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Bromatological composition and ruminal degradability of Xaraés palisade grass under grazing in integrated systems

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ABSTRACT. To evaluate the bromatological composition and ruminal degradability of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) of Xaraés palisade grass (*Urochloa brizantha* 'Xaraes' syn *Brachiaria brizantha*) under grazing in integrated crop, livestock (ICL), and forest (ICLF) systems, we conducted an *in situ* degradability trial in randomized blocks with three non-lactating 3/4 Gyr × 1/4 Holstein cows, provided with ruminal cannula. The management of Xaraés palisade grass was similar in both systems, differing only regarding shading in the ICLF system provided by eucalyptus trees (average 65% crown cover). Grass samples were incubated for 0, 3, 6, 9, 12, 24, 36, 48, 72, and 96 hours. Considering the passage rate 2% h^{-1}, the Xaraés palisade grass of ICL system had greater NDF effective degradability in relation to ICLF (46.38 *vs* 44.98%). However, the palisade grass CP potential degradability was greater in the ICLF than in the ICL system (68.92% *vs*. 65.40%). The presence of trees in the pasture has effect on nutritional traits of the Xaraés palisade grass, increasing its protein content and degradability and reducing its fiber degradability.

Keywords: agricultural integration; *in situ* degradation; dairy cattle.

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Introduction

The increasing interest in agricultural integration systems has resulted in demands for studies about the different possible arrangements and the interrelationship among the components. The integrated crop, livestock (ICL) and forest (ICLF) systems, which differ only regarding the presence of the tree component, represent a sustainable production alternative, with the potential to reduce the negative impact of traditional production systems on environment equilibrium and to maximize production of field crops (Balbino, Kichel, Bungenstab, & Almeida, 2014; Gléria, Silva, Santos, Santos, & Paim, 2017).

The knowledge about forage characteristics which are influenced by animal grazing in different production systems is essential, since the environmental conditions to which grasses are exposed affect their morphophysiological traits and nutritional responses (Oliveira, Santos, André, Santos, & Oliveira, 2017; Guimarães, Ribeiro, Viana, Pereira, & Santos, 2018; Faria, Morenz, Paciullo, Lopes, & Gomide, 2018), which are directly related to animal performance in grazing systems.

Systems with trees and crops in integration, such as ICLF, sunlight availability for grasses is reduced compared with pastures without trees. This lower radiation interception may decrease production, but simultaneously it may increase forage nutrients (Lopes et al., 2017).

One must consider that the forage nutritional value depends not only on its chemical composition, but also on the way the nutrients is used by animals – in ruminants the nutrient metabolism results from the symbiosis between the animal and its rumen microbial flora. Kinetics of nutrient *degradation* in the *rumen* is an important component of feed *evaluation* systems for ruminants.

Medeiros and Marino (2015) warn of the need to know not only the concentration but also the ruminal degradation of protein, as even with a high concentration in the diet, this nutrient may be unavailable for use by ruminal bacteria. This situation can occur if the sources show low protein degradability, resulting in inadequate nitrogen availability for ruminal bacteria.

The aim of this study was to evaluate the bromatological composition and ruminal degradation parameters of Xaraés palisade grass (*Urochloa brizantha* 'Xaraes' syn *Brachiaria brizantha*) under grazing in integrated crop, livestock (ICL) and forest (ICLF) systems.

Material and methods

We conducted the study in the experimental field of Embrapa Rondônia, located in the municipality of Porto Velho, Rondônia, Brazil (8°47′38"S and 63°50′46"W). According to *Köppen* and Geiger classification system, the climate is of Am type, characterized by two well-defined seasons: rainy (November to April) and dry (May to September). The temperature and average annual rainfall are 26°C and 2,095 mm, respectively.

All procedures with the animals were analyzed and approved by the Ethics and Animal Use Committee – CEUA of Embrapa Rondônia (protocol 02-2018).

The Xaraés palisade grass was compared in pasture cultivated under two systems: integrated crop, livestock (ICL) and forest (ICLF). Each system had an area of five hectares divided into four 1.25 ha paddocks. The forestry component of the ICLF was eucalyptus planted in March 2013. At the experimental period, the average tree crown cover was 65%. The agricultural management of both areas followed the Santa Fe system (Kluthcouski & Aidar, 2003): in the establishment year (year 0), eucalyptus was planted in rows, and soybean was planted in the plots between the tree stands; in the following year (year 1), plots were sown with a maize/palisade grass intercrop. The fertilization was performed with 500 kg ha^{-1} of 04-20-16 (equivalent in percentage of N-P_2O_5-K_2O), applied at sowing (corn + grass), plus 300 kg ha^{-1} of urea 45% applied in coverage. After corn harvesting in June 2015, the Xaraés palisade grass was forming the pasture, which was managed with intermittent stocking with ten days of occupation and 30 days of rest, with a stocking rate of 2.5 AU ha^{-1} and forage allowance of 41.9 and 32.3 kg DM 100 kg^{-1} LW in the ICL and ICLF systems, respectively.

From September to November 2015, during four consecutive days (from the third to the sixth day of paddock occupation period), palisade grass samples of both systems were obtained by hand-plucking method (Prohmann et al., 2012). The samples were oven-dried at 55°C for 72 hours and milled at 5 mm. Five grams of these samples were placed in non-woven (100 g m^{-2}) bags heat sealed on size 7 x 16 cm. For performing the *in situ* degradability trial in randomized block design with three replications, three non-lactating 3/4 Gyr × 1/4 Holstein cows provided with ruminal cannula were used. Their average live weight (LW) was 613.7 ± 114 kg and they were grazing Xaraés palisade grass pasture with free access to water and mineral salt. Ruminal incubation times were 0, 3, 6, 9, 12, 24, 36, 48, 72, and 96 hours. At 0 time, the soluble fraction (a) was estimated by immersing the bags in 39°C water for 30 minutes. Bags were removed simultaneously from the rumen and immediately were dipped in cold water to stop microbial fermentation. Then, they were manually washed in tap water. Subsequently, they were dried in air-forced oven at 55°C for 72 hours, put in a dissecator and then weighed.

Dried 1-mm samples of grass and incubation residue were analyzed for dry matter (DM), mineral matter (MM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin (LIG) following the methodologies of the National Institute of Science and Technology of Animal Science (INCT-CA) reported by Detmann et al. (2012). The hemicellulose and cellulose were found by the difference between NDF and ADF; and ADF and lignin, respectively (Detmann et al., 2012).

From the soluble fraction (a) and non-degradable residue (C) was estimated the potential degradable insoluble fraction $(b) = 100 - (a + C)$. The degradation rate (c) was obtained by regression of the incubation times on the weight of incubation residues transformed by natural logarithm (*In*), to adjust on the model of potential degradability (PD) proposed by Mehrez and Ørskov (1977):

$DP = a + b\,(1 - e^{-ct})$, for t > L.

where:
L - colonization time (h);
a - soluble fraction (%);
b - potentially degradable insoluble fraction (%);
c - constant degradation rate of b fraction (% h^{-1});
t - incubation time (h).

Effective degradability (ED) was estimated according to Ørskov and McDonald (1979) model:

$$DE = a + b.c/(c + k).$$

where:
a - soluble fraction (%);
b - potentially degradable insoluble fraction (%);
c - constant degradation rate of b fraction (% h^{-1});
k - passage rate (2, 5 or 8% h^{-1}, corresponding to low, medium and high intake levels, respectively).

Statistical analyses were performed using GLM (general linear models) procedure of SAS (Statistical Analysis System Institute Inc., Cary, NC). Means of the variables observed in each system were compared by Tukey test at 5% significance.

Results and discussion

There were numerical differences between the ICL and ICLF systems in terms of DM, MM, and CP concentrations of Xaraés palisade grass (Table 1). The numerical reduction in the DM of the ICLF grass can be attributed to the lower evapotranspiration resulting from the mild microclimate under the tree canopy, which is related to higher water concentration in tissues of shaded plants (Abraham et al., 2014).

Table 1. Bromatological composition of Xaraés palisade grass (*Urochloa brizantha* 'Xaraés'), under grazing in Crop-Livestock Integration (ICL) and Crop-Livestock-Forest (ICLF) systems.

Component	System	
	ICL	ICLF
Dry matter (DM, %)	32.38	26.02
Mineral matter (MM, % DM)	4.80	6.12
Organic matter (OM, % DM)	95.20	93.88
Crude protein (CP, % DM)	9.52	12.57
Neutral detergent fiber (NDF, % DM)	59.91	60.24
Acid detergent fiber (ADF, % DM)	27.53	28.89
Lignin (% DM)	2.24	2.60
Cellulose (% DM)	25.29	26.29
Hemicellulose (% DM)	32.38	31.35

The Xaraés palisade grass MM content of ICLF system was 27.50% higher than that of the ICL. Lana, Lana, Reis, and Lemes (2016) also observed a higher MM level in *Urochloa brizantha* integrated with eucalyptus trees when compared to monoculture. These differences can be attributed to the active mineralization in soil of shaded environments that can contribute to a greater availability of minerals for the plant (Rodrigues et al., 2015).

We observed an increase of 33.89% in the CP content in the grass of the ICLF system compared with that of the ICL. In both systems, however, the CP content was above from that considered critical (7.0%) for proper functioning of the rumen (Van Soest, 1994) and for the efficient use of forage fibrous carbohydrates (Lazzarini et al., 2009). Increasing protein content in response to shading agrees with other studies with tropical grasses (Lopes et al., 2017; Lima et al., 2018). This increase may be related to the intense organic matter (OM) degradation and nitrogen recycling in the shaded soil, which is influenced by the higher nitrogen availability and its absorption by plants (Xavier et al., 2014). Dalchiavon, Montanari, and Andreotti (2017) reported positive correlation between forage CP content and soil OM and moisture contents when evaluating *Urochloa decumbens* DM yield regarding the physicochemical attributes of the soil, emphasizing the relevance of agricultural practices aiming to raise soil OM content, since the benefits for increasing the CP content in the forage become evident.

The grass fiber concentrations were similar between the evaluated systems, with averages of 60.07% of NDF and 28.21% of ADF. The NDF concentration higher than 60% is negatively related with animal voluntary intake (Van Soest, 1994). Generally, in tropical forages the NDF content is higher than 60% (Dalchiavon et al., 2017; Lagunes, Pell, Blake, Lagunes, & Rodríguez, 2018). As such, the results found in this study can be considered satisfactory. When assessing the nutritional value of *Urochloa brizantha* 'Marandu' at different locations within the pasture in silvopastoral system, Tosta et al. (2015) also found no differences in fiber concentrations (mean 73.3% NDF). Oliveira et al. (2017) found similar results in *Urochloa brizantha* 'Marandu" and *Panicum maximum* 'Mombaça' within systems with 0.25 and 50% of natural shading (averages of 62.7 and 63.9% of NDF for Marandu and Mombaça grasses, respectively).

Comparing the degradability parameters of Xaraés palisade grass in the ICL and ICLF systems (Table 2), differences ($p < 0.05$) in the soluble fraction (a) of DM and CP were observed. The greater disappearance at 0 time can be attributed to the greater presence of soluble compounds in the plant, since the soluble fraction (a) corresponds to the soluble part of the food, as well as the particles that are eliminated through the mesh of the bags during their immersion in 39°C water for 30 minutes.

Table 2. Parameters of ruminal degradability *in situ* (a, b and c), Potential Degradability (PD) and Effective Degradability (ED) at pass rates (% h^{-1}) 2 (DE2), 5 (DE5), and 8 (DE8) of the nutrients of Xaraés palisade grass (*Urochloa brizantha* 'Xaraés') managed under grazing in Crop-Livestock Integration (ICL) and Crop-Livestock-Forest (ICLF) systems.

System	a (%)	b (%)	c (% h^{-1})	PD (%)	ED2 (%)	ED5 (%)	ED8 (%)
			Dry matter (DM)				
ICL	18.36 a	51.10	4.12	68.39	52.74	41.47	35.77
ICLF	13.04 b	57.08	4.67	69.46	52.99	40.60	34.08
			Crude protein (CP)				
ICL	37.38 a	28.77 b	3.92	65.40 b	56.39	50.02	46.85
ICLF	20.99 b	50.77 a	4.03	68.92 a	53.31	50.45	37.16
			Neutral detergent fiber (NDF)				
ICL	0.00	65.36	4.89	64.76	46.38 a	32.31	24.79
ICLF	0.00	63.74	4.84	63.06	44.98 b	31.23	23.93
			Acid detergent fiber (ADF)				
ICL	0.00	56.31	3.80	54.80	36.85	24.28	18.11
ICLF	0.00	54.97	4.66	54.23	38.27	26.34	20.09

Means followed by different lowercase letters in column are different by Tukey test at 5%, a = soluble fraction; b = potentially degradable fraction l; c = constant rate of b fraction degradation (% h^{-1}).

Shaded plants tend to present a reduction in soluble carbohydrate content (Kyriazopoulos, Abraham, Parissi, Koukoura, & Nastis, 2012), and an increase in chlorophyll contents (Lopes et al., 2017), which are water-insoluble molecules composed by the nitrogen present in chloroplasts (Senge, Wiehe, & Ryppa, 2006). Such factors may justify the lower soluble fraction of DM and CP in the grass of ICLF system in relation to that of ICL.

Despite the difference ($p < 0.05$) in the soluble fraction of grass DM in both systems, no differences were found in the potentially degradable fraction (b) of DM, with consequent similarity between the PD and ED of the grass DM of both systems. The ED values of grass DM for the 2% h^{-1} passage rate are close to those reported by Sousa et al. (2017) of 53.30 and 51.47% observed in *Urochloa brizantha* 'Marandu' in silvopastoral and monoculture systems, respectively. These authors also did not observe differences between systems for this parameter.

The values of degradation rate (c) are within the 2.0 to 9.2% h^{-1} to maintain an adequate DM intake (NRC, 2001). However, the results were higher than those reported by Lopes et al. (2017) for *Urochloa brizantha* in silvopastoral (3.55%) and monoculture (3.49%) systems in the dry-rain transition period. Araújo et al. (2016) reported DM degradation rates below 3.15%, when evaluating *Urochloa brizantha* in monoculture or silvopastoral system formed with different babassu densities.

The lower soluble fraction (a) of grass CP in the ICLF compared with ICL resulted in a higher potentially degradable fraction (b) and, consequently, higher PD of the CP of the shaded grass (Table 2). When evaluating the *Urochloa brizantha* 'Marandu' in silvopastoral and monoculture systems, Sousa et al. (2017) observed higher kinetics of grass CP degradation in a shaded system during dry-rain transition period, with means of 70.96 and 63.29 of ED at 2% h^{-1} in silvopastoral and monoculture systems, respectively.

The ICL grass had higher NDF ED at 2% h^{-1} when compared with that of ICLF ($p < 0.05$). These values are close to those reported by Lopes et al. (2010), for *U. brizantha*, *U. decumbens*, *U. humidicola*, and *U. ruziziensis*, of 44.9, 41.8, 43.6, and 43.8, respectively. For the palisade grass ADF, no differences in the ruminal degradability parameters were found between the systems.

There is a consensus among recent reporting about the higher CP content of shaded grass, but there are no agreement about the effect of shading on the concentration of other plant nutrients or on the DM digestibility (Araújo et al., 2016; Oliveira et al., 2017; Sousa et al., 2017).

Comparing disappearance of different fractions of the palisade grass in function of the incubation times (Figure 1), the DM degradation curves were similar between the systems, for both in degradation kinetics and in the degradation rate. It was possible to observe the greatest degradation of DM of the palisade grass after 48 hours of incubation, which represented 90% of total DM apparent degradation (AD) (Figure 1A). The NDF and ADF degradation curves were also similar between the systems; however, ADF degradation was slower than that of the NDF, and it was observed that 86% of AD occurred within 96 hours (Figure 1B and C).

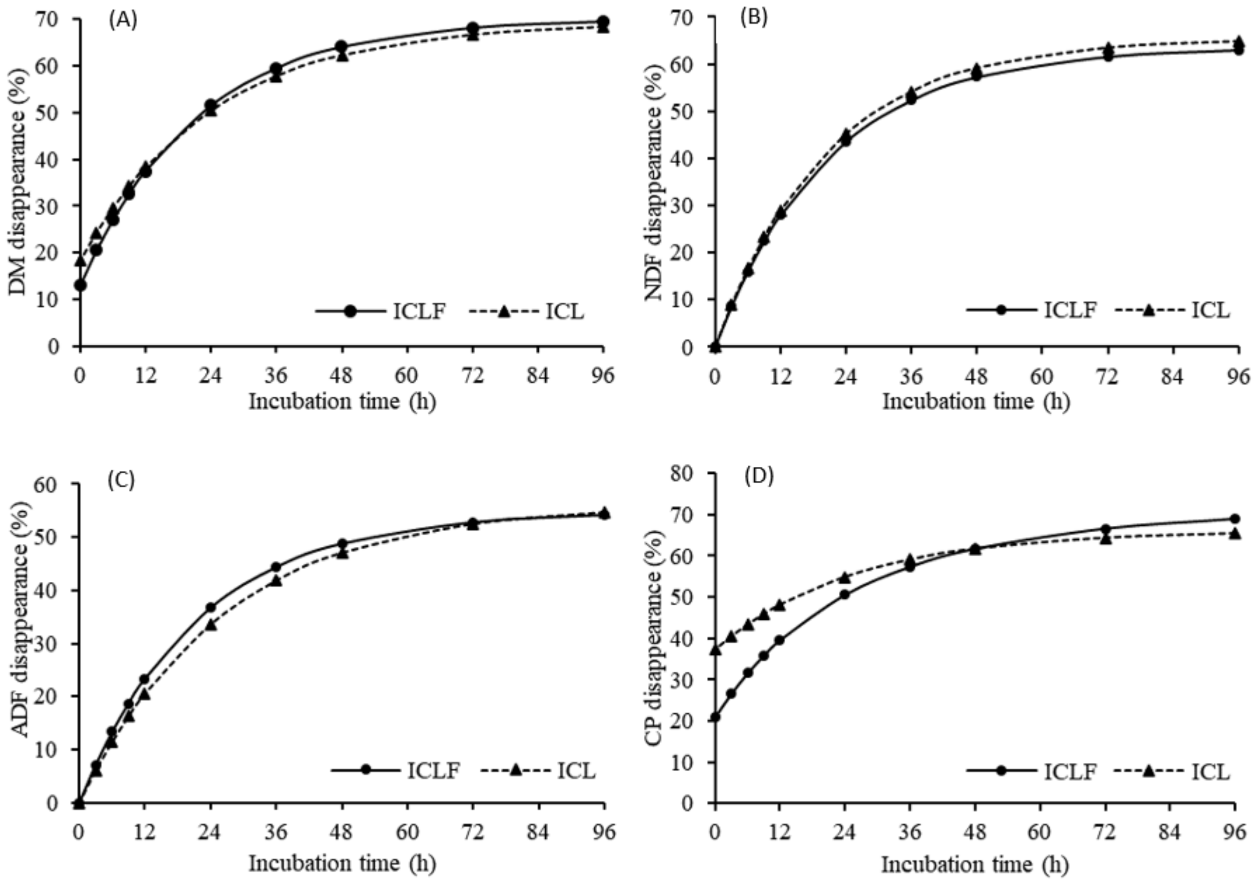

Figure 1. Disappearance of dry matter – DM (A), neutral detergent fiber – NDF (B), acid detergent fiber – ADF (C), and crude protein – CP (D) of Xaraés palisade grass in different incubation times (*Urochloa brizantha* 'Xaraés') in Integrated Crop-Livestock (ICL) and Integrated Crop-Livestock-Forest (ICLF) systems.

Comparing *Urochloa brizantha* 'Marandu' in silvopastoral systems with different babassu densities, Tosta et al. (2015) observed differences in degradation at 6, 24, and 96 hours of rumen incubation according to the location of grass sampling in the pasture (full sun, intermediate shade, and total shade) in systems with low and medium density of palm trees. However, no differences were found in the system with high palm density. It is noteworthy that in the present study, no differences were found in DM degradability at 96 hours of incubation (PD 68.39 and 69.46% in the ICL and ICLF, respectively; Table 2).

In relation to CP degradation kinetics, there was an evident difference between the grass from the two systems in the first 24 hours, probably due to the high CP soluble fraction in grass of full sun pasture in relation to the shaded grass (Figure 1D). The grass of the ICLF system had a higher CP PD ($p < 0.05$) after 96h of incubation, as it also can be observed in Table 2 (65.40 *vs* 68.92, ICL and ICLF).

For analyzing the results about soluble fraction of grass CP, the solubility of the protein has to be considered because an ingredient with higher soluble protein content need to be offered concomitantly with sources of soluble energy, which was limited in the diet of the animals used in the present study. Diet exclusive on pasture (without concentrate supplementation) is rich in fibrous fraction, which is insoluble. Thus, it should be occurred an asynchronous release of ammonia and energy in the rumen resulting in an inefficient use of fermentable substrates and reduction of microbial protein synthesis (NRC, 2001) and, therefore, may not improve rumen fermentation.

Conclusion

The presence of trees in the integration system affects the nutritional composition of the Xaraés palisade grass by increasing protein content and degradability and reducing fiber degradability.

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