

Short Communication

Chemical composition of hays of the Caatinga shrub legumes mororó and sabiá from different parts of the plant

Composición química de henos de mororó y sabiá, leguminosas arbustivas nativas en la vegetación de Caatinga, Brasil

OSNIEL F. DE OLIVEIRA¹, AMANDA F. DE LIMA¹, MÉRCIA V.F. DOS SANTOS¹, ADRIANA GUIM¹, MÁRCIO V. DA CUNHA¹ AND MÁRIO DE A. LIRA²

¹Departamento de Zootecnia, Universidade Federal Rural de Pernambuco (UFRPE), Campus Recife, Recife, Pernambuco, Brazil. www.ufrpe.br

²Instituto Agrônomo de Pernambuco (IPA), Recife, Pernambuco, Brazil. www.ipa.br

Abstract

Native forages are important feed sources in the northeastern semi-arid region of Brazil. The objective of this study was to evaluate the chemical characteristics of hays made from the native shrub legumes, sabiá (*Mimosa caesalpinifolia* Benth.) and mororó [*Bauhinia cheilantha* (Bong.) Steud.], using different plant fractions: leaves only and leaves plus twigs. Analyses carried out were: concentrations of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), ether extract (EE), ash, total digestible nutrients (TDN) and non-fiber carbohydrates (NFC). Sabiá leaf hay contained greater CP concentration (182 g/kg DM) than mororó leaf hay (126 g/kg DM) but hay made from leaf plus twigs showed similar CP for both legumes (mean 106 g/kg DM). Concentrations of NDF (368 g/kg DM), NFC (418 g/kg DM) and TDN (481 g/kg DM) of mororó leaf hay were superior to those of sabiá leaf hay (465, 258 and 311 g/kg DM, respectively). The findings suggest that these native legumes can be conserved as hay during the growing season to provide a supplementary feed with acceptable nutritive value for feeding during the period of inadequate feed availability and quality in semi-arid Brazil. However, more samples from a range of growth stages and locations are needed to confirm these preliminary findings and to provide data on possible yields, while more feeding studies with ruminants are needed to confirm the preliminary data in terms of liveweight performance.

Keywords: *Bauhinia cheilantha*, *Mimosa caesalpinifolia*, native forages, non-fiber carbohydrates, plant fractions.

Resumen

En la región semiárida del nordeste de Brasil, las plantas nativas son una fuente importante de forraje. El objetivo de este estudio fue evaluar las características químicas de los henos de las leguminosas arbustivas nativas: sabiá (*Mimosa caesalpinifolia* Benth.) y mororó [*Bauhinia cheilantha* (Bong.) Steud.], utilizando diferentes fracciones de las plantas: solo hojas y hojas más ramificaciones delgadas (<8 mm diámetro) de tallos. Los análisis incluyeron: concentraciones de materia seca (MS), proteína cruda (PC), fibra detergente neutra (FDN), extracto de éter (EE), ceniza, nutrientes digestibles totales (NDT) y carbohidratos no fibrosos (CNF). El heno de hojas de sabiá presentó mayor concentración de PC (182 g/kg de MS) que el heno de hojas de mororó (126 g/kg de MS); no obstante en ambas leguminosas las concentraciones de PC fueron similares cuando se analizaron hojas más ramificaciones de tallos (106 g/kg de MS en promedio). Las concentraciones de FDN (368 g/kg de MS), CNF (418 g/kg de MS) y NDT (481 g/kg de MS) del heno de hojas de mororó fueron superiores a las del heno de hojas de sabiá (465, 258 y 311 g/kg de MS, respectivamente). Los resultados sugieren que en la región semiárida de Brasil estas leguminosas nativas, conservadas como heno durante

Correspondence: Osniel F. de Oliveira, Departamento de Zootecnia, Universidade Federal Rural de Pernambuco, Rua Dom Manuel de Medeiros, s/n, Dois Irmãos, Recife CEP 52171-900, PE, Brazil.
E-mail: niel_zoo@hotmail.com

el período de crecimiento, pueden proporcionar un alimento suplementario de aceptable valor nutritivo durante el período de baja disponibilidad y calidad de forraje. Sin embargo, se necesitan muestreos adicionales de un rango de fases de crecimiento de las plantas y sitios tanto para confirmar estos resultados preliminares como para proporcionar datos sobre producción de MS. Además se requieren estudios de alimentación con rumiantes para evaluar el efecto de los henos en la producción animal.

Palabras clave: *Bauhinia cheilantha*, carbohidratos no fibrosos, forrajes nativos, fracciones de planta, *Mimosa caesalpinifolia*.

Introduction

In semi-arid northeast Brazil, rainfall is irregular and evapotranspiration is high, which results in a negative water balance affecting both animal husbandry and agriculture, through increased risk ([Moreira et al. 2006](#); [Silva and Alcântara 2009](#)) and variation in forage quantity and quality ([Bailey and Brown 2011](#); [Hughes et al. 2012](#)). Livestock productivity on natural pastures is affected ([Santana et al. 2011](#); [Lima et al. 2015](#)), requiring the feeding of supplements. While this can be expensive, supplementing of herds should prioritize alternatives that minimize production costs. The use of fresh forage, hay or silage from native forages in much of the pasturelands during the dry season can correct nutritional deficiencies at relatively low cost ([Alves et al. 2011](#); [Parente and Maia 2011](#)).

Many legumes that occur in the Caatinga, the native vegetation of Brazil's semi-arid northeast region, are suitable for haymaking, but there is limited information on their dry matter (DM) yields, nutritional value and labor required for hay production ([Arruda 2011](#); [Silva et al. 2012](#)). Conservation of forage for feeding during periods of deficiency, e.g. the dry season, seems a possible alternative to strategic use of native plants from Caatinga, since most of these are deciduous and shed leaves before they are needed ([Santos et al. 2010](#)).

Sabiá (*Mimosa caesalpinifolia* Benth.) and mororó [*Bauhinia cheilantha* (Bong.) Steud.] are native pioneer legumes, which add to diversity in Caatinga vegetation and are naturally selected by grazing animals in different seasons, especially the rainy season ([Santos et al. 2010](#); [Silva AB et al. 2013](#)). [Santana et al. \(2011\)](#) reported that mororó was common in the diet, ranging from 14.2 to 19.7%, with leaves being preferred by animals. This preference for the legumes may be linked to their chemical composition. While branches and leaves of sabiá and mororó can contain up to 279 and 235 g crude protein (CP)/kg DM, respectively, up to 67.7 and 52.3% of the protein may be fiber-bound ([Silva et al. 2012](#)), so that up to 60% of this protein can be non-degradable in the rumen ([Pereira et al. 2010](#)). [Alves et al. \(2011\)](#) observed that the presence of condensed tannins in sabiá reduced the consumption by sheep and goats by 13.3 and

4%, respectively. In addition, composition of hay can vary according to season, species and plant fractions, and in the case of woody legumes, many leaves are lost during the process of haymaking, resulting in considerable overall forage quality loss.

Useful forage mass of mororó can vary from 228 to 551 kg DM/ha and from 56 to 99 kg DM/ha in the rainy and dry seasons, respectively ([Moreira et al. 2006](#); [Santana et al. 2011](#)). On the other hand, sabiá can produce up to 4,270 kg DM/ha of fresh browse ([Meirelles and Souza 2015](#)).

We conducted this study in an endeavor to evaluate the chemical composition of hays made from different plant fractions of the native forage shrubs sabiá and mororó.

Materials and Methods

Sabiá hay was produced from plants on the Experiment Station of the Instituto Agronômico de Pernambuco (IPA) in Itambé, Pernambuco, Brazil, from October 2005 to November 2005. Mororó hay was produced using plants collected from Caatinga vegetation in the IPA Experiment Station in Serra Talhada, Pernambuco, during March 2005. The estimated age of the plant material was 6–8 months. Green leaves and whole twigs (up to 8-mm diameter, since browser forage comprises leaves and twigs) were collected during the seed-maturity stage and spread to dry on concrete floors in full sunlight with manual turning for a 60 h period.

Experimental treatments included hay made from 2 fractions of the plant: leaves only and leaves plus twigs. The dried hay was stored in nylon bags and transported to the Department of Animal Science-UFRPE. Three composite samples from the hay bags were collected for chemical analysis in the Animal Nutrition Laboratories, UFRPE. The samples were ground in Wiley mills with a 1-mm sieve.

Analyses of DM, CP, ether extract (EE) and ash were conducted according to [Silva and Queiroz \(2002\)](#), while neutral detergent fiber (NDF) was determined as described by [Van Soest \(1994\)](#) and non-fiber carbohydrates (NFC) by the formula: $NFC = 100 - (\%CP + \%NDF + \%EE + \%ash)$ ([Mertens 1997](#)).

Feed intake and nutrient digestibility data were used to estimate total digestible nutrients (TDN) as described by [Sniffen et al. \(1992\)](#), where: $TDN = \text{digestible CP} + \text{digestible carbohydrates} + 2.25 \text{ digestible EE}$. For that, 8 wether goats (18.4 kg), dewormed and without a defined breed, were placed in individual pens containing water and mineral salt and offered the 2 hays (4 goats for each hay). After a 10-day adjustment period, feed offered, refusals and feces were recorded over 5 days to determine nutrient digestibility. Nutrient digestibility was calculated based on food intake less the refusals and the nutrient amounts contained in the food, refusals and feces.

Data were submitted to descriptive analysis consisting of a mean and confidence interval at 95% probability.

Results

While DM concentration in hays made of leaves only and leaves plus twigs varied little (Table 1), hays made from leaves only showed higher CP and lower NDF concentrations than hays made from leaves plus twigs. Mororó leaf hay contained lower CP concentration than sabiá leaf hay (126 vs. 182 g/kg DM) but CP in hays made from leaf plus twigs was similar for both species (106 vs. 107 g/kg DM).

Concentrations of NFC were lower in sabiá hays than in mororó hays, with higher levels in leaf hay than leaf plus twig hay for both species. The reverse was the case with NDF, where concentrations were lower in mororó hays than in sabiá hays and higher in leaf plus twig hays than in leaf hays for both species.

The EE of hays ranged from 19.9 to 42.5 g/kg DM, with higher values for sabiá hay than for mororó hay. Leaves contained greater EE than leaf plus twigs in both plants (Table 1). Ash concentrations in both species ranged from 51.6 to 73.7 g/kg DM with higher levels in leaf hays. Sabiá and mororó hays had low TDN concentrations, although leaf provided greater TDN than leaf mixed with twigs.

Discussion

This study has shown that hay can be made quite successfully from foliage of both sabiá and mororó legumes for feeding during periods of feed shortage. However, these preliminary findings suggest that the nutritive value of the hays, especially those from sabiá, is not high like herb legume hay. Further samples need to be made and fed to animals in intake and digestion studies to obtain a broader understanding of the merit of this strategy for addressing the period of feed shortage in northeast Brazil. Leaf normally displays better forage quality than twig, except in the case of tender new twigs or browse, which synthesize only a digestible primary cell wall and middle lamella ([Ding et al. 2012](#)). Thus, we expected that leaves would have higher CP and lower NDF concentrations than twigs and that addition of twigs, even those only 8-mm diameter, to leaf material would lower quality of hay. While this was the case, the hays made from leaf plus twigs still had CP concentrations above 7%, the level suggested by [Van Soest \(1994\)](#) as that below which DM intake of ruminants might be lowered.

When labor expenses for harvesting and drying and quantity of material harvested are considered, making hay from a mixture of leaf plus stem (1:1) becomes attractive. In fact, most hays made by farmers are a mixture of different plant fractions, the proportions depending on season and hydric conditions. [Santiago et al. \(2001\)](#) observed leaf:twig ratios in sabiá of 0.99, 0.95 and 0.84 for control, moderate and severe hydric stress conditions, respectively, and leaf:twig ratios of 1.09 and 0.86 for 25 and 50 days of growth, respectively. Removing the need to separate leaves from twigs would significantly reduce the cost of labor, and make turning of hay faster and more economical. The loss of leaves during the haymaking process, mainly during harvesting and transportation, especially in some arboreal legumes, is a limitation of this process ([Silva MSJ et al. 2013](#); [Pasqualotto et al. 2015](#)).

Table 1. Average and confidence interval (95% probability) of chemical composition (g/kg) of mororó and sabiá hays made from leaves only and leaf plus twigs.

Parameter	Mororó hay		Sabiá hay	
	Leaf	Leaf + Twigs	Leaf	Leaf + Twigs
Dry matter	878 ± 8.5	887 ± 1.0	946 ± 9.7	961 ± 6.1
Crude protein	126 ± 45.6	107 ± 7.8	182 ± 15.9	106 ± 21.2
Neutral detergent fiber	368 ± 7.6	421 ± 33.3	465 ± 26.7	597 ± 44.6
Ether extract	24.4 ± 5.7	19.9 ± 1.8	42.5 ± 3.8	28.8 ± 5.2
Ash	73.7 ± 2.5	63.7 ± 3.5	73.6 ± 43.3	51.6 ± 3.7
Non-fiber carbohydrates	418 ± 36.0	388 ± 33.2	258 ± 21.6	194 ± 25.3
Total digestible nutrients	481 ± 37.4	452 ± 35.8	311 ± 24.3	267 ± 19.3

Alves et al. (2011) and Silva et al. (2012) also reported higher CP concentration in sabiá hay made from leaves and noted that this hay was superior to mororó hay in terms of selection by goats. However, Beelen et al. (2006a) found similar CP concentrations in mororó and sabiá plants (190 vs. 178 g CP/kg DM) during the growing stage. By flowering and seed-maturity stages, CP in mororó had decreased to 134 and 144 g CP/kg DM, while sabiá remained at 177 and 163 g CP/kg DM, respectively.

Crude protein concentration of forage can be misleading as an indicator of the feed value as part of the nitrogen in hay may be fiber-bound in some native plants (Santos et al. 2010; Silva et al. 2012). Legumes from Caatinga synthesize a great amount of insoluble protein, which adheres to the fiber (Santana et al. 2011), lignin and condensed tannins (Beelen et al. 2006a; Oliveira et al. 2015), affecting nutrient digestibility (Beelen et al. 2006b; Silva et al. 2012). Most forages in the northeastern semi-arid region can synthesize anti-nutritional factors, such as tannins and lignins, from the secondary metabolism of plants, which can bind to protein and other nutrients, negatively influencing animal performance (Beelen et al. 2006b; Pereira et al. 2010). Furthermore, forage legume management can influence the accumulation of those compounds, as grazed plants can have more condensed tannins than ungrazed ones (Adams et al. 2013). Unfortunately, limited resources did not allow us to determine the tannin concentrations in the hays we made.

Alves et al. (2011) studied sabiá hay made from leaves plus twigs and found similar NDF concentrations (631 g/kg DM), but CP (162 g/kg DM) was greater than found in the present work. This might be a function of different leaf:twig ratios in the forages. The CP and fiber of the hays studied are important aspects in their use as a food supplement for animals in different seasons. In a parallel study with the same hays, Goyanna (2009) reported that sabiá and mororó hay had 34 and 33 g tannins/kg, respectively, which seemed not to have affected dry matter digestibility of sabiá (665 g/kg) and mororó (679 g/kg). Effective digestibility of CP in sabiá hay was greater than that in mororó (131 vs. 102 g/kg), which could have promoted greater sabiá intake (3.6% live weight, LW) than mororó (3.1% LW) by goats when offered individually, as well as when offered side-by-side to allow choice (2.0 vs. 1.2% LW).

Making legume hays can be a good strategy for conserving forage before leaves fall from deciduous forages in Caatinga lands. The hays in our study could provide an important source of protein and fiber for animals receiving, for example, cactus pear, which contains low CP (48 g/kg DM) and NDF (291 g/kg DM) (Tosto et al. 2007), and could lower methane emissions,

reduce helminths and other biological activities associated with tannin concentration.

Conclusions

The chemical composition of hay made from leaf showed higher quality, in terms of CP and NDF concentrations, than that of hay made from leaf mixed with twigs, regardless of the species. Sabiá leaf hay had higher CP concentration than mororó hay. These hays were adequate to support at least maintenance in livestock and thus should be appropriate for use during periods of feed shortage. As this hay was a single sample made from forage at a given stage of growth, more studies are needed to determine how much variation in quality exists over a range of situations and what potential yields might be. Feeding studies with ruminants are needed to confirm that animal responses are as chemical analyses suggest.

Acknowledgments

We thank the researchers of IPA for the hay-making support and the National Council for Scientific and Technological Development (CNPq) for scholarships provided.

References

- Adams RP; Muir JP; Taylor CA; Whitney TR. 2013. Differences in chemical composition between browsed and non-browsed *Juniperus ashei* Buch. trees. *Biochemical Systematics and Ecology* 46:73–78. DOI: [10.1016/j.bse.2012.09.020](https://doi.org/10.1016/j.bse.2012.09.020)
- Alves AR; Beelen PMG; Medeiros AN; Neto SG; Beelen RN. 2011. Consumo e digestibilidade do feno de sabiá por caprinos e ovinos suplementados com polietilenoglicol. *Revista Caatinga* 24:152–157. goo.gl/H4s2eu
- Arruda AMV. 2011. Digestibilidade *in vitro* de leguminosas do semiárido com inóculo cecal de aves. *Ciência Rural* 41:519–523. DOI: [10.1590/S0103-84782011000300026](https://doi.org/10.1590/S0103-84782011000300026)
- Bailey DW; Brown JR. 2011. Rotational grazing systems and livestock grazing behavior in shrub-dominated semi-arid and arid rangelands. *Rangeland Ecology & Management* 64:1–9. DOI: [10.2111/REM-D-09-00184.1](https://doi.org/10.2111/REM-D-09-00184.1)
- Beelen PMG; Berchielli TT; Beelen R; Araújo Filho J; Oliveira SG. 2006a. Characterization of condensed tannins from native legumes of the Brazilian Northeastern semi-arid. *Scientia Agricola* 63:522–528. DOI: [10.1590/S0103-90162006000600002](https://doi.org/10.1590/S0103-90162006000600002)
- Beelen PMG; Berchielli TT; Buddington R; Beelen R. 2006b. Efeito dos taninos condensados de forrageiras nativas do semiárido nordestino sobre o crescimento e atividade celulolítica de *Ruminococcus flavefaciens* FD1. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* 58:910–917. DOI: [10.1590/S0102-09352006000500029](https://doi.org/10.1590/S0102-09352006000500029)

- Ding SY; Liu YS; Zeng Y; Himmel ME; Baker JO; Bayer EA. 2012. How does plant cell wall nanoscale architecture correlate with enzymatic digestibility? *Science* 338:1055–1060. DOI: [10.1126/science.1227491](https://doi.org/10.1126/science.1227491)
- Goyanna GJF. 2009. Caracterização nutricional dos fenos de sabiá (*Mimosa caesalpiniiifolia* Benth.) e de mororó (*Bauhinia cheilantha* (Bong.) Steud.) em caprinos. M.Sc. Thesis. Federal Rural University of Pernambuco, Recife, PE, Brazil. tede2.ufrpe.br:8080/tede2/handle/tede2/6787
- Hughes MP; Jennings PGA; Mlambo V; Lallo CHO. 2012. Effect of season and harvesting method on chemical composition, predicted metabolizable energy and *in vitro* organic matter digestibility of rotationally grazed tropical pastures. *Online Journal of Animal and Feed Research* 2:405–417. goo.gl/9xbDMY
- Lima RP; Fernandes MM; Fernandes MRM; Matricardi EAT. 2015. Aporte e decomposição da serapilheira na Caatinga no sul do Piauí. *Floresta e Ambiente* 22:42–49. DOI: [10.1590/2179-8087.062013](https://doi.org/10.1590/2179-8087.062013)
- Meirelles AC de; Souza LAG de. 2015. Produção e qualidade da biomassa de leguminosas arbóreas cultivadas em um sistema de aleias em solo Latossolo Amarelo da Amazônia Central. *Revista Brasileira de Agroecologia* 10:67–74. goo.gl/TCTNwc
- Mertens DR. 1997. Creating a system for meeting the fiber requirements of dairy cows. *Journal of Dairy Science* 80:1463–1481. DOI: [10.3168/jds.s0022-0302\(97\)76075-2](https://doi.org/10.3168/jds.s0022-0302(97)76075-2)
- Moreira JN; Lira MA; Santos MVF; Ferreira MA; Araújo GGL; Ferreira RLC; Silva GC. 2006. Caracterização da vegetação e da dieta de ovinos em área de Caatinga no sertão de Pernambuco. *Pesquisa Agropecuária Brasileira* 41:1643–1651. DOI: [10.1590/s0100-204x2006001100011](https://doi.org/10.1590/s0100-204x2006001100011)
- Oliveira OF; Ferreira RLC; Almeida ACS; Santos MVF; Muir JP; Cunha MV; Lira MA. 2015. Season and rainfall gradient effects on condensed tannin concentrations of woody rangeland species. *Revista Brasileira de Ciências Agrárias* 10:165–169. DOI: [10.5039/agraria.v10i1a4329](https://doi.org/10.5039/agraria.v10i1a4329)
- Parente HN; Maia MO. 2011. Impactos do pastejo sobre a compactação dos solos com ênfase no Semiárido. *Revista Trópica: Ciências Agrárias e Biológicas* 5(3):3–15. goo.gl/4cJ3Mq
- Pasqualotto M; Neres MA; Guimarães VF; Klein J; Inagaki AM; Ducati C. 2015. Gas exchanges and dehydration in different intensities of conditioning in Tifton 85 bermudagrass: Nutritional value during hay storage. *Asian-Australasian Journal of Animal Science* 28:807–815. DOI: [10.5713/ajas.14.0826](https://doi.org/10.5713/ajas.14.0826)
- Pereira ES; Pimentel PG; Duarte LS; Villarroel ABS; Regadas Filho JGL; Rocha Júnior JN. 2010. Digestão intestinal da proteína de forrageiras e co-produtos da agroindústria produzidos no Nordeste Brasileiro por intermédio da técnica de três estágios. *Revista Brasileira de Saúde e Produção Animal* 11:403–413. goo.gl/5tLQz9
- Santana DFY; Lira MA; Santos MVF; Ferreira MA; Silva MJA; Marques KA; Mello ACL; Santos DC. 2011. Caracterização da Caatinga e da dieta de novilhos fistulados, na época chuvosa, no semiárido de Pernambuco. *Revista Brasileira de Zootecnia* 40:69–78. DOI: [10.1590/s1516-35982011000100010](https://doi.org/10.1590/s1516-35982011000100010)
- Santiago AMP; Nogueira RJMC; Lopes EC. 2001. Crescimento em plantas jovens de *Mimosa caesalpiniiifolia* Benth., cultivadas sob estresse hídrico. *Revista Ecosistema* 26: 23–30. goo.gl/adxqT5
- Santos MVF; Lira MA; Dubeux Júnior JCB; Guim A; Mello ACL; Cunha MV. 2010. Potential of Caatinga forage plants in ruminant feeding. *Revista Brasileira de Zootecnia* 39:204–215. DOI: [10.1590/s1516-35982010001300023](https://doi.org/10.1590/s1516-35982010001300023)
- Silva AB; Lira Junior MA; Dubeux Junior JCB; Figueiredo MVB; Vicentin RP. 2013. Estoque de serapilheira e fertilidade do solo em pastagem degradada de *Brachiaria decumbens* após implantação de leguminosas arbustivas e arbóreas forrageiras. *Revista Brasileira de Ciência do Solo* 37:502–511. DOI: [10.1590/s0100-06832013000200021](https://doi.org/10.1590/s0100-06832013000200021)
- Silva DF da; Alcântara CR. 2009. Déficit hídrico na região Nordeste: Variabilidade espaço-temporal. *UNOPAR Científica Ciências Exatas e Tecnológicas* 8:45–51. goo.gl/AuA5Qk
- Silva DJ; Queiroz AC de. 2002. Análise de alimentos: Métodos químicos e biológicos. 3th Edn. Universidade Federal de Viçosa, Viçosa, MG, Brazil. goo.gl/W2qM5z
- Silva MA da; Santos MVF dos; Lira MA; Dubeux Júnior JCB; Silva DKA; Santoro KR; Leite PMBA; Freitas EV de. 2012. Qualitative and anatomical characteristics of tree-shrub legumes in the Forest Zone in Pernambuco state, Brazil. *Revista Brasileira de Zootecnia* 41:2396–2404. DOI: [10.1590/s1516-35982012001200003](https://doi.org/10.1590/s1516-35982012001200003)
- Silva MSJ da; Jobim CC; Nascimento WG do; Ferreira GDG; Silva MS da; Três TT. 2013. Estimativa de produção e valor nutritivo do feno de estilosantes cv. Campo Grande. *Semina: Ciências Agrárias* 34:1363–1380. DOI: [10.5433/1679-0359.2013v34n3p1363](https://doi.org/10.5433/1679-0359.2013v34n3p1363)
- Sniffen CJ; O'Connor JD; Van Soest PJ; Fox DG; Russell JB. 1992. A net carbohydrate and protein for evaluating cattle diets. II. Carbohydrate and protein availability. *Journal of Animal Science* 70:3562–3577. DOI: [10.2527/1992.70113562x](https://doi.org/10.2527/1992.70113562x)
- Tosto MSL; Araújo GGL; Oliveira RL; Bagaldo AR; Dantas FR; Menezes DR; Chagas ECO. 2007. Composição química e estimativa de energia da palma forrageira e do resíduo

