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RESEARCH PAPER

Nutritional value of *Brachiarias* and forage legumes in the humid tropics of Ecuador

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Abstract

D.G. Balseca, E.G. Cienfuegos, H.B. López, H.P. Guevara, and J.C. Martínez. 2015. Nutritional value of *Brachiarias* and forage legumes in the humid tropics from Ecuador. Cien. Inv. Agr. 42(1): 57-63. This research evaluated the nutritional value of five varieties of *Brachiarias*: *B. decumbens* Stapf; *B. brizantha* Marandú; *B. brizantha* Piatá; *B. brizantha* Xaraés; and Mulato II [*B. ruziziensis* × *B. brizantha*]. The *Brachiarias* were combined at different inclusion rates (0, 10 and 15%) with two tropical forage legume species (*Centrosema pubescens* and *Cajanus cajan*, ECV22). The samples were collected at the experimental farm, The Oasis, a property of the Universidad Tecnológica Equinoccial (Ecuador), with 42 d of regrowth for the *Brachiarias* and 150 d for the legumes in the dry season. The proximate analysis and the Van Soest procedure were performed in the laboratory of food science and animal nutrition of the Escuela Superior Politécnica de Chimborazo (Ecuador). The *in situ* digestibility of dry matter (ISDDM) was assessed in three Holstein cows (560 ± 23 kg) with ruminal cannula. The proximal and Van Soest variables were analyzed with a complete randomized design, and for the variable ISDDM, a randomized block design was used. Significant differences for ISDDM ($P \leq 0.05$) between the *Brachiaría* varieties were found, with the highest percentages for the cv. *B. decumbens* Stapf and *B. brizantha* Marandú (63.9 and 63.2%, respectively). The diet with 10% *C. cajan* had average percentages of CP, NDF and ADF of 8.7, 70.7 and 47.6%, respectively, for all the *Brachiaría* varieties used in the study. It was found that diets with *B. decumbens* and *B. Mulato II* plus 10% of *C. cajan* were the best in terms of CP, NDF, ADF and ISDDM (9.3, 70.5, 46.4 and 64.1% and 8.6, 69.9, 50.3 and 63.5%, respectively). The results of this research showed that the value of CP meets the minimum requirements of nitrogen in the ration and that the ISDDM, DM, CF, NDF, ADF and ADL values are within the ranges reported for the genus *Brachiaría*.

Key words: *Brachiaría*, *Cajanus cajan*, *Centrosema pubescens*, digestibility, grasses, legumes, nutritional value.

Introduction

The extensive and intensive production systems of grasses that are found in tropical and subtropical

regions produce the primary, inexpensive food for the ruminants that are the main source of animal protein for the human population (Velásquez *et al.*, 2010).

they possess excellent forage qualities that allow them to substantially improve the indices of productive systems (Cuadrado *et al.*, 2004). Their characteristics are favorable to adaptation to the most difficult environmental conditions and to a variety of cultivation and management systems. There are a wide number of varieties or genotypes of *Brachiaria* that can well tolerate grazing, different levels of humidity, and different levels of soil acidity or salinity and that have an acceptable nutritional value when compared with legumes (Avellaneda *et al.*, 2008; Rincon *et al.*, 2008).

The capacity of a pasture to provide the nutritional requirements for the maintenance, growth and reproduction of grazing animals is known as the nutritional value of the plant. In general terms, the nutritional value of forage species is the result of intrinsic plant factors, such as chemical composition, digestibility, environmental factors, as well as factors characteristic of the animal and the interaction between pastures, animals and the environment (Barahona and Sanchez, 2005; Pirela, 2005).

To compare the nutritional value of the food from the perspective of the ruminants' nutritional needs and to determine if the nutritional requirements of the animals are met, it is necessary to evaluate the digestibility (the capacity of a nutrient to be assimilated by an animal). This is because not all the food that is eaten is assimilated by the organism; in fact, part of it is removed, mainly by slop, which represents the greatest nutritional loss in the process of energy use or incomplete digestion (Rodriguez *et al.*, 2007).

The incorporation of legumes into pasture for beef production has been reported to provide numerous benefits for the soil-plant-animal trilogy: for the soil, the legumes improve the mineral composition and guarantee the capacity to fix atmospheric nitrogen; for plants, these species increase production and the protein quality of associated grasses and improve air quality; for the animals, they contribute to productivity by increasing the edible

biomass, the voluntary intake, the digestibility of the forage and the incorporation of vitamins A, B, C and D in the diet (Diaz *et al.*, 2012; Paciullo *et al.*, 2014).

The objective of this research was to evaluate the nutritional value of mixtures consisting of five varieties of *Brachiaria* combined with different inclusion rates of two species of tropical forage legumes.

Materials and methods

The agronomic material was established during 2012 on the experimental farm, The Oasis, of the Escuela de Ingenieria Agricola Universidad Tecnologica Equinoccial, Campus Santo Domingo, Ecuador. The experimental site is located at 00° 13' 37" LS and 79° 15' 04" LW; the prevailing climate is tropical humid with an annual average temperature of 23.5 °C and an annual rainfall of 2,600 to 2,800 mm distributed in the rainy months with six dry months. The laboratory analyses (proximal and Van Soest) were conducted in the Laboratory of Food Science and Animal Nutrition of the Escuela Superior Politecnica de Chimborazo, Ecuador.

The experimental material was *B. decumbens* Stapf; *B. brizantha* Marandu; *B. brizantha* Piata; *B. brizantha* Xaraes; and Mulato II (*B. ruziziensis* × *B. brizantha*). The plants were set in plots of 4 × 4 m distributed randomly in three replicates, and samples were taken during the first year of establishment at 42 days of regrowth in the dry season. The two species of legumes in the study, *Centrosema pubescens* and *Cajanus cajan* (ECV22), were obtained in the first year of establishment. They were distributed randomly in 3 × 3 m plots in three replicates, and samples were taken at 150 days of growth in the dry season.

Thirty experimental mixtures were made incorporating combinations of the five varieties of *Brachiaria* with the three percentages of inclusion (0, 10, and

15%) of each legume (*C. pubescens* and *C. cajan*). The *in situ* dry matter digestibility (ISDMD) was determined in three Holstein cows with an average weight of 560 ± 23 kg that were supplied with cannula rumen (Giraldo, 1996) and were kept in the Centro Experimental Tunshi the Escuela Superior Politecnica de Chimborazo, Ecuador. The bromatological determinations of dry-matter (DM), ash (A), ether extract (EE), crude protein (CP), and crude fiber (CF) were in accordance with the official methods of analysis (AOAC, 1990); neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were measured in accordance with Van Soest (1994).

A random block design corresponding to a factorial design ($5 \times 2 \times 3$) where factor A = varieties of *Brachiaria*, factor B = proportion of legumes, and factor C = leguminous type was established to evaluate the percentage of *in situ* digestibility of dry matter (ISDDM):

$$Y_{ijklm} = \mu + B_i + G_j + I_k + L_l + (GI)_{jk} + (GL)_{jl} + (IL)_{kl} + \varepsilon_{ijklm}$$

where Y_{ijklm} = dependent variable; μ = general mean; B_i = effect of block (cattle with rumen fistula); G_j = the effect of the grass; I_k = percentage of leguminous inclusion; L_l = and leguminous type effect; $(GI)_{jk}$ = interaction of the grass and percentage legume inclusion; $(GL)_{jl}$ = interaction of the grass and legume type; $(IL)_{kl}$ = interaction of the legume inclusion with legume type; and ε_{ijklm} = experimental error.

A random block design corresponding to a factorial design ($5 \times 2 \times 3$) where factor A = varieties of *Brachiaria*; factor B = proportion of leguminous inclusion; and factor C = leguminous type, was used to evaluate the percentage of dry matter (DM), crude fiber (CF), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL):

$$Y_{ijklm} = \mu + G_j + I_k + L_l + (GI)_{jk} + (GL)_{jl} + (IL)_{kl} + \varepsilon_{ijklm}$$

where Y_{ijklm} = dependent variable; μ = general mean; G_j = the effect of the grass; I_k = percentage of leguminous inclusion; L_l = leguminous type effect; $(GI)_{jk}$ = interaction of the grass and percentage legume inclusion; $(GL)_{jl}$ = interaction of the grass and legume type; $(IL)_{kl}$ = interaction of the legume inclusion with legume type; and ε_{ijklm} = experimental error.

For both designs, the Tukey multiple comparisons test, with a significance level of $P \leq 0.05$, was applied using the SAS V.8 program (SAS Institute, Cary, NC, USA, 2001).

Results and discussion

In the present experiment, the overall mean ISDDM for the varieties of *Brachiaria* was 62.0%, and there was no treatment effect ($P > 0.05$). This result is different from that reported by Moreira *et al.* (2013) for the differences observed in the *in vitro* digestibility of the dry matter (IVDDM) of different *Brachiaria* varieties and grazing systems. Similarly, Quintino *et al.* (2013) found that the age of the plant affected the IVDDM of *B. brizantha* cv. BRS and *B. brizantha*. Digestibility depends mostly on the nutritional composition of the grass–legume mixture; the estimated values of the apparent digestibility of the fractions corresponding to proteins and lipids, without including the contributions of endogenous compounds of the same type, are always lower than the true digestibility coefficients (Ramirez *et al.*, 2009). The utility of working with ruminants is that the contribution of endogenous nitrogen is approximately 0.5 to 0.6 g per 100 g DM⁻¹ consumed, so the coefficients of apparent digestibility in rations containing less than 4% protein, are negative (Giraldo *et al.*, 2007).

The ISDDMs according to the varieties of *Brachiaris* are presented in Table 1. While *B. decumbens* and *B. brizantha* Marandu are the species that presented the highest values for ISDDM (63.2 and 63.7%, respectively); these differences were

Table 1. *In situ* digestibility of dry matter (ISDDM), dry matter (DM), crude fiber (CF), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) for different varieties of *Brachiaria* in the humid tropics of Ecuador.

Varieties	Proximate Analysis				Van Soest		
	ISDDM Mean (SD)	DM Mean (SD)	CF Mean (SD)	CP Mean (SD)	NDF Mean (SD)	ADF Mean (SD)	ADL Mean (SD)
<i>B. decumbens</i> Stapf	63.2(6.2)	22.7(0.7) bc	42.9(2.4) ab	9.1(0.9) a	71.3(1.6) b	46.2(0.7) d	17.6(0.1) b
<i>B. brizantha</i> Marandú	63.7(9.6)	23.4(0.7) ab	41.9(3.1) b	8.3(1.2) ab	71.7(0.6) b	47.6(0.7) c	19.9(1.9) ab
Mulato II (<i>B. ruziziensis</i> x <i>B. brizantha</i>)	62.4(4.9)	23.2(0.4) ab	45.4(3.3) a	7.9(0.9) b	70.6(0.8) b	49.4(1.0) b	18.9(3.2) ab
<i>B. brizantha</i> Piatá	60.8(5.5)	23.7(1.1) a	43.2(1.2) ab	7.7(0.6) b	73.9(2.9) a	51.0(1.9) a	20.6(1.0) a
<i>B. brizantha</i> Xaraés	60.0(6.6)	21.9(0.7) c	41.1(1.1) b	8.3(1.2) ab	70.4(1.9) b	48.9(0.9) bc	18.3(2.7) ab

a, b, c in the columns indicate significantly different results according to the Tukey test $P \leq 0.05$; SD = standard deviation.

not significant ($P > 0.05$). However, Avellaneda *et al.* (2008) studied the ISDDM of varieties of *Brachiarias* at different days of cultivation. While some age- and species-related variability was noted, no significant differences in digestibility for the different plant ages ($P > 0.05$) was found. Moreira *et al.* (2013) found no differences in the ISDDM for the varieties Xaraés and Marandú ISDDM. Ramirez *et al.* (2009) found that the ISDDM was affected ($P \leq 0.05$) by the age of the grasses (*B. decumbens* cv. Basilisk and hybrid *Brachiaria* cv. Mulatto). All double interactions for all the factors for ISDDM were non-significant ($P > 0.05$).

In addition, DM, CF and CP were 23.0, 42.9 and 8.3%, respectively, and it was observed that these values were affected ($P \leq 0.05$) by the variety of *Brachiarias*. Table 1 shows that *B. decumbens* presented the highest percentage of CP (9.1%), while *B. brizantha* only reached 7.7% of CP ($P \leq 0.05$). Some authors report that in the fibrous diets ruminants consume, the volume of the DM and the amount of time that the DM remains in the rumen affect consumption; consumption, in turn, has a negative relationship with digestibility, which is controlled by the animal's energy requirements (Barahona and Sanchez, 2005). However, Avellaneda *et al.* (2008) observed that the DM and CP content were

not modified ($P > 0.05$) by the variety of *Brachiaria*, which is most likely because the DM and CP are more related to climatic variations and the age of the pasture growth. The main component of the fodder that influences digestibility and consumption is the cell wall, the thickness of which is inversely proportional to the digestibility and voluntary intake. The reduction in digestibility is explained because the more easily digestible nutrients are contained in the cell cytoplasm, while the less digestible components are found in the cell wall (Morales *et al.*, 2013).

For fiber, the NDF, ADF and ADL fractions were 71.6, 48.6 and 19.1%, respectively. As in the previous cases (varieties), the treatment affected ($P \leq 0.05$) the percentages of fibers. Slightly lower results were reported by Cuadrado *et al.* (2004) in a trial conducted in Colombia that studied the effect of the time and the varieties *B. decumbens* and *B. brizantha*. The study reported values of 69.8 and 67.6%, respectively, for NDF and 34.1 and 40.6%, respectively, for ADF using these varieties. Another study reported that the ADF is inversely proportional to the digestibility, while the NDF is directly related to the ability to forage and to the ideal volume in the gastrointestinal tract and consumption of the MS (Cruz and Sanchez, 2000).

Similarly, the percentage of ADL (lignification of the cell wall of plants) is inversely related to the degradability of DM and, consequently, a low IVDMD and ISDMD (Ramírez *et al.*, 2002). These results lead us to suggest that *B. decumbens* and *B. brizantha* offered alone could be an option in a livestock production system.

Finally, the percentages of ISDMD, DM, CF, CP, NDF, ADF and ADL were 62.3, 22.8, 43.4, 8.4, 71.3, 48.5 and 19.0%, respectively. Table 2 presents the results for the level of legume included (0, 10, and 15%) and the leguminous type (*C. pubescens* and *C. cajan*), which did not affect the ISDMD, DM, CF, CP, NDF, ADF or ADL ($P>0.05$). Results contrary to those in the present study were reported by Morales *et al.* (2013), who observed that the nutritional quality of pastures showed differences ($P\leq 0.04$) when bird foot clover was included (*Lotus uliginosus*). This association was apparent in terms of voluntary forage intake ($P\leq 0.05$) and milk production ($P\leq 0.05$).

Because tropical grasses have low nutritional value, one management strategy is to include legumes in the diets of animals or to include grasses associated with legumes in pastures for direct consumption during grazing (protein banks). This

is because legumes have higher nutritional value than grasses, and rations that combine grasses and legumes are consumed in larger quantities by animals than diets containing only grasses, as reflected by increased weight gain (Diaz *et al.*, 2012). Some studies have reported that species of leguminous trees and shrubs used as supplements in the diets of ruminants improve the nutritive value of the pasture forage, increase voluntary consumption, reduce the nutritional stress in animals and can increase the protein:energy relationship of the rations (Galindo *et al.*, 2005). In general, the greater the content of NDF (cell wall) of one fodder, the lower its digestibility. However, this relationship does not always hold because cell wall digestibility depends on the degree of lignification.

The results of this research showed that the value of CP meets the minimum requirements of nitrogen in the ration and that the ISDMD, DM, CF, NDF, ADF and ADL are within the ranges reported for the genus *Brachiaria*. However, the inclusion of legumes (*C. pubescens* and *C. cajan*) provided no improvement in the quality of rations composed of different varieties of *Brachiaria*. All double interactions for all the factors and variables were non-significant effects ($P>0.05$).

Table 2. *In situ* digestibility of dry matter (ISDDM), dry matter (DM), crude fiber (CF), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) as a result of the inclusion of different proportions of *Centrosema pubescens* and *Cajanus cajan* of *Brachiaria* in the humid tropics of Ecuador.

	<i>Centrosema pubescens</i>			<i>Cajanus cajan</i>	
	Control (0%)	(10%)	(15%)	(10%)	(15%)
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
ISDDM (%)	61.5(7.3)	65.3(5.4)	61.1(6.0)	62.5(6.6)	61.0(7.3)
DM (%)	23.6(0.9)	22.7(0.9)	23.1(0.8)	22.6(0.7)	22.2(0.9)
CF (%)	40.3(1.5)	44.5(3.1)	44.1(2.1)	44.6(2.2)	43.6(1.7)
CP (%)	7.4(0.4)	7.8(0.5)	8.3(0.7)	8.7(1.0)	9.9(0.9)
NDF (%)	72.9(2.6)	71.3(1.3)	71.0(1.7)	70.7(1.2)	70.8(1.9)
ADF (%)	49.4(2.4)	48.9(1.9)	48.7(1.7)	47.6(1.3)	47.8(1.5)
ADL (%)	19.2(1.5)	19.1(2.1)	19.7(3.8)	17.7(2.8)	19.5(1.2)

SD = standard deviation.

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Resumen

D.G. Balseca, E.G. Cienfuegos, H.B. López, H.P. Guevara y J.C. Martínez. 2015. Valor nutritivo de *Brachiarias* y leguminosas forrajeras en el trópico húmedo de Ecuador. Cien. Inv. Agr. 42(1): 57-63. En la presente investigación se evaluó el valor nutritivo de cinco variedades de *Brachiarias* (*B. decumbens* Stapf; *B. brizantha* Marandú; *B. brizantha* Piatá; *B. brizantha* Xaraés; y Mulato II [*B. ruziziensis* x *B. brizantha*]), combinadas con diferentes porcentajes de inclusión (0, 10 y 15%) de dos leguminosas forrajeras tropicales (*Centrosema pubescens* y *Cajanus cajan*, ECV22). Las muestras fueron colectadas en la granja experimental "El Oasis" de la Universidad Tecnológica Equinoccial a una edad de rebrote para *Brachiarias* de 42 d y para leguminosas de 150 d en época seca. Los análisis proximal y de Van Soest se realizaron en el laboratorio de bromatología y nutrición animal de la Escuela Superior Politécnica de Chimborazo (ESPOCH), la digestibilidad *in situ* de la materia seca (DISMS) se evaluó en tres vacas Holstein (560 ± 23 kg) con cánula ruminal. Las variables del análisis proximal y Van Soest fueron analizadas con un modelo completamente al azar y para la variable DISMS con un diseño de bloques al azar. Se encontraron diferencias ($P \leq 0,05$) entre variedades para DISMS con los porcentajes más altos para las *B. decumbens* Stapf y *B. brizantha* Marandú (63,9 y 63,2%). La mezcla con 10% de *C. cajan* tuvo porcentajes de PC, FDN y FDA de 8,7; 70,7 y 47,6%, respectivamente en promedio para todas las variedades de *Brachiararia*. Se encontró que las dietas con *B. decumbens* Stapf y Mulato II más el 10% *C. cajan* fueron las mejores en términos de PC, FDN, FDA y DISMS (9,3; 70,5; 46,4 y 64,1% y 8,6; 69,9; 50,3 y 63,5%, respectivamente). Los resultados de esta investigación mostraron que el valor de PC satisface las necesidades mínimas de nitrógeno en la ración y que la DISMS, MS, FC, FDN, FDA y LDA están dentro de los rangos reportados para el género *Brachiararia*.

Palabras clave: *Brachiararia*, *Cajanus cajan*, *Centrosema pubescens*, digestibilidad, gramíneas, leguminosas, valor nutritivo.

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