CAPÍTULO 4

NUTRITIONAL VALUE OF FORAGE PEANUT (*Arachis Pintoi* CV. BRS MANDOBI) AND ELEPHANT GRASS SILAGES

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ABSTRACT: *Arachis pintoi*, commonly known as forage peanut, is a leguminous plant with good forage yield and nutritional quality adapted to the Brazilian environmental conditions and used in grass/legume pastures or preserved as silage or hay. In this study, we evaluated the nutritional value and dry matter losses of silages produced with different proportions of forage peanut cv. BRS Mandobi and elephant grass. Five levels of substitution of elephant grass (0, 25, 50, 75, and 100%, fresh matter basis) for the legume were tested in a completely randomized design with four replicates. The fiber components of the silages, except lignin, decreased with higher levels of forage peanut. Crude protein content and *in vitro* dry matter digestibility presented maximum values of 16.9% and 62.5%, increasing by 0.07 and 0.15 units with every 1% of the legume added to the silage, respectively. Silage pH rose from 3.8 to 5.4, although gas and effluent losses had estimated reductions of 0.01 and 0.66 units for each additional unit of the legume. Silages composed of elephant grass and more than 50% forage peanut improve the nutritional value of the feed and increase dry matter recovery of the ensiled forage mass. Silages with these proportions of forage peanut have high protein and low fiber contents.

KEYWORDS: Dry matter recovery; ensilage; legume; nutritive value; roughage.

INTRODUCTION

The excellent adaptation of *Arachis pintoi* to the wet tropics, coupled with its aggressiveness and productivity characteristics, good establishment, resistance to grazing, good palatability, and excellent nutritional value, makes this plant one of the most important legume species in the entire Amazon (Valentim 1996; Valentim *et al*. 2001; Barrett, Valentim, Turner 2013). Ten months after planting, its dry matter yield ranges from 9 to 15 t ha^{-1} (Assis and Valentim 2009) in harvests performed at heights greater than 5 cm above the soil, maintaining 64% of the total biomass — especially of stolons — available in the soil to ensure regrowth (Cavali *et al.* 2002).

With high crude protein contents, low fiber, and high digestibility (Ramos *et al.* 2010), this leguminous plant has little variation in forage quality between the leaf and stem fractions as it ages when compared with other tropical forage species, mainly grasses (Lascano 1994; Ramos *et al.* 2010).

Valentim *et al*. (2003) observed mean crude protein contents ranging from 17.9 to 21.7% in accessions and cultivars of forage peanut in Rio Branco - AC, Brazil and reported 62% digestibility in leaves of *Arachis pintoi* during the dry season and 67% in the rainy season. Oliveira *et al*. (2011) obtained an *in vitro* dry matter digestibility (IVDMD) of 76.1% in cultivar Belmonte in the spring, in São Carlos - SP, Brazil. Azevedo *et al.* (2014) evaluated forage peanut genotypes in the state of Acre and reported average calcium contents between 14.24 and 21.06 g kg^{-1}, 4.42 to 9.17 g kg^{-1} magnesium, 0.97 to 2.3 g kg^{-1} phosphorus, and 7.61 to 22.68 g kg^{-1} potassium in the shoot biomass; the authors stressed that the production potential of forage peanut is related to the fungal mycorrhizal richness in the rhizosphere, which is potentiated by phosphate fertilization (Miranda, Silva, Saggin Jr. 2016). Azevedo *et al*. (2014) identified the occurrence of 21 species of arbuscular mycorrhizal fungi in soil samples of 45 forage peanut genotypes.

Fernandes *et al*. (2011) investigated the quality of hay from *A. pintoi* at 30 days of regrowth using the *in vitro* digestibility method and found a CP content of 24.18%, which is higher than those reported in the literature for tropical grasses. The authors concluded that this legume plant is a great source of this component for animal feeding, even at advanced ages. As for IVDMD, these researchers observed a higher value (79.21%) than those mentioned in other studies with tropical legumes, in which only alfalfa showed superior digestibility. The authors emphasized the ever-growing importance of this legume among the alternatives to improve the nutritional quality of pastures grown in the tropics, given their large high-quality forage yield.

Cultivar BRS Mandobi was obtained by massal selection performed at Embrapa Acre (Brazilian Agricultural Research Corporation) from the forage peanut accessions evaluation network installed in 1999 (Assis and Valentim 2009), registered in 2008, at Brazil’s National Cultivar Register and protected in 2011, according to the norms of the Ministry of Agriculture, Livestock, and Supply. One of the main characteristics of cv. Mandobi is its high seed yield, of over 4.000 kg ha^{-1} at 18 to 21 months after planting, in the environmental conditions of Acre State (Valentim and Assis 2009). Moreover, the cultivar has great vigor, a dry matter yield of over 18 t ha^{-1} at 10 months after planting (Balzon *et al*. 2005), good establishment, tolerance to low-permeability soils, and good leaf production (Assis *et al*. 2013).

Santos (2012) evaluated genotypes Belmonte and Mandobi in Rio Branco - AC, Brazil, during the low-rainfall period, and observed a less marked reduction of the CP content at the harvest ages of 28 to 70 days for cultivar BRS Mandobi compared with *Arachis pintoi* cv. Belmonte. In addition, cultivar BRS Mandobi displayed average NDF, ADF, and lignin contents of 50.7%, 24.21%, and 7.28%, which were lower values than those found in cultivar Belmonte, besides an IVDMD of 74.6% irrespective of age, and dry matter accumulation of 20 t ha^{-1}. The use of legume plants in the ruminant production system is a supplementary-protein alternative for animals as a source of preserved roughage. Andrade *et al.* (2012) suggested its use in grass-intercropping systems.

Ladeira *et al*. (2002) fed ruminants with forage peanut hay and observed high intake and nutrient digestibility levels, demonstrating that this feedstuff can be used to meet the requirements for ruminant production. However, despite the elevated energy contents, they recommended supplementation with energy sources of high availability, aiming at an optimum production potential.

Another advantage of the use of legumes and the nitrogen uptake through biological fixation by soil bacteria associated with the plant is the expressive increase in carbon fixation into the soil and the reduced greenhouse gas emission. Comparative studies in areas with grass pastures and pastures with grasses intercropped with legumes have shown significant increases in carbon stocks in intercropped pastures (Barcellos *et al*. 2008; Paris *et al.* 2009; Fernandes *et al.* 2011; Paulino *et al*. 2012).

Harvesting and ensiling the surplus forage production is an alternative to renew the forage sward and increase the carbon incorporation, maintaining the high system turnover.

The ensiling of forage peanut associated with elephant grass has shown to be an option to improve the nutritional value of the silage, as a result of the balance between the components of the ensiled biomass, improving the fermentation profile. Elephant grass, commonly used for silage making at its point of maximum nutritional value, provides an increase in dry matter content and a reduction in the amount of ammonia produced in forage peanut silages. Including this legume in the ensiling of this grass is a practice aimed at generating feed of better quality and nutritional value, reducing the fiber content, and consequently increasing the intake, digestibility, and performance of animals.

The objective of this study was to evaluate the nutritional content and dry matter losses of silages produced with different levels of forage peanut and elephant grass.

MATERIALS AND METHODS

The experiment was conducted in the Agrostology Unit at the Federal University of Viçosa (657 m asl), where the average annual precipitation was 1,341 mm, 86% of which occurred in the months of October to March. Mean temperature ranged from 14.0 to 26.1 ºC.

The elephant grass (*Pennisetum purpureum* cv. Cameroon) was harvested during the regrowth of the already established grass pasture, to which cattle manure was incorporated throughout the year. Forage peanut (*Arachis pintoi* cv. BRS Mandobi) was planted in 2009, after soil preparation, and was fertilized biannually with cattle slurry; the grass was leveled in October 2010. At the harvest, the elephant grass and forage peanut were at 50 and 110 days of regrowth, and with a height of 1.5 m and 60 cm, respectively. The forages were harvested manually at 15 cm and 2 cm from the soil surface, respectively, using a machete, and then chopped to particles of approximately two centimeters in a stationary forage chopper.

The elephant grass:forage peanut ratios in the silage were 0:100, 25:75, 50:50, 75:25, and 100:0%, fresh matter basis. A completely randomized design with five replicates (five elephant grass:forage peanut ratios) and four replicates was adopted. The material was ensiled in plastic buckets (experimental silos) with 18-L capacity equipped with a Bunsen valve on their lid to allow the escape of fermentation-derived gases. Three kilograms of dry sand were placed at the bottom of the buckets, separated from the forage by a layer of fabric, for a later estimate of the effluent production. The average specific mass or compaction density of the buckets containing elephant grass and forage peanut only were 801 and 643 kg forage/m^3, respectively. Silos were sealed with adhesive tape, weighed, and stored in a covered area at room temperature until they were opened, which occurred 40 days after ensiling. On this occasion, the silo content was weighed again to quantify losses due to fermentation, and samples were collected for determinations of pH and ammonia nitrogen $N\text{-}NH_3$.

For pre-drying, a 500-g sample of the substrate from each treatment was harvested, in triplicate, before ensiling and after silo opening, and then packed in paper bags. Samples were dried in a forced-air oven at 60 ± 5 ºC for 72 h and then ground through a Wiley mill to 1 mm particles. Dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, lignin, total nitrogen, water-soluble carbohydrates (SC), and *in vitro* apparent dry matter digestibility (IVDMD) were determined at 48 h, according to Silva and Queiroz (2002); NDF and ADF corrected for ash and protein (NDF_{ap} and ADF_{ap}) according to Hall (2003); and neutral (NDIP) and acid (ADIP) detergent insoluble protein following Licitra *et al* (1996). The rumen inoculant for *in vitro* incubation was collected from rumen-cannulated crossbred cattle feeding *ad libitum*, which received 2 kg of concentrate and chopped sugarcane.

For determination of pH, 25-g samples were collected to which 100 mL distilled water were added, and then left to rest for 2 h. After this time, the pH was read using a digital pH meter. In another 25-g sample, 200 mL of a 0.2 N H_2SO_4 solution were added, and the mixture was left to rest for 48 h in a refrigerator; after this period, the mixture was filtered through a Whatman® 54 filter paper. The N-NH_3 content as a percentage of the total N was measured in the filtrate using KOH a 2 mol L^{-1}.

Dry matter losses as gases and effluent were quantified as follows: gas losses (%DM) were calculated as the difference in weight between the full bucket at silo closure and opening (kg) divided by the forage mass at closure (kg) and multiplied by the herbage dry matter at closure and by 1,000. Effluent loss (kg t^{-1} fresh matter) was calculated as the difference in weight of the sand (kg) before and after ensiling, relative to the forage mass (kg) at silo closure, multiplied by 100. Dry matter recovery was obtained as the difference in forage weight (kg) from ensiling to silo opening and respective dry matter contents in the silos (%), following the methodology described by Jobim *et al.* (2007).

Treatment means were subjected to variance and regression analyses, and orthogonal contrasts were used to check the possible linear, quadratic, cubic, and quartic effects for the different proportions of forage peanut and elephant grass, adopting $\alpha = 0.05$.

RESULTS AND DISCUSSION

Before ensiling, elephant grass showed an average dry matter (DM) content of 16.8% (Table 1), which is considered low to provide adequate fermentation conditions and prevent effluent production. According to Jones and Jones (1995), a minimum DM content of 25% is required to prevent significant effluent production in silages. The DM values recorded for the elephant grass are due to its early harvest, at 50 days of regrowth, and corroborate the values reported by Valadares Filho *et al*. (2015) for this cultivar harvested at 60 days of growth.

In cv. Mandobi, except for DM, the other chemical components of the cultivar agreed with the mean values found in other leguminous plants of the species *Arachis pintoi* compiled by Valadares Filho *et al*. (2015) and Paulino *et al*. (2012). These authors observed a linear decrease in protein content from 23.5 to 19.1%, in the forage dry matter, from 64 to 142 days of growth, and a decrease in the NDF, ADF, and cellulose contents of forage peanut cv. Belmonte of 49.5, 38.0, and 29.0% DM, respectively. These authors stressed that even at more advanced ages, the nutritional values are adequate and the legume is appropriate for ruminant feeding.

Nascimento *et al*. (2010) evaluated forage peanut cv. Alqueire-1 and found a CP content of 20.8% at 84 days of growth and emphasized its flexibility to the frequency of harvests and deferment management for dry periods of up to 180 days, with no losses of forage quality. The authors stressed the alternative of the use of the legume in production systems for the forage scarcity period.

Santos (2012) evaluated cultivar Mandobi at different harvest ages and observed

22.6% CP, 50.7% NDF, 24.2% ADF, and 7.28% lignin in the dry season of the year at 70 days of regrowth. The author also reported an IVDMD of 74.6%, which is higher than the 64.2% found for cv. Belmonte in the present study at 110 days.

Paulino *et al.* (2012) did not observe differences for the concentrations of condensed tannins and total tannins and phenols as a function of the harvesting age of forage peanut cv. Belmonte. Tannin levels were below 40 g kg^{-1} DM, considered minimum tolerance of toxicity to ruminants without adverse effects on palatability or animal production.

Mean non-fibrous carbohydrates (NFC) contents of 10 and 23% were detected for elephant grass and forage peanut, respectively (Table 1). Woolford (1984) recommended a soluble carbohydrates (SC) content above 8% in the dry matter and a moisture content of approximately 70% as potential for fermentation during ensiling. However, there is an inverse relationship between the need for SC and the forage DM content for good fermentation to take place. Adequate soluble carbohydrate contents are desirable, because, during the normal fermentation process, they are converted to organic acids, mainly lactic acid, causing a reduction of pH, which in turn inhibits the action of other undesirable microorganisms, especially those of the genus *Clostridium* (McDonald *et al.* 1991).

Haigh (1990) suggested the existence of an inverse relationship between the need for sugars and the dry matter content of the forage, for proper fermentation. Van Soest (1994), by contrast, stated that the SC:buffering capacity ratio must be high so as to generate good-quality silage, should the forage dry matter be reduced.

In the silages, all chemical-composition variables were influenced by the increasing proportions of forage peanut replacing elephant grass, except for the organic matter, total digestible nutrients, and NH_3-N contents (Table 2).

Results observed for the silages containing forage peanut cv. BRS Mandobi solely are close to the mean values found by Paulino *et al.* (2009) in forage peanut cv. Belmonte, whereas the values observed for elephant grass are below those obtained by Valadares Filho *et al.* (2015). Paulino *et al.* (2009) observed DM, CP, NDF, and IVDMD values of 19.9%, 21.6%, 45.1%, and 64.8%, respectively, in silage containing forage peanut cv. Belmonte only, harvested at 60 days of regrowth.

Increasing the forage peanut levels from 0 to 100% resulted in a linear increase in the DM content of the silages from 16 to 23% (Table 2). This response is due to the maturity of the forages and the higher dry matter content of the legume in relation to the grass at the early harvest, performed at 50 days of regrowth. Paulino *et al.* (2009) added forage peanut at the levels of 10, 20, and 30% to elephant grass cv. Paraíso silage at 100 days of regrowth and observed an increase in DM from 18.3 to 20.0% and in CP from 15.5 to 17.6%. They also observed a downward trend in the NDF contents of silages with a higher percentage of elephant grass: 59.0% vs. 61.6%, caused by the lower proportion of cell wall in the peanut harvested at 60 days of regrowth.

The NDFap, ADFap, and hemicellulose contents decreased as the proportions of forage peanut in the silages were increased ($P < 0.05$); this was an expected result, given the lower proportion of cell wall in the legumes. This can be explained by the non-fibrous carbohydrates (NFC) contents, which rose by 0.15 units with every 1% forage peanut added. The non-structural carbohydrate levels are much higher in legumes than in grasses, and in the leaves compared with stems. This affects the forage digestibility, which is reduced as the plant ages — and even more markedly in grasses than in legumes.

Overall, NFC contents increased by 1.38% with the addition of 25% forage peanut to the ensiled forage biomass. The non-fibrous carbohydrates represent the fractions most rapidly digested in the rumen, including pectin, starch, and sugars (Silva and Silva 2013; Nussio *et al.* 2011). These compounds are rapidly fermented by lactic acid bacteria, promoting an increase in lactic acid content, characterized by the pH decline in the silage compared with the ensiled mass. The high NFC content of the silages, especially in those with forage peanut rates greater than 50%, may also be associated with the rupture of chemical bonds of structural carbohydrates, mainly hemicellulose (Table 2), as stressed by Nussio *et al.* (2011). Therefore, the substitution of forage peanut for elephant grass might have influenced the tannin contents, since lignin, associated with the polymers from the plant cell wall, increased while the NDF content decreased (Bai *et al.* 2011).

Non-fibrous carbohydrate contents, represented by fractions A + B1, were higher in the silages (Table 2) as compared with the ensiled mass (Table 1).

The difference in carbohydrate fractions between crops is related to differences in the structural characteristics of plants. As stated by Naeini *et al.* (2014), highly soluble carbohydrate fractions increase with the ensiling period, which may be attributed to the cell wall degradation resulting from the activity of microbial enzymes (cellulase and hemicellulase) and organic acid production during fermentation.

According to Detmann *et al* (2014a), in terms of maximization of rumen microbial development, a minimum CP concentration of 124 g/kg DM is recommended to provide balance between the input and output of N into and from the rumen and ensure its proper availability for other animal-metabolism requirements. They also recommend an optimal ratio between protein and energy of 288 g CP/kg digestible organic matter or TDN, which optimizes the voluntary forage intake by the animal by potentiating the use of the latent energy from tropical forages (Detmann *et al.* 2014b).

Andrade *et al.* (2010) stressed that feeds like elephant grass, with high levels of fractions A + B1, are excellent energy sources for the development of microorganisms that use NFC, suggesting the addition of protein sources of rapid and medium degradation in the rumen — in this case, the forage peanut — for greater synchrony between the release of energy and nitrogen.

Neutral (NDIP) and acid (ADIP) detergent insoluble protein values rose as the proportion of forage peanut was increased. From the nutritional perspective, an increase in ADIP levels is not desirable, since the nitrogen retained in ADF is unavailable to the rumen microorganisms, as it is in the subsequent gastrointestinal tract. The unavailable protein from all ensiled forage increases as a result of both the physiology of the plant and the Maillard reaction, a process that leads to excessive heating of the ensiled mass (McDonald 1981), whereby the protein reacts with the plant carbohydrates (Van Soest 1994). Therefore, according to the author and with the data shown in Table 1, ADIN increases as the soluble protein is decreased and CP is increased due to heat.

The lignin content increased linearly ($P < 0.05$) with the addition of peanut, which is related to the higher value of this component in the peanut in relation to elephant grass. In general, the lignin content relative to the NDF content of the forage is negatively correlated with the degradation of the fibrous fraction, since lignin prevents the digestion of cell wall carbohydrates by approximately 1.4 times its own weight (Van Soest 1981). Paulino *et al.* (2009) obtained 45.0%, 39.0%, and 9.3% NDF, ADF, and lignin, respectively, in a forage peanut-only silage.

Based on the data described in Table 2, there is a negative correlation between the lignin content and IVDMD. According to Van Soest (1994), this fact is due to the greater concentration of hemicellulose in the grasses, linked covalently to the lignin. Jung (1989) remarked that the lignin composition may influence the fiber digestibility. The phenolic acids p-coumaric and ferulic, which represent the non-core lignin, and which are present on the cell wall of forage plants, have a negative effect on digestibility, mainly p-coumaric acid. In this way, histological and anatomical differences in plants from heterogeneous photosynthetic groups, classified into C4 and C3, constitute tropical and leguminous grasses, respectively. In ensiling, greater proportions of elephant grass compromised digestibility because of its higher indigestible NDF and lower NFC contents (Table 2) compared with those found in the silages with higher rates of forage peanut.

The treatment with alkalis in grasses results in a considerable solubilization of lignin and an effect on digestibility (Van Soest 1994); however, it has little influence on the digestibility of lignin in legumes, which may explain the higher lignin contents in the silages with greater levels of forage peanut, compared with the same levels before ensiling (Table 1). High NDF, ADF, and lignin levels and low IVDMD may be related to the advanced maturity stage of the peanut. This fact likely led to a reduction of the leaf:stem ratio, increased number of reproductive branches, and longer stolons, which may result in higher cellulose and lignin concentrations, yielding lower-quality forage.

In vitro dry matter digestibility increased ($P < 0.05$) with the higher proportions of forage peanut. Paulino *et al*. (2009) observed an IVDMD for forage peanut-only silages of 64.8%, which is higher than the 62.5% obtained in the present study; however, they did not find differences between the elephant grass silages including 10, 20, or 30% forage peanut (average 61.5%).

The pH increased from 3.8 to 5.4 as the peanut levels in the silages were increased (Table 2), while N-NH_3 had a maximum value of 5.8% at the forage peanut level of 43.6%. Paulino *et al*. (2009) observed a pH of 5.48 and 18.22% N-NH_3 in silages containing forage peanut only. The higher pH values detected with higher levels of *Arachis* in the silages is due to the typical buffering effect of legumes, which possess a larger amount of organic ions and form buffers, preventing the development of lactic acid-producing bacteria. Despite their elevated pH as compared with the silages containing grass only (5.4 vs. 3.8), silages containing forage peanut alone displayed similar N-NH_3 values (3.96 vs. 4.31), as a result of the DM contents of 23.0% and 16.6% of the forages in the ensiled mass, respectively (Table 2)

Van Soest (1994) mentioned that pH values may not be so relevant for silage quality when dry matter contents are elevated. However, in the present study, despite the low DM content of elephant grass at ensiling, the pH reached a maximum of 5.4. Paulino *et al* (2009) obtained, in mixed silages, pH values of 3.15, 3.4, and 3.5 for the peanut levels of 10, 20, and 30% added to elephant grass, respectively. These pH values are lower than the 5.3 detected in the present study for the silages with forage peanut levels greater than 25%. This fact can be explained by the high buffering capacity of legumes, resulting in resistance against pH decline during fermentation. This variable also increased ($P < 0.05$) as the proportion of peanut in the silages were increased (Table 2). Muhammad *et al.* (2008) worked with levels of inclusion of different legumes in the ensiling of Sorghum almum Parodi and observed a pH rise from 5.3 to 5.7 in the silages with peanut levels of up to 40%.

Gas and effluent losses decreased linearly as the proportions of forage peanut in the silages were increased. Estimated reductions of 0.01 and 0.68 units, respectively, were obtained for every 1% forage peanut added (Table 3), which must be associated with the increasing dry matter content of the silages resulting from addition of the legume, as found in the present study. This directly contributed to the reduction of undesirable fermentations in the silo and promoted greater recovery of the ensiled mass DM.

Leandro *et al.* (2015) studied the epiphytic population of forage peanut silage at different fermentation periods and observed dominance of the genus *Weissela*, found in the composition of the epiphytic population of alfalfa, followed by a small participation of the genus *Pediococcus* in the final stages of fermentation. The genus *Lactobacillus*, however, appeared modestly in silages at 56 days of fermentation, and the family Enterococcaceae disappeared during fermentation; this was an expected finding, given the unfavorable conditions, i.e., pH decline after fermentation, which inhibits the growth of bacteria of this family.

CONCLUSIONS

Forage peanut silage has optimal nutritional characteristics such as high protein and low fiber contents. Ensiling elephant grass with proportions of forage peanut greater than 50% improves the nutritional value and increases the recovery of the ensiled dry matter.

REFERENCES

Andrade CMS, Garcia R, Valentim JF, Pereira OG (2012) Dynamics of sward condition, productivity, utilization efficiency and botanical composition in mixed pastures of marandugrass, forage peanut and tropical kudzu. *Braz J Anim Sci* 41: 501-511.

Andrade IVO, Pires AJV, Carvalho GGP de, Veloso CM, Bonomo P (2010) Fracionamento de proteína e carboidratos em silagens de capim-elefante contendo subprodutos agrícolas. *Rev Bras Zootec* 39: 2342-2348.

Assis GML, Valentim JF, Andrade CMS (2013) BRS Mandobi: a new forage peanut cultivar propagated by seeds for the tropics. *Trop Grasslands* 1: 39-41.

Assis GML de, Valentim JF (2009) Programa de melhoramento genético do amendoim forrageiro: avaliação agronômica de acessos no Acre. *Amazônia: Ciência e Desenvolvimento* 4: 207-215.

Azevedo JMA, Assis GML, Saggin Junior OJ, Azevedo HSFS (2014) Riqueza e frequência de espécies de fungos micorrízicos arbusculares em genótipos de amendoim forrageiro no Acre, Norte do Brasil. *Acta Amazônica* 44: 157-168.

Miranda EM, Silva EMR, Saggin Jr OJ. (2016) Mycorrhizal inoculation and phosphate fertilizer in the production of seedlings of the forage peanut. *Revista Ciência Agronômica* 47: 240-246.

Balzon TA, Valentim JF, Andrade CMS. Efeito do material propagativo e de métodos de plantio na produção de biomassa e de sementes do *Arachis pintoi* Ap 65. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 42. 2005, Goiânia. *Anais...* Goiânia: Sociedade Brasileira de Zootecnia, 2005.

Barrett K, Valentim J, Turner BL (2013) Ecosystem services from converted land: the importance of tree cover in Amazonian pastures. *Urban Ecosystems* 16: 573-591.

Barcellos AO, Ramos ABK, Vilela L, Martha Júnior GB. (2008) Sustentabilidade da produção animal baseada em pastagens consorciadas e no emprego de leguminosas exclusivas, na forma de banco de proteína, nos trópicos brasileiros. *Rev Bras Zootec* 37: 51-67.

Cavali J, Valentim JF, Gomes SES, Andrade CMS. Produção de matéria seca de amendoim forrageiro sob diferentes alturas e intervalos de corte. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 39, Recife, PE, 2002. *Anais...* Recife, 2002.

Detmann E, Valente EEL, Batista ED, Huhtanen P (2014a) An evaluation of the performance and efficiency of nitrogen utilization in cattle fed tropical grass pastures with supplementation. Livest Sci 162: 141-153.

Detmann E, Paulino MF, Valadares Filho SC, Huhtanen P (2014b) Nutritional aspects applied to grazing cattle in the tropics: a review based on Brazilian results. *Semina Ciências Agrárias* 35: 2829-2854.

Fernandes GM, Possenti RA, Ferrari Jr, Paulino VT (2011) Valor nutritivo do feno de amendoim forrageiro em diferentes idades de corte. *Bol ind anim* 68: 133-138.

Haigh PM (1990) Effect of herbage water-soluble carbohydrate content and weather conditions at ensilage on the fermentation of grass silages made on commercial farms. *Grass Forage Sci* 45: 263-271.

Hall MB (2003) Challenges with non-fiber carbohydrate methods. *J Anim Sci* 81: 3226-3232.

Jobim CC, Nussio LG, Reis RA, Schmidt P (2007) Avanços metodológicos na avaliação da qualidade da forragem conservada. *Rev Bras Zootec* 36: 101-119.

Jones DIH, Jones R (1995) The effect of crop characteristics and ensiling methodology on grass silage effluent production. *J Agr Eng Res* 60: 73-81.

Jung HG. 1989 Forage lignins and their effects on fiber digestibility. *Agr J,* 81: 33-38.

Ladeira MM, Rodriguez NM, Borges I, Gonçalves LC, Saliba EOS, Brito SC, Sá LAP (2002) Avaliação do feno de *Arachis pintoi* utilizando o ensaio de digestibilidade in vivo. *Rev Bras Zootec* 31: 2350-2356.

Lascano CE. Nutritive value and animal production of forage *Arachis*. In: Kerridge PC, Hardy B. (Eds.) *Biology and Agronomy of forages Arachis*. Cali: CIAT, 1994. p.109-121.

Leandro ES, Pereira OG, Oliveira MNV, Rufino LD, Ribeiro KG. Microbial characterization of *Arachis pintoi* silage at different fermentation periods. In: INTERNATIONAL SYMPOSIUM ON FORAGE QUALITY AND CONSERVATION, IV, 2015, *Proceedings...* Piracicaba, SP: ESALQ, p.518, 2015.

Licitra G, Hernandez TM, Van Soest PJ (1996) Standardization of procedures for nitrogen fractionation of ruminant feeds. *Anim Feed Sci Tech* 57: 347-358.

McDonald P. *The biochemistry of silage*. Chichester: John Wiley & Sons, 1981. 218p.

Muhammad IR, Baba M, Mustapha A, Ahmad MY, Abdurrahman LS (2008) Use of legume in the improvement of silage quality of *Columbus grass (Sorghum almum* Parodi). *Res J Anim Sci* 2: 109-112.

Naeini SZ, Emami NK, Rowghani E, Bayat A (2014) Influence of ensiling time on chemical composition, fermentation characteristics, gas production and protein fractions of sweet sorghum silage. *Res Opin Anim Vet Sci* 4: 286-293.

Bai C, Zhang R, Jiang C, Yan R, Han J, Zhu Y, Zhang Y (2011) Characterization of carbohydrate fractions and fermentation quality in ensiled alfalfa treated with different additives. *Afr J Biotech* 10: 9958-9968.

Nascimento IS, Monks PL, Vahl LC, Coelho RW, Silva JB, Fischer V (2010) Aspectos qualitativos da forragem de amendoim forrageiro cv. Alqueire-1 sob manejo de corte e adubação PK. *Rev Bras Agrociência* 16: 117-123.

Nussio LG, Campos FP, Lima MLM. Metabolismo de carboidratos estruturais. In: Berchielli TT, Oliveira SG, Pires AV (Org.). *Nutrição de ruminantes*. 2 ed. Jaboticabal, SP: FUNEP, p. 193-238, 2011.

Oliveira PPA, Assis GML, Campana M. Yield ad forage quality of cultivars and accessions of perennial peanuts. In: INTERNATIONAL SYMPOSIUM ON FORAGE BREEDING, 3., 2011, Bonito. *Proceedings...* Bonito, 2011.

Paris W, Cecato U, Martins EN, Limão VA, Galbeiro S, Oliveira E. 2009. Estrutura e valor nutritivo da pastagem de *Coastcross*-1 consorciada com *Arachis pintoi*, com e sem adubação nitrogenada. *Rev Bras Saúde Prod Anim*, 10: 513-524.

Paulino VT, Ferrari Júnior E, Possenti RA, Lucenas TL (2009) Silagem de amendoim forrageiro (*Arachis pintoi* cv. Belmonte) com diferentes aditivos. *Bol Ind Anim* 66: 33-43.

Paulino VT, Bueno MS, Abdalla AL (2012) Composição química e compostos fenólicos em *Arachis pintoi* Belmonte. *Arch zootec* 61: 611-614.

Paulino VT, Teixiera EMC, Santos KM, Shumann AM (2012) Carbon and nitrogen stocks and forms of

N in a red dystrophic argisol grown or not with peanut forage. *Bol Ind Anim* 69: 5-5.

Ramos AKB, Barcellos AO, Fernandes FD. Gênero *Arachis*. In: Fonseca DM, Martuscello JA. (Ed.). *Plantas Forrageiras*. Viçosa, MG: Editora UFV, 2010.

Santos EC. *Características agronômicas e bromatológicas de amendoim forrageiro em diferentes intervalos de corte*. 2012. 96 f. Dissertação (Mestrado em Produção Vegetal) – Universidade Federal do Acre, Rio Branco, AC, 2012.

Silva DJ, Queiroz AC. *Análises de alimentos (métodos químicos e biológicos).* 3.ed. Viçosa, MG: Editora UFV, 2002. 235p.

Silva SP, Silva MMC (2013) Fracionamento de carboidrato e proteína segundo o sistema CNCPS. *Vet Noticia* 19: 95-108.

Valadares Filho SC, Machado PAS, Furtado T, Chizzotti ML, Amaral HF. *Tabelas brasileiras de composição de alimentos para Ruminantes*. Cqbal 3.0., 4 ed. Viçosa: UFV. Universidade Federal de Viçosa, 2015. 473p.

Valentim JF, Assis GML. Efeito da época de semeadura e de colheita na produção de sementes de *Arachis pintoi* BRA 040550 em Rio Branco, Acre. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 46. *Anais…* Maringá. Inovação científica e tecnológica em zootecnia. Brasília, DF: Sociedade Brasileira de Zootecnia: UEM, 2009. 1 CD-ROM.

Valentim JF, Andrade CMS, Mendonça HA, Sales MFL (2003) Velocidade de estabelecimento de amendoim forrageiro na Amazônia ocidental. *Rev Bras Zootec* 32: 1569-1577.

Valentim JF, Carneiro JC, Sales MFL. *Amendoim forrageiro cv. Belmonte: leguminosa para a diversificação das pastagens e conservação do solo no Acre*. Rio Branco: Embrapa-CPAF Acre, 2001. 18p. (Circular Técnica, 43).

Valentim JF. *Potencial forrageiro de acessos de Arachis sp. nas condições ambientais do Acre*. Rio Branco, AC: Embrapa – CPAF/AC, 1996, 28p. (Embrapa – CPAF/AC. Boletim de Pesquisa, 10).

Van Soest PJ. *Nutritional ecology of the ruminants.* 2.ed. Ithaca: Cornell University Press, 1994. 476p.

Van Soest PJ (1981) Limiting factors in plant residues of low biodegradability. *Agr Environ* 6: 135-143.

Woolford MK. 1984. *The silage fermentation*. New York: Marcel Dekker. 305p.

Variable	EG:PP ratio (% fresh matter)				
	100:0	75:25	50:50	25:75	0:100
Dry matter (%)	16.89	19.39	21.90	24.40	26.90
Organic matter[1]	82.74	83.10	83.46	83.82	84.18
Crude protein[1]	10.07	11.78	13.50	15.21	16.93
Ether extract[1]	1.84	1.87	1.91	1.94	1.98
Neutral detergent insoluble protein[1]	3.17	4.23	5.28	6.34	7.39
Acid detergent insoluble protein[1]	0.91	1.31	1.71	2.11	2.52
Non-fibrous carbohydrates	10.44	13.59	16.74	19.88	23.03
Neutral detergent fiber corrected for ash and protein[1]	59.79	55.07	50.36	45.64	40.92
Acid detergent fiber corrected for ash and protein[1]	38.82	37.11	35.41	33.71	32.01
Hemicellulose[1]	20.97	17.96	14.95	11.93	8.92
Lignin[1]	5.56	5.95	6.35	6.74	7.13
In vitro dry matter digestibility[1]	56.55	53.48	60.42	62.35	64.28
Indigestible neutral detergent fiber[1]	26.09	24.16	22.22	20.29	18.36

pH	5.8	5.7	5.65	5.70	5.90
Ammonia nitrogen, in % total nitrogen	0.58	0.56	0.49	0.44	0.40

[1] % dry matter.

Table I. Chemical composition, *in vitro* digestibility, and *in situ* degradability of the forage DM before ensiling, as a function of levels of elephant grass (EG) and forage peanut (*Arachis pintoi* cv. BRS Mandobi; PP).

Variable	EG:PP ratio[1]					CV (%)	Regression equation	R^2	P-value
	100:0	75:25	50:50	25:75	0:100				
Dry matter (%)	16.62	17.62	18.97	21.47	23.02	3.03	$\hat{Y}$ = 15.8143 + 0.0719 *PP	0.95	0.0001
Organic matter[1]	87.80	87.92	88.32	88.37	88.27	0.53	$\hat{Y}$ = 88.14		
Crude protein[1]	9.42	11.60	12.60	15.20	16.90	4.87	$\hat{Y}$ = 9.4435 + 0.0743 *PP	0.94	0.0001
Ether extract[1]	3.92	2.88	2.74	2.73	2.65	10.7	$\hat{Y}$ = 3.7535 – 0.0238 *PP	0.63	0.0002
Neutral detergent insoluble protein[1]	1.54	3.56	4.74	5.82	6.34	5.50	$\hat{Y}$ = 2.0280 + 0.0475 *PP	0.93	0.0001
Acid detergent insoluble protein[1]	0.79	1.42	1.68	1.89	2.14	10.6	$\hat{Y}$ = 0.9550 + 0.0126 *PP	0.85	0.0001
Non-fibrous carbohydrates	14.45	18.81	24.31	28.18	28.59	8.54	$\hat{Y}$ = 15.3426 + 0.1506*PP	0.86	0.0001
Neutral detergent fiber corrected for ash and protein[1]	60.00	54.60	48.50	42.30	40.00	4.00	$\hat{Y}$ = 59.5530 – 0.2088 *PP	0.93	0.0001
Acid detergent fiber corrected for ash and protein[1]	42.00	40.90	38.50	36.30	35.50	1.57	$\hat{Y}$ = 42.1980 – 0.0706 *PP	0.93	0.0001
Hemicellulose[1]	17.99	13.68	10.00	5.96	4.58	19.3	$\hat{Y}$ = 17.3525 – 0.1381 *PP	0.87	0.0001
Lignin[1]	5.17	6.54	7.28	7.66	8.77	5.07	$\hat{Y}$ = 5.4230 + 0.0334 *PP	0.90	0.0001
In vitro dry matter digestibility[1]	53.57	54.76	57.30	60.81	62.49	1.82	$\hat{Y}$ = 51.4125 + 0.1477 *PP	0.94	0.0001
Indigestible neutral detergent fiber[1]	25.70	25.27	22.20	20.50	20.50	5.67	$\hat{Y}$ = 25.9095 – 0.0612 *PP	0.73	0.0004
Total digestible nutrients[1]	57.43	55.47	56.22	56.96	56.41	1.43	$\hat{Y}$ = 56.50		
pH	3.85	5.33	5.47	5.45	5.48	2.76	$\hat{Y}$ = 4.0695 + 0.3362*PP	0.84	0.0001
Ammonia nitrogen, in % total nitrogen	4.31	5.99	5.54	5.08	3.96	9.05	$\hat{Y}$ = 4.64282 + 0.05275*PP – 0.00060*AM^2	0.78	0.0001

* significant at the 5% level, by the t test. [1] % dry matter.

Table II. Chemical composition of silages and regression equations adjusted for the silages as a function of increasing levels of forage peanut (*Arachis pintoi* cv. BRS Mandobi; PP) added to elephant grass (EG) grass

Variable	EG:PP ratio[2]					CV (%)	P-value	Regression equation	R^2
	100:0	75:25	50:50	25:75	0:100				
Gas losses[1]	4.22	4.32	3.72	3.52	3.20	16.5	0.0118	$\hat{Y}$ = 4.5286-0.0135*PP	0.91
Effluent losses[2]	67.15	51.22	14.17	6.30	4.25	6.23	0.0001	$\hat{Y}$ = 61.2071-0.66221*PP	0.88
Recovered dry matter[1]	89.07	90.55	94.85	95.82	96.37	0.72	0.0104	$\hat{Y}$ = 89.3643+0.7940*PP	0.87

[1] g/kg dry matter; [2] g/kg fresh matter. R^2 = coefficient of determination. P = 0.05

Table III. Mean contents for losses of dry matter from the ensiled mass and regression equations adjusted for the silages as a function of increasing levels of forage peanut (*Arachis pintoi* cv. BRS Mandobi; PP) in relation to elephant grass (EG)

Figure. Management of Forage peanut BRS Mandobi.