopy

Métodos de secagem e qualidade bromatológica de forrageiras avaliadas por espectroscopia no infravermelho próximo

DOI:10.34117/bjdv8n9-238

Recebimento dos originais: 23/08/2022
Aceitação para publicação: 26/09/2022

Alexandra de Souza Tolentino Pamato
Graduado Zootecnia pela Universidade Federal de Santa Catarina (UFSC)
Institution: Universidade Federal de Santa Catarina (UFSC)
Address: Rod. Admar Gonzaga, 1346, CEP: 88040-900, Florianópolis - SC
E-mail: ale.pamato@gmail.com

Caroline Massignani
Mestrado em Agroecossistemas pela Universidade Federal de Santa Catarina (UFSC)
Institution: Universidade Federal de Santa Catarina (UFSC)
Address: Rod. Admar Gonzaga, 1346, CEP:88040-900, Florianópolis - SC
E-mail: carol.massig@gmail.com

Daniele Cristina da Silva Kazama
Doutorado em Zootecnia pela Universidade Estadual de Maringá (UEM)
Institution: Universidade Federal de Santa Catarina (UFSC)
Address: Rod. Admar Gonzaga, 1346, CEP:88040-900, Florianópolis - SC
E-mail: daniele.kazama@ufsc.br

Diego Peres Netto
Doutorado em Zootecnia pela Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) – Botucatu
Institution: Universidade Federal de Santa Catarina (UFSC)
Address: Rod. Admar Gonzaga, 1346, CEP:88040-900, Florianópolis - SC
E-mail: d.peres@ufsc.br

Milene Puntel Osmari
Doutorado em Zootecnia pela Universidade Estadual de Maringá (UEM)
Institution: Universidade Federal de Santa Catarina (UFSC)
Address: Rod. Admar Gonzaga, 1346, CEP:88040-900, Florianópolis - SC
E-mail: milene.osmari@ufsc.br

ABSTRACT

The determination of dry matter (DM) of forages is carried out in feed analysis laboratories mainly with the aid of a forced ventilation oven (FVO), a slower technique than the determination using a microwave oven (MO). Thus, the objective was to evaluate the influence of 2 drying methods on the nutritional composition of forages evaluated by Near Infrared Spectroscopy (NIRS). Six forage species were evaluated, dried in a forced ventilation oven (FVO) and microwave oven (MO). The experimental design used was completely randomized in a 2 x 6 factorial arrangement (2 drying methods and 6 forage

species). Then, the drying methodology influenced only the DM contents of the Paiaguás and Marandu cultivars, presenting lower values when dried in MO. For crude protein levels, the cultivar Xaraés was lower when dried in FVO, opposite behavior to that observed for Marandu, which showed lower value through MO. The NDF and ADF contents were not influenced by drying methods. The use of MO for the determination of DM is promising however further studies are needed to evaluate possible changes in the composition of the feed, mainly when evaluated by NIRS.

Keywords: *Brachiaria*, chemical composition, stove, dry matter, microwave, *Panicum.*

RESUMO

A determinação da matéria seca (MS) das forrageiras é realizada em laboratórios de análises de alimentos principalmente com o auxílio de estufa de ventilação de ar forçada (EST), técnica mais lenta que a determinação utilizando forno de micro-ondas (FMO). Assim, objetivou-se avaliar a influência de 2 métodos de secagem na composição nutricional de forrageiras avaliadas em Espectroscopia do Infravermelho Próximo (NIR). Foram avaliadas 6 espécies forrageiras, secadas em estufa de ventilação forçada (EST) e forno de micro-ondas (FMO). O delineamento experimental utilizado foi inteiramente casualizado em um arranjo fatorial 2 x 6 (2 métodos de secagem e 6 espécies forrageiras). A metodologia de secagem influenciou somente os teores de MS dos cultivares Paiaguás e Marandu, apresentando menores valores quando seco em FMO. Para os teores de proteína bruta, o cultivar Xaraés foi menor quando seca em EST, comportamento oposto ao verificado para o Marandu, que apresentou menor valor através do FMO. Os teores de FDN e FDA não foram influenciados pelos métodos de secagem. A utilização de FMO para a determinação de MS é promissora, entretanto são necessários estudos posteriores avaliando possíveis alterações na composição do alimento, especialmente quando esse é avaliado pelo NIR.

Palavras-chave: *Brachiaria*, composição química, estufa, matéria seca, micro-ondas, *Panicum***.**

1 INTRODUCTION

Brazilian livestock is mostly produced on the basis of pastures, since it is the most economical and practical alternative to provide food for cattle (Ferraz & Felício, 2010), which guarantees low production costs.

According to estimates from the last Brazilian Agricultural Census (IBGE, 2017), the total area of pastures (natural and planted) in Brazil is 158.6 million hectares, distributed in approximately five million of farms. Pasture-based animal husbandry is the predominant production system in the country, since approximately 95% of Brazilian beef is currently produced on pastures. Thus, the cultivation of forage plants, which serve as food for national livestock, assumes a fundamental role for the production chain.

However, pastures cannot maintain their quantitative and qualitative homogeneity throughout the year. This variation between the supply and demand of nutrients

throughout the year is due to seasonality in forage production, where there is a reduction in forage production and structural changes in the canopy; accumulation of stalk and dead material, due to reduced light availability; the average temperature is lower and rainfall is drastically reduced, which causes a drop in forage quality in the dry season of the year (autumn/winter) (Reis et al., 2012).

The determination of feed' dry matter (DM) is the starting point for estimating its quality, and it is the main procedure used in research on pastures, mainly for estimates of yield and forage availability, and may vary according to species, maturity and management of culture, environmental conditions and season of the year (Bueno et al., 2017).

The DM, as the name implies, represents the fraction of feed that is not water. The simplest and most usual way to estimate it is by removing water by heating, which turns into steam and leaves the sample. This practice is necessary to prepare the sample for milling and storage, as it avoids its degradation and/or alterations during the storage period that precedes the chemical analyses. In addition, this procedure proposes to estimate the amounts of nutrients present in the feed, which are presented on a dry basis as it is a standardized measure (EMBRAPA, 2015).

Traditionally, the most used method in feed analysis laboratories for the determination of DM requires the use of a forced air ventilation oven (FVO), but the presence of this equipment in farms is uncommon (Bueno et al., 2017) .

Therefore, studies carried out by Pastorini et al. (2002) verified that maize and bean plants, when dried in microwave oven (MO) and FVO, showed no difference in the DM contents. Similar results were found by Petruzzi et al. (2005), where they evaluated the DM levels of two *Panicum* species using FVO and MO, and found no significant difference. The same author points out as advantages, the determination by practical MO, being possible to determine the amount of DM of the forage to be supplied to the animals, allowing a better evaluation of the quality of the used forages, resulting in higher animal productivity and lower cost (Petruzzi et al., 2005). Lacerda et al. (2009) found similar DM contents obtained by FVO and MO, thus describing MO as an alternative for drying wet materials and to DM determination, being this technique faster and simpler, in addition to being accessible to farmers.

For chemical analysis, the traditional method has been widely used in laboratories, but it is a time-consuming and expensive method, since it requires reagents and longer

time to carry out the evaluations, in addition to providing destruction of the samples during the process of evaluation.

Among the alternative techniques already developed, the use of Reflectance Spectroscopy in the Near Infrared Region (NIRS) stands out. This methodology consists of collecting the spectra of samples, with which the chemical composition of feeds and/or diets can be predicted from the development of regression models. According to Stuth et al. (2003), the NIRS technique is fast and generally does not require intensive work in the processing of the materials to be evaluated, allowing large-scale sampling, in addition to not generating polluting waste, as it does not use reagents and does not destroy the samples.

Based on the above, this work aims to comparatively evaluate the influence of two methodologies for drying samples in relation to the effects on the chemical composition of forages evaluated by Reflectance Spectroscopy in the Infrared Region (NIRS).

2 MATERIAL AND METHODS

The experiment was carried out in the Laboratory of Agrostology of the Experimental Farm of Ressacada (FER) and in the Laboratory of Forage Culture of the Center of Agricultural Sciences, belonging to the Federal University of Santa Catarina (CCA-UFSC), Florianópolis (SC), between the months of January and July 2019. The agrostological area was located at coordinates 27°35'48" S latitude and 48°32'57" W longitude and at an average altitude of 3 m above sea level.

Two methods of drying samples (forced ventilation oven and microwave oven) and their influence on the bromatological quality of forage species were evaluated, analyzed by Near Infrared Reflectance Spectroscopy (NIRS). The equipment used was the FT-NIR MPA spectrophotometer (BRUKER OPTIK GmbH, Rudolf Plank Str. 27, D-76275 Ettlingen).

In December, before the experimental period, for the purpose of standardizing the beds of forage species, a mowing was carried out at a height of 20 cm from the ground.

All forage species used came from individual beds measuring 3 m x 3 m (9 m²) and samples were collected with the aid of scissors and a 1 m² square, followed by weighing. To estimate the forage mass (FM), the weight of the material collected in 1 m² was extrapolated to 1 hectare and after drying the material, it was possible to calculate the forage availability (kg DM/ha).

Samples of *Brachiaria brizantha* (Xaraés, Paiaguás and Marandu) and cultivars of *Panicum maximum* (Colonião, Mombaça and Tanzânia) cultivars were collected. Thus, the experimental design used was completely randomized in a 2 x 6 factorial arrangement (2 drying methods x 6 forage species).

The DM content evaluation by the conventional method in FVO was performed following the methodology proposed by Silva and Queiroz (2009) and the obtaining of the DM content using MO was performed following the methodology described by Bueno et al. (2017). For each drying process, approximately 200g of fresh forage was used.

For the drying process in MO, two devices were used to speed up the drying procedure of the samples, one of which was only for the cultivars of *Brachiaria brizantha* (capacity of 30 L, power 1000 watts) and another for the species *Panicum maximum* (20 L capacity, 1130 watts power). In both cases, to avoid burning and damage to the samples, a cup with ~150 mL of water was added inside the equipment, as suggested by Silva & Queiroz (2009).

The drying process by MO was carried out through cycles with different times, with the sample being kept first in heating for 3 cycles of 5 minutes, moving to a cycle of 3 minutes and soon after a cycle of 2 minutes, followed by cycles of 1 minute until the samples showed constant weight (Bueno et al., 2017).

To obtain the DM, the evaluated forage samples were weighed on a precision scale before and after drying according to the corresponding treatment. The DM content was calculated based on the initial and final weight, as described by Silva & Queiroz (2009).

After obtaining the DM, in both drying procedures, the samples were ground in a knife mill, in a 1 mm sieve. Subsequently, all samples were evaluated for DM content, crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) using the NIRS equipment. Calibration curves with coefficient of determination (R^2) of 94%, 95% and 98% were used for NDF, FDA and CP, respectively (Massignani et al., 2021).

The data collected for each variable were submitted to analysis of variance, using the GLM procedure of the SAS (2002) statistical program, and the differences between the means were compared using the Tukey test at a significance level of 5%. Furthermore, a test of interaction between forage species (FE) and drying methods (DMe) was performed.

3 RESULTS AND DISCUSSION

The drying method did not influence the estimate of FM among the evaluated forage species (Table 1; P>0.05). In this way, it is possible to use MO in farms aiming at estimating the production of DM/ha and the adequacy of the stocking rate (kg PV/ha), ensuring an adequate pasture management and, consequently, the efficient use of forage resources. .

At the time of cutting, the forage that presented the highest total DM production (kg/ha) was the cultivar Colonião, standing out with a value of 23,761.44 kg/ha of DM when dried in FVO and 22,491.65 kg/ha of DM in MO (Table 1). In general, there was still superiority of cultivars of the genus *Panicum maximum* in relation to FM production and height of the evaluated Brachiarias.

Studies at different times of the year confirm that the growth and development of *Panicum maximum* show greater accumulation of green and dry plant biomass during the summer period, as this season provides better conditions for precipitation and temperature, resulting in higher residual biomass with compared to other times of the year (Torres et al., 2013).

Table 1. Height (cm) and forage mass (Kg DM/ha) in relation to the drying method of forage species

Species	Cultivars	Height (m)	Forrage Mass (kg DM/ha)		P<
			FVO*	MO*	
Brachiaria brizantha	Xaraés	0.691	22,018.2	17.654,1	0,67
	Paiaguás	0.543	14,350.6	11.844,7	0,81
	Marandu	0.537	19,575.8	16.290,1	0,75
Panicum maximum	Colonião	0.965	23,761.4	22,491.7	0.90
	Mombaça	1.102	16,158.7	14,312.9	0.86
	Tanzânia	1.010	20,290.4	18,235.3	0.84

*FVO= forced ventilation oven; MO= microwave oven.

There was an influence of drying methods (P<0.05) on DM levels only in *B. brizantha* cv Paiaguás and cv. Marandu, in which they presented higher values when dried in a FVO. However, the DM levels of *P. maximum* cv. Mombaça showed a trend (P<0.10) of superiority of 11.5% when the material was dried in a FVO (Table 2). Thus, under the conditions of this research, the use of MO proved to be inefficient in determining the DM of the forages mentioned above.

It was impossible to observe a difference in the DM attainment by the drying methods for the other forages (Table 2; P>0.05). This could be related to one of the aspects of MO, such as selective heating. Different from the FVO, where all the materials that are inside undergo homogeneous heating, in the MO the heating will depend on the material present in its interior (Barboza et al., 2001). During the experiment, it was observed the need to revolve the sample during the cycles, so that it received the radiation homogeneously and, consequently, the temperature necessary for drying to constant weight.

According to Barboza et al. (2001), among the principles involved in heating by MO, are the chemical concepts, such as: temperature, heat capacity, chemical bond, molecular structure, dipole moment, polarization, dielectric constant. In addition, the MO heating process, which causes the evaporation of water present in the forage, takes place quickly, unlike the forced air oven, in which the sample remains at 55°C for up to 72 hours.

In a study carried out by Ruggiero et al. (2002) there was no difference in obtaining DM by the drying methods in MO and in a FVO for *P. maximum* cv Mombaça and *Brachiaria brizantha* MG5, however, they emphasized that the MO was not efficient for the determination of DM in sorghum and sugar cane silages. In the same sense, results found by Batista (2018) for cacti, show that the drying efficiency in MO was irregular. For the author, this response may be related to factors inherent to plants, such as their anatomical characteristics, particularities of the species and physiological maturity, as well as factors related to the methodology, such as particle size and drying time, which may be the physiological maturity associated with the particle size the main cause of the differences observed.

In this experiment, the average time for drying of forage species in MO was 27 minutes. In results obtained by Ruggiero et al. (2002), it took approximately 22 minutes for drying, using MO with a power of 2500 watts. Lacerda et al. (2009), using MO of 1250 watts, reached 22 minutes for drying, both works obtained similar results for the drying of the samples. These results demonstrate that it is possible to use MO in daily activities on farms, especially those related to forage management.

Some factors influence the forage quality and among them, the species, origin, cultivation conditions, temperature x environment during growth, maturity, leaf:stem ratio, plant part of the sampled fraction (top or bottom) and the structural characteristics of the cell wall. In general, the CP contents (based on DM) of Colonião, Paiaguás and

Marandu were higher in relation to the other evaluated forages, regardless of the drying methods used (Table 2). Regarding the drying methods, the cultivar Xaraés showed lower levels of CP when dried in FVO, opposite behavior to that observed for Marandu, which showed a lower value when dried in MO (Table 2). However, all forage species presented CP levels higher than the 7% recommended for the good ruminal functioning of production animals (Van Soest, 1994).

Lacerda et al. (2009), using *Panicum maximum*, *Brachiaria ruziziensis* and corn silage, found that only the CP of corn silage was influenced by the drying method, where a higher CP content was observed when dried in MO. The same was possible to verify in an experiment carried out by Rezende et al. (2009) when analyzing *Panicum maximum* cv. Mombaça, corn and corn silage, which observed that for the CP content, only corn was influenced by the drying methods, where the highest values were found for the drying method in the MO. Serafim et al. (2017), evaluating Mombaça grass, corn silage and corn grain, found that in terms of CP analysis, drying methods influenced this variable only for corn silage, where a higher CP content was detected when dried in MO. For the author, the possible explanation for this fact is that, when the plant material is dried in an oven with forced air circulation, it can promote the volatilization of organic acids and ammonia, thus favoring biochemical changes in the comparison of the material.

NDF and ADF contents were not influenced by drying methods ($P>0.05$; Table 2). Opposite results were found by Bueno et al. (2017), where it was possible to observe that the use of MO was able to increase the NDF content of the evaluated forages. For the author, the increase in temperature on the sample may cause alterations in the composition of the cell wall, increasing the fiber content of the forage, since the fibrous fraction of the forage is inert, which means that no matter how much the temperature during drying on the sample, there will be no loss or accumulation of cell wall. The opposite occurs with other volatile compounds such as organic acids, nitrogenous compounds such as ammonia, or soluble carbohydrates, if drying is slow.

According to Van Soest (1994), NDF levels in forages influence the feed intake by ruminants. The fibrous fraction has a negative correlation with forage consumption, especially when NDF levels are equal to or greater than 60%, which was verified for all species evaluated, regardless of the drying process used. In any case, the drying processes used can be viable alternatives for farmers to send the forage samples collected on their farms to the laboratory, after drying in MO for the evaluation of the nutritional value through the NIRS (Table 2).

4 CONCLUSIONS

The microwave oven drying technique is promising for the determination of forage quality in farms, as it is a faster technique for obtaining results. In addition, the use of the microwave oven becomes an alternative tool to calculate the production of forage mass/hectare on the farm, making it possible to assist the farmers in adjusting the animal stocking rate per area. However, further studies are needed to evaluate the impact of the technique on changes in feed composition, since there may be little variation in water withdrawal and chemical quality, evaluated by Near Infrared Spectroscopy (NIRS).

Table 2. Chemical composition of forage species in relation to the drying method.

Species	Cultivars	%DM		P<	%CP		P<	%NDF		P<	%ADF		P<
		FVO*	MO*		FVO	MO		FVO	MO		FVO	MO	
Brachiaria brizantha	Xaraés	32.69	26.48	0.49	11.38	13.38	0.04	67.67	68.04	0.71	38.21	37.96	0.81
	Paiaguás	34.60	28.36	0.01	14.69	14.01	0.08	70.63	71.42	0.43	42.05	41.42	0.55
	Marandu	33.82	27.86	0.01	13.95	12.12	0.04	67.28	67.79	0.61	38.75	38.40	0.74
Panicum maximum	Colonião	30.42	28.25	0.31	15.04	14.17	0.31	67.07	67.47	0.69	37.03	36.26	0.45
	Mombaça	31.92	28.26	0.09	11.55	12.63	0.21	69.20	67.94	0.21	39.29	38.12	0.26
	Tanzânia	33.15	29.76	0.12	12.45	13.85	0.11	68.50	67.86	0.53	38.43	37.15	0.22

*FVO= forced ventilation oven; MO= microwave oven.

REFERENCES

BARBOZA, A. C.; CRUZ, C. V.; GRAZIANI, M. B.; LORENZETTI, M. C.; & SABADINI, E. Aquecimento em forno de microondas / desenvolvimento de alguns conceitos fundamentais**. Química Nova**, São Paulo, v.24, n.6, p. 901-904, dez. 2001.

BATISTA, T. S.. Comparação de metodologias para determinação de matéria seca em diferentes espécies forrageiras**.** In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA; CONGRESSO BRASILEIRO DE ZOOTECNIA, 55., 2018, Goiânia. **Anais... .** Cruz das Almas: Zootecnia Brasil, 2018. p.1 - 5

BUENO, A.V.I.; JOBIM, C.C.; RIBEIRO, M.G.; & DE OLIVEIRA, J.P. Método de obtenção de matéria seca e composição química de volumosos. **Ciência Animal Brasileira**, v.18, nov 2017. DOI: 10.1590/1089-6891v18e-44913.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. **Nutrição de bovinos de corte: fundamentos e aplicações**. Sérgio Raposo de Medeiros, Rodrigo da Costa Gomes, Davi José Bungenstab. -- Brasília, DF: Embrapa, 2015. Available at: < https://ainfo.cnptia.embrapa.br/digital/bitstream/item/120040/1/Nutricao-Animal-livro-em-baixa.pdf >. Accessed on: Nov. 27 2019.

FERRAZ, J.B.S.; & de FELÍCIO, P.E. Production systems - An example from Brazil. **Meat Science**, v.84, n.2, p.238-243, 2010. DOI: 10.1016/j.meatsci.2009.06.006.

FIGUEIREDO, M. P. et al. Determinação do teor de matéria seca do capim elefante (*Pennisetum purpureum* Schum), em três estádios de maturidade fisiológica, pelo forno de microondas. **Magistra**, Cruz das Almas, Bahia. v.16, n.2, p.113-119, 2004.

IBGE – Instituto Brasileiro de Geografia e estatística. **Censo Agropecuário 2017**. Brasil: IBGE, 2017. Available at:<https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/estabelecimentos.html. Accessed on: Dec. 10 2018.

LACERDA, M. J. R.; FREITAS, K. R.; SILVA, J. W. Determinação da matéria seca de forrageiras pelos métodos de microondas e convencional. **Bioscience Journal**, v.25, p.185-190. Jun 18 2009.

MASSIGNANI, C.; VANDRESEN, B.B.; MARQUES, J.A.; KAZAMA, R.; OSMARI, M.P.; SILVA-KAZAMA, D.C. A single calibration of near-infrared spectroscopy to determine the quality of forage for multiple species. **Research, Society and Development**, v.10, n.10, 2021.

PASTORINI, L.H.; BACARIN, M.A.; ABREU, C.M. Secagem de material vegetal em forno de micro-ondas para determinação de matéria seca e análises químicas. **Ciência e Agrotecnologia**, Lavras, v.26, p.1252-1258, Dez 2002.

PETRUZZI, H. J.; STRITZLER, N.P.; FERRI, C.M.; PAGELLA, J.H.; RABOTNIKOF, C.M. Determinación de materia seca por métodos indirectos: utilización del horno a microondas. **Boletín de Divulgacíon Técnica** 88, p.08-11, 2005.

REIS, R.A.; RUGGIERI, A.C.; OLIVEIRA, A.A.; AZENHA, M.V.; CASAGRANDE, D.R. Suplementação como estratégia de produção de carne de qualidade em pastagens tropicais. **Rev. Bras. Saúde Prod. Anim.**, Salvador, v.13, n.3, p.642-655, Sept. 2012 .

REZENDE, A.V.; RABELO, C.H.S.; JUNQUEIRA, F.P.; SALVADOR, F.M.; RABELO, F.H.S.; FARIA JUNIOR, D.C.N.A.; ANANIAS, L.C.S. Características bromatológicas de forrageiras desidratadas por diferentes métodos de secagem. In: Reunião Anual da Sociedade Brasileira de Zootecnia, 2009, Maringá. **Anais.** Maringá, 2009.

RUGGIERO, J. A., FREITAS, K. R.; ROSA, B. Determinação da matéria seca de forrageiras pelo método do microondas. In: REUNIÃO DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 39., 2002. Recife. **Anais.** Recife, 2002.

SERAFIM, R.S.; ANTONELLI, A.; SANTOS M.A.T. Determinação da matéria seca e proteína bruta pelo método convencional e microondas. **FAZU em Revista**, Uberaba, n.11, p.39-43, 2017.

SILVA, D. J. & QUEIROZ, A.C. **Análises de alimentos: métodos químicos e biológicos.** 3. ed. Viçosa, MG: Universidade Federal de Viçosa, 2002. 235p.

STUTH, J.; JAMA, A.; TOLLESON, D. Direct and indirect means of predicting forage quality trough near infrared reflectance spectroscopy. **Field Crops Research**, v.84, p.45-56, Nov. 2003. DOI: 10.1016/S0378-4290(03)00140-0

TORRES, F.E.; OLIVEIRA, E.P.de; TEODORO, P.E.; SILVEIRA, M.V.; RIBEIRO, L.P; SILVEIRA, L.P.O. Produção de forragem de cultivares de *Panicum maximum* submetidas a diferentes estações de cultivo e tipos de sementes. **Revista de Ciências Agrárias**, Lisboa, v.36, n.4, p.435-440, out. 2013.

VAN SOEST, P.J. **Nutritional ecology of the ruminant**. 2.ed. Ithaca: Cornell University Press, 1994. 476p.