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Original

Fermentative profile, nutritional composition, and aerobic stability of elephant grass (*Pennisetum purpureum Schum*) and forage peanut (*Arachis pintoi*) mixed silages

Cleyton de Almeida Araújo[1]; Judicael Janderson da Silva Novaes[1]; Janiele Santos Araújo[1]; Amelia de Macedo[1]; Crislane de Souza Silva[1]; Tamiris da Cruz da Silva[1]; João Emerenciano Neto[2]; Gherman Garcia Leal de Araújo[3]; Fleming Sena Campos[4]; Glayciane Costa Gois[1]*.

[1]Universidade Federal do Vale do São Francisco, Petrolina, PE, Brazil.
[2]Universidade Federal do Rio Grande do Norte, Macaíba, RN, Brazil.
[3]Embrapa Semiárido, Petrolina, PE, Brazil.
[4]Universidade Federal do Maranhão, Chapadinha, MA. Brazil.
*Correspondencia: glayciane_gois@yahoo.com.br

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ABSTRACT

Objective. Determine the fermentative profile, proximate composition, and aerobic stability of mixed silages of elephant grass combined with levels of forage peanut. **Materials and methods.** Different levels of forage peanut (0.0, 20.0, 40.0, 60.0, and 80.0% on FM basis) were added to elephant grass silages. A completely randomized design was adopted, with 5 treatments and 3 repetitions, totaling 15 experimental silos that were opened after 30 days of sealing. Fermentative profile, proximate composition, and aerobic stability were evaluated. **Results.** The increase in the forage peanut levels in the elephant grass silages promoted a increasing on porosity, permeability, density, and pH ($p<0.001$). A 0.58 reduction in Flieg index for every 1% forage peanut added to the elephant grass silage was observed ($p<0.001$). The sum of the silage temperature difference compared to the environment ($p=0.032$) and aerobic stability ($p<0.001$) showed a quadratic effect. The forage peanut inclusion in elephant grass silages reduced the dry matter, organic matter, neutral and acid detergent fiber, hemicellulose, cellulose, and total carbohydrates ($p<0.05$) and increased the mineral matter, crude protein, lignin, non-fibrous carbohydrates, and total digestible nutrients ($p<0.05$). **Conclusions.** Under the experimental conditions, recommend the inclusion of up to 40% forage peanut combined with elephant grass to compose mixed silages, due to the better fermentative dynamic, nutritional profile, and aerobic stability.

Keywords: *Arachis pintoi*; heating capacity; forages preservation; tropical forages (*Source: CAB*).

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RESUMEN

Objetivo. Determinar el perfil fermentativo, composición centesimal y estabilidad aerobia de ensilajes mezclados de hierba-elefante combinadas con niveles de maní forrajero. **Materiales y métodos.** Distintos niveles de maní forrajero (0,0, 20,0, 40,0, 60,0 y el 80,0% en la base de la materia fresca) se adicionaron a los ensilajes de hierba-elefante. Se adoptó el delineamento enteramente casualizado, con 5 tratamientos y 3 repeticiones, totalizando 15 silos experimentales que se abrieron tras 30 días de sellados. Perfil fermentativo, composición centesimal y estabilidad aerobia. **Resultados.** Se evaluaron el aumento de los niveles de maní forrajero en los ensilajes de hierba elefante promovió aumento en la porosidad, permeabilidad, densidad y pH (p<0.001). Se observó reducción de 0.58 en el índice de Flieg para cada 1% de maní forrajero adicionado al ensilaje de hierba -elefante (p<0.001). La suma de la diferencia de temperatura del ensilaje con relación al ambiente (p=0.032) y estabilidad aerobia (p<0.001) presentó efecto cuadrático. La inclusión de maní forrajero en los ensilajes de hierba elefante redujo la materia seca, materia orgánica, fibra en detergente neutro y ácido, hemicelulosa, celulose y carbohidratos totales (p<0.05) y aumentó la materia mineral, proteína bruta, lignina, carbohidratos no fibrosos, y nutrientes digestibles totales (p<0.05). **Conclusiones.** En las condiciones experimentales, se recomienda la inclusión de hasta el 40% de maní forrajero combinado con hierba elefante para componer ensilajes mezclados, debido a la mejor dinámica fermentativa, perfil nutricional y estabilidad aerobia.

Palabras clave: *Arachis pintoi*; capacidad de calentamiento; preservación de forrajes; forrajeros tropicales (*Fuente: CAB*).

INTRODUCTION

The use of legumes in ruminants feeding can contribute to increasing the efficiency of the production system, as it provides a low-cost protein input, reducing the need to include other sources of this nutrient (1). Forage peanut (*Arachis pintoi* cv. Belmonte) is successfully used in intercrop pasture systems, monoculture, hay production, or even as a protein bank. This specie is adapted to low-fertility soils and is persistent as submitted to grazing (2). However, there are few studies that evaluate the use of forage peanuts in the silages composition.

The use of legumes in silage production promote improvements in the nutritional quality and fermentation profile, especially as associated with grass (3). However, it is necessary to determine the ideal inclusion level of each species. The elephant grass points out due to its rusticity and productivity, being widely used in ensiling process due to its proximate composition (22.9% dry matter and 73.1% neutral detergent fiber) (4).

Elephant grass is widely used in silage, however, problems related to losses during the fermentation process reduce the silage nutritional quality with losses of the plant's most digestible part, elevating the fibrous fractions and minerals components during the effluent's percolation (5). In this sense, Pacheco et al (6) observed improvements in the elephant grass silage by including 20% gliricidia hay, with reduced losses and increased dry matter and protein content. In this sense, it was hypothesized that the use of forage peanuts to compose elephant grass mixed silages may improve the nutritional profile and reduce the fermentation losses by increasing aerobic stability.

Therefore, the aim of this study was to evaluated the fermentation profile, proximate composition, and aerobic stability of mixed silages of elephant grass combined with levels of forage peanut.

MATERIALS AND METHODS

Location. The experiment was conducted at Universidade Federal do Vale do São Francisco (UNIVASF), Pernambuco, Brazil (9º 19′ 28″ South latitude, 40º 33′ 34″ West longitude, 393m altitude).

Design and silages production. Levels of forage peanuts inclusion (0.0, 20.0, 40.0, 60.0, and 80.0% on fresh matter basis)) were evaluated in elephant grass silage, in a completely randomized experimental design, with 5 treatments and 3 repetitions, totaling 15 experimental silos.

Elephant grass (cv. Cameron) used for making the silages came from a planted grass field and harvested after 60 days of regrowth, cut manually at 10 cm from the ground. The forage peanut came from an experimental area used as a protein bank, established for 4 years ago, being manually harvested after 75 days of regrowth and cut at 10 cm from the ground. The harvested material was processed in a forage chopper. Samples of elephant grass and forage peanuts were evaluated for average particle size (Table 1) using the State Particle Size Separator (SPSS), with diameters of 19.0 to 4.0 mm of porosity and a bottom box (7) (Table 1).

Table 1. Particles and proximate composition of elephant grass and forage peanut before ensiling.

	Elephant grass	Forage peanut
Particle size		
>19 mm	24.23	46.58
9 – 19 mm	47.15	42.02
4 – 8 mm	15.43	5.52
< 4 mm	12.07	4.36
Proximate composition (g/kg DM)		
Dry matter*	291.91	234.06
Mineral matter	66.12	88.69
Organic matter	933.88	911.31
Ether extract	31.87	27.77
Crude protein	59.39	214.39
Neutral detergent fibre	761.08	509.04
Acid detergente fibre	448.88	308.05
Hemicellulose	312.20	200.99
Cellulose	412.50	262.18
Lignin	36.38	45.87
Total carbohydrates	842.62	669.15
Non-fibrous carbohydrates	81.54	160.11
Total digestible nutrients	345.65	522.07

DM- Dry matter; *in g/kg fresh matter

The material was manually mixed according to the treatment levels and ensiled in silos equipped with a Bunsen valve to allow the exit of gases from fermentation. For drainage of effluents, 1 kg dry sand was deposited at the bottom of the experimental silos, protected by a cotton tissue, avoiding contact between the ensilage mass and the sand. Once sealed, the silos remained for 30 days in a covered shed.

Silages density and fermentation losses determination. Silos were weighed empty, after ensiling and weighed again at their opening, after 30 days. The silage mass density was determined by the equation:

$$D = m/V$$

where: D = density; m = weight of the silage material; V= silage volume. The experimental silos volume was obtained by the equation:

$$V = \pi \times r^2 \times h$$

where: V= volume (cm^3); π= 3.14; r^2= silos ray in cm; h= silos ray in cm. After this, data were converted in cubic meters and kilogram, respectively, to express density as kg/m^3.

The effluent losses (EL), gas losses (GL), and dry matter recovery (DMR) were estimated according Amorim et al. (8). The permeability (*K,* in μm^2) was estimated by Williams (9), and silage porosity (POR, in μm) was determined by van Verseveld and Gebert (10).

Fermentation profile. For the evaluation of the fermentation profile, the internal temperature (T, in °C), and the temperature of the silo panel (TP, in °C) was measured at the time of opening with the aid of a digital infrared thermometer (Benetech, Rio de Janeiro – RJ, Brazil).

pH, maximum pH recorded after opening the silos (maximum pH), final pH, time to reach maximum pH (maximum TpH, in hours), maximum temperature after opening the silos (MT, in °C), time to reach maximum temperature (TMT, in hours), the maximum difference between silage temperature and the environment temperature (DTS, in °C), the sum of the maximum difference of the silage temperature with the environment (ΣDT, in °C), and the time for the silage temperature showing an upward trend (STUT, in hours) were analyzed according to Jobim et al. (11).

Flieg index. The Flieg index was calculated by the equation (12):

$$\text{Flieg index} = [220 + (2 \times \%DM - 15) - 40 \times pH]$$

where: DM= dry matter. The point was interpreted by the following scores: Worst quality silages (score < 20.0); bad silages (score between 21.0 and 40.0); mild quality silages (score between

41.0 and 60.0); good silages (score between 61.0 and 80.0), and excellent silages (score > 81.0).

Aerobic stability. Aerobic stability (AS, in hours) was assessed following the methodology of Costa et al. (13): The internal temperature of the silages was measured at 1-h intervals for 120 hours. During the stability test, the pH was monitored at 6-hour intervals until 96 hours of air exposure (14).

Heating capacity. Silages heating was quantified as degrees-day by the equation (15):

$$°AHD = \sum [(T_{máx} + T_{mín}) /2] - T_{amb}$$

where: °AHD= accumulated heating degrees-day; $T_{máx}$= Daily maximum temperature; $T_{mín}$= Daily minimal temperature; T_{amb}= Mean environmental temperature.

Proximate composition. Samples were pre-dried in a forced ventilation oven at 55ºC for 72-h and processed in a knife mill, using 1 mm sieves. Proximate analyses were made according to the AOAC (16) to determine the dry matter (DM), mineral matter (MM), crude protein (CP), ether extract (EE) and acid detergent fiber (ADF). Neutral detergent fiber (NDF), lignin (LIG), hemicellulose (HEM) and cellulose (CEL) were determined according to Van Soest et al. (17). Total carbohydrates (TC) were estimated by Sniffen et al (18). Non-fibrous carbohydrates (NFC) content were calculated by Hall (19), and Total digestible nutrients (TDN) were estimated by Horst et al (20).

Statistical analysis. A descriptive analysis of temperature and pH peaks during aerobic stability was performed according to Wilkinson and Davies (21). Data were subjected to analysis of variance (ANOVA) and regression at 5% probability for type I error. The significance of the models estimated parameters and determination coefficients were the criterion to select the regression models.

RESULTS

The forage peanut inclusion of elephant grass silages modified the silages' physical features promoting a growing linear effect ($p<0.001$) on silages POR and *K*, with a 0.05 µm and 1.39 µm^2 growth for the variables, respectively, for each 1% of forage peanut included (Table 2).

Table 2. Losses and fermentative profile of elephant grass silages with forage peanuts inclusion levels.

Items	Forage peanuts levels (%)					SE	*P value*	
	0	20	40	60	80		L	Q
GL	21.34	22.94	21.85	21.96	23.16	0.96	0.406	0.913
EL	26.69	33.84	22.10	48.22	20.16	10.46	0.969	0.425
DMR	90.26	90.39	92.21	89.62	92.18	1.50	0.533	0.938
POR[1]	71.05	71.87	72.92	74.25	75.36	0.36	<0.001	0.551
K[2]	835.90	837.15	909.45	912.93	937.66	10.55	<0.001	0.592
D[3]	398.60	391.64	453.61	443.76	457.51	8.53	<0.001	0.364
pH[4]	3.48	3.77	4.13	4.19	4.45	0.10	<0.001	0.362
T	27.83	27.50	28.16	27.50	27.83	0.25	0.998	0.998
TP[5]	24.00	24.00	24.16	25.33	25.50	0.10	<0.001	0.007

GL- Gas losses (% Dry matter), EL- Effluent losses (kg/t Natural matter), DMR- Dry matter recovery (% Dry matter), POR- Porosity (µm), *K*- Permeability (µm^2), D- Density (kg/m^3), pH- Hydrogenionic potential, T- Temperature (°C), TP- Temperature of the silo panel (°C), SE- Standard error, L- Linear, Q- Quadratic. Significance at 5% of probability.
[1]$\hat{y}$= 70.8987 + 0.0549x, R^2= 0.99; [2]$\hat{y}$= 830.7645 + 1.3965x, R^2= 0.88; [3]$\hat{y}$= 395.0427 + 0.8497x, R^2= 0.73; [4]$\hat{y}$= 3.5333 + 0.0118x, R^2= 0.96; [5]$\hat{y}$= 23.7333 + 0.0217x, R^2= 0.83.

There was a growing linear effect of the forage peanut included on the silages density. Each 1% of peanut inclusion increased the silage density by 0.849 kg/m^3 ($p<0.001$; Table 2). The forage peanut inclusion in the elephant grass silage did not alter the GL, EL, and DMR ($p<0.05$; Table 2).

Silages pH increased linearly as including the forage peanut to the elephant grass silages ($p<0.001$; Table 2). Silage temperature was not affected ($p=0.998$) by the forage peanut inclusion, however, the temperature of the silo panel showed a increasing ($p< 0.001$), estimating a 0.02 °C increase per each 1% forage peanut included in the elephant grass silage (Table 2).

A linear reduction in the Flieg index, with a 0.58 decrease on the Flieg scale per each 1% of forage peanut inclusion to the elephant grass silage ($p< 0.001$; Figure 1).

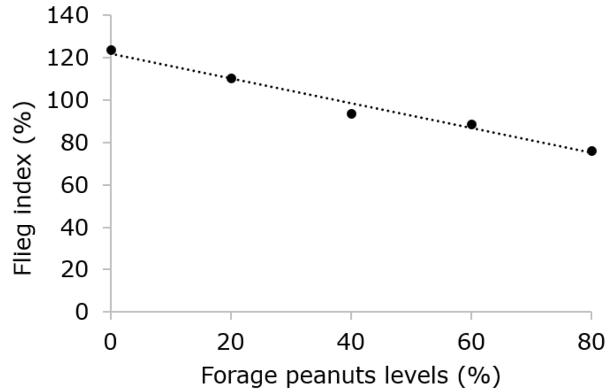

Figure 1. Flieg index in elephant grass silages with forage peanuts inclusion levels ($\hat{y}= 121.8500 - 0.5831x$; $R^2= 0.98$; $p<0.001$)

The forage peanut levels provided a quadratic effect to the silages final pH ($p< 0.001$), with a increase of 25.34% for the 80% (4.55) inclusion forage peanut, as compared to the exclusive elephant grass silage - 0% forage peanut inclusion (3.63) (Table 3).

Table 3. Aerobic stability of elephant grass silage with forage peanuts inclusion levels.

Items	Forage peanuts levels (%)					SE	P *value*	
	0	20	40	60	80		L	Q
Maximum pH	3.95	4.75	4.75	4.26	4.61	0.16	0.145	0.050
Final pH[1]	3.63	3.77	4.11	4.22	4.55	0.06	<0.001	0.512
TM	27.16	26.83	26.50	27.16	26.83	0.29	0.731	0.391
FT[2]	26.83	26.83	26.50	26.16	25.50	0.25	0.002	0.198
TMT[3]	30.66	30.66	4.00	4.00	4.00	4.21	<0.001	0.099
DTS	4.00	2.66	2.50	2.50	2.50	0.47	0.060	0.139
ΣDT[4]	44.83	34.83	28.73	32.83	33.50	3.38	0.044	0.032
AS[5]	28.00	24.00	48.00	24.00	24.00	0.89	0.018	<0.001

TM- Maximum temperature (°C), FT- Final temperature (°C), TMT- time to reach maximum temperature (h), DTS- maximum difference between silage temperature and the environment temperature (°C), ΣDT- sum of the maximum difference of the silage temperature in relation to the environment (°C), AS- Aerobic stability (h), SEM- Standard error, L- Linear, Q- Quadratic. Significance at 5% of probability.
[1]$\hat{y}= 3.6020 + 0.0114x$, $R^2= 0.97$; [2]$\hat{y}= 27.0333 - 0.0167x$, $R^2= 0.89$; [3]$\hat{y}= 30.6667 - 0.4100x$, $R^2= 0.74$; [4]$\hat{y}= 44.3848 - 0.5738x + 0.0056x^2$, $R^2= 0.92$; [5]$\hat{y}= 25.4857 + 0.5314x - 0.0071x^2$, $R^2= 0.47$.

The FT increased linearly with the forage peanut inclusion ($p=0.002$), displaying a 0.01°C increase per each 1% forage peanut included. The forage peanut inclusion did not affect the maximum pH, MT, and DTS ($p>0.05$; Table 3). TMT displayed a decreasing, anticipating by 0.41 hours the TMT silage per each 1% forage peanut included in the elephant grass silage ($p<0.001$; Table 3).

There was a quadratic effect ($p=0.032$) on ΣDT, with a 35.91% reduction as the 40% forage peanuts inclusion (28.73°C), compared to the 0% inclusion (44.83°C). Aerobic stability displayed quadratic effect ($p<0.001$), with higher stability (48 hours) for the silages containing 40% of forage peanut in its composition, and a 20 hours delay in silage deterioration as compared to the silages containing exclusively elephant grass (28 hours) (Table 3).

The AHD linearly reduced, with a reduction in 0.005°C silage accumulated heating per each 1% of forage peanut included ($p=0.039$; Figure 2).

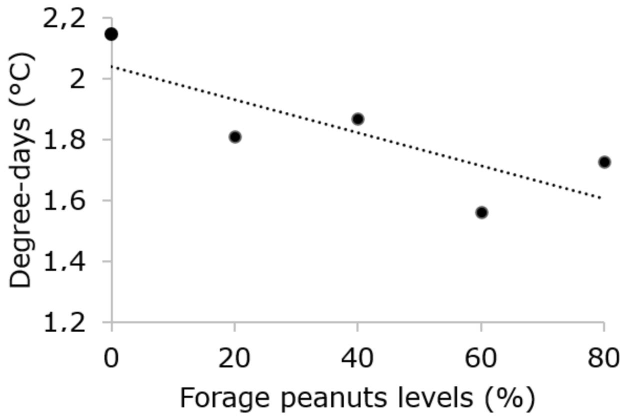

Figure 2. Accumulated degree-days heating in aerobic stability elephant grass silages with forage peanuts inclusion levels ($\hat{y}= 2.0408 - 0.0054x$; $R^2= 0.64$; $p= 0.039$).

The forage peanut levels displayed temperature peaks preceding the silage deterioration. The 0, 20, 60, and 80% levels displayed peaks between 25 and 40 exposition hours (Figure 3A). Only the 60% peanut silage displayed two pH elevation peaks during the oxygen exposition (Figure 3B).

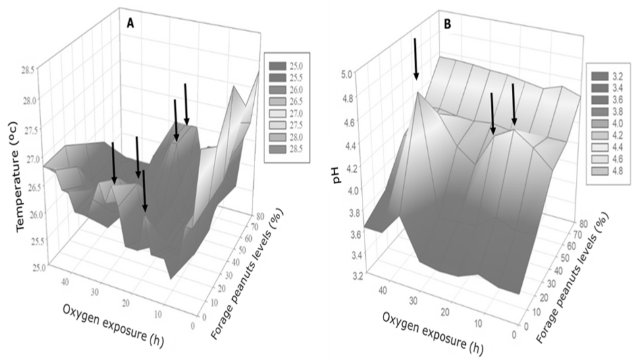

Figure 3. Distribution of temperature (A) and pH (B) elevations of elephant grass silages with forage peanuts inclusion levels during aerobic stability.

The forage peanut inclusion reduced DM, NDF, ADF, HEM, CEL, and TC contents ($p<0.001$; Table 4), and increased MM ($p=0.001$), CP ($p<0.001$), LIG ($p=0.001$), NFC ($p<0.001$), and TDN ($p<0.001$) contents in the elephant grass silages (Table 4).

Table 4. Proximate composition of elephant grass silage with forage peanuts inclusion levels.

Itens g/kg DM	Forage peanuts levels (%)					SE	P *value*	
	0	20	40	60	80		L	Q
DM*[1]	289.43	281.20	270.75	257.41	246.81	3.69	<0.001	0.592
MM[2]	64.29	66.86	70.74	67.91	77.74	1.75	0.001	0.261
EE[3]	19.72	26.61	22.04	25.73	23.98	0.70	0.007	0.007
CP[4]	66.27	88.56	93.01	106.81	141.31	5.03	<0.001	0.103
NDF[5]	800.22	721.46	688.91	645.44	577.69	10.52	<0.001	0.784
ADF[6]	519.50	479.89	464.30	415.24	377.60	13.13	<0.001	0.561
HEM[7]	280.72	241.57	224.61	230.20	183.51	11.85	<0.001	0.870
CEL[8]	480.28	439.81	423.34	372.47	334.94	12.74	<0.001	0.563
LIG[9]	39.21	40.07	40.96	42.77	43.16	0.73	0.001	0.995
TC[10]	849.72	817.96	814.21	799.55	756.96	5.24	<0.001	0.128
NFC[11]	49.50	96.50	125.30	154.11	179.28	11.41	<0.001	0.331
TDN[12]	318.25	417.54	396.16	426.59	474.02	7.36	<0.001	0.784

*g/kg Natural matter MM- Mineral matter, EE- Ether extract, CP- Crude protein, NDF- Neutral detergent fiber, ADF- Acid detergent fibre, HEM- Hemicellulose, CEL- Cellulose, LIG- Lignin, CT- Total carbohydrates, NFC- Non-fibrous carbohydrates, TDN- Total digestible nutrients, SE- Standard error, L- Linear, Q- Quadratic. Significance at 5% of probability.
[1]$\hat{y}= 290.9307 - 0.5453x$, $R^2= 0.99$; [2]$\hat{y}= 63.9153 + 0.1398x$, $R^2= 0.73$; [3]$\hat{y}= 20.7997 + 0.1673x - 0.0016x^2$, $R^2= 0.37$; [4]$\hat{y}= 65.5287 + 0.8446x$, $R^2= 0.92$; [5]$\hat{y}= 790.9613 - 2.6054x$, $R^2= 0.98$; [6]$\hat{y}= 520.9933 - 1.7422x$, $R^2= 0.98$; [7]$\hat{y}= 273.2833 - 1.0290x$, $R^2= 0.86$; [8]$\hat{y}= 481.7753 - 1.7901x$, $R^2= 0.98$; [9]$\hat{y}= 39.120 + 0.0529x$, $R^2= 0.96$; [10]$\hat{y}= 848.4660 - 1.0196x$, $R^2= 0.91$; [11]$\hat{y}= 57.5033 + 1.5859x$, $R^2= 0.98$; [12]$\hat{y}= 324.7260 + 1.8208x$, $R^2= 0.98$.

DISCUSSION

Physical characteristics, such as Dens and POR modulated the oxygen penetration rate in the silage mass (12). In turn, Dens and DM influence *K* deeply. Higher Dens and DM entail lower *K* (9), but the present research did not point out this effect due to the reduction of silage DM level. Densities between 350 and 450 kg/m³ can result in K from 275 to 375 µm² (9) being lower than the K estimated in this study.

On the other side, silages' Dens increased by the peanut inclusion. This result was expected: humidity increase involves better particles aggregations as compared to higher DM levels silages. *K* and POR increases influenced the aerobic silages stability (12), inducing higher oxygen diffusions, allowing the aerobic microorganisms to develop. Borreani et al. (22) found that porosity of 35.00 to 75.00 µm can be found in silages with DM content between 300 to 600 g/kg based on natural matter. This result does not corroborate the findings of the present research, in which even the silages with DM contents between 246.81 and 289.43 g/kg based on natural matter (Table 4), presented porosity within the range established by Borreani et al (22).

Silages pH increased as the forage peanuts inclusion. This effect was expected due to the legumes buffering capacity, their high orthophosphate and organic acid salts levels, and high protein rate, factors responsible for a forage crop buffering capacity (23). The inclusion of forage peanuts from 40% provided the silages with pH values within the range considered adequate for properly fermented silages (3.8 to 4.2) (24). This result differs from the findings by Gomes et al (25) who observed that levels from 25% of forage peanut in Marandu grass silages provided the silages with pH values within the established limits.

The highest pH was observed in the 80% forage peanut silage (4.45). Even if the silage displayed, this 27.87% pH elevation as the control of the silages, displayed low pH (below 5.00) to inhibit enterobacteria growth and development (26). According to Liu et al (27), some fungi and yeasts can grow at relatively low pH values, however a pH below 4.5 inhibits the development of these microorganisms and reduces silage's deterioration.

The temperature increase is a reflex of the biological activity and fermentation inside the silos. Temperature rise as the forage peanut inclusion indicates an increase of the aerobic phase inside the silo. As oxygen runs out, the temperature tends to reduce (28). Azevedo et al (29) when working with elephant grass silage with inclusion levels of *Moringa oleifera*, observed temperatures between 28 and 29°C, being higher than those observed in this study (24– 25.5°C).

Flieg index demonstrated that silages with up to 60% forage peanut inclusion have excellent quality (score > 81.0) according to Dong et al (12). On the other side, the silage with 80% peanut displayed good fermentation, with a Flieg index between 61–80 (30). Legumes silages usually display Flieg indexes of about 60.00, characterized as silages with a jeopardized preservation (23).

The aerobic microorganisms' activation begins during the silage oxygen exposition. These bacteria multiply and prevail in the medium by the residual carbohydrates consumption and the products of the aerobic fermentation, such as the lactic acid (31). In this sense, the activity of the aerobic microorganisms increases associates with pH, temperature, and carbon dioxide increase. As silages are exposed to oxygen, their final pH increased. Nascimento et al (32) when evaluating the pH of corn silages during exposure to oxygen, they observed a gradual increase in pH during the exposure period, going from a pH of 3.5 (first 24 hours of exposure) to 6.5 (the 144 hours of exposure). The pH elevation is associated with the silage oxygenation process: as this process is activated, the yeasts' metabolism reboots (succinic and lactic acids), causing a pH increase (28).

Temperature increase derives from the biological activity that produces heat and carbon dioxide. Oxygen diffusion also allows a higher silos aeration by the silage *K* and POR increase. The peanuts inclusion reduced the silages' heating capacity. This effect is derived from the silage DM reduction, promoting higher humidity and increasing the heat required to warm a water molecule up. The AS increase observed in silages with 40% forage peanut inclusion may associate with the lactic acid production increase (23), as disorders in the acetic acid and lactic acid fermentation and production can reduce the aerobic stability (21). Aerobic stability was superior to that found by Amaral et al (33) with an aerobic stability of elephant grass exclusive silage of 21.2 hours, with a maximum recorded temperature of 33.8°C and a TMT of 33.1 hours.

The accumulated heating degrees-day in stability displayed reduction, fact also observed by Ziech et al (34), who observed a reduction in degrees-day as the proportions of forage peanuts in association with Coastcross and Tifton - 85 grasses were increased. The reduction in degree days may have been related to the temperature peaks observed during the silage exposure to the aerobic medium. The deterioration is initially demonstrated by the temperature rise (35). During the temperature elevations, it is possible to observe that the first temperature elevation is associated with the yeasts and acetic acid-producing bacteria activity, which induced the pH rise. After the first temperature peak, the second rise derives from the fungi activity (21).

Silages' nutritional composition derives from the nutritional quality of the isolated ingredients. Similar to the present study, Carvalho et al (36), found that the inclusion of 30% forage peanut in corn and sorghum silages reduced the DM content compared to the control treatments. The DM reduction are associated with higher forage peanuts in the silage process (Table 1).

The mean values observed for MM increased with the presence of forage peanut in the composition of the silages. This increase in MM contents is due to the greater proportion of this component in the nutritional composition of forage peanut. in relation to elephant grass (Table 1). This fact was also observed by Nurhayu et al (37) when associating a legume (*Indigofera* sp.) with elephant grass in the production of silages. The authors noted that at increasing levels of up to 60% of *Indigofera* sp. increased the MM of elephant grass silages (159.5 g/kg DM) compared to the control treatment (143.9 g/kg DM).

The silages containing forage peanut had the highest EE values compared to the silage containing 100% elephant grass (0% forage peanut). According to Carvalho et al (36), the association of cultures helps to balance the energy value of silage, which is important in rumen fermentation, fiber digestibility and passage rate. Similar values of EE were found by Chen et al (38) evaluating low dry matter silages produced with mixtures of 75% sweet sorghum and 25% alfalfa in relation to the highest value (26.21g/Kg DM) obtained in the present study at the level of 20% forage peanut and 80% of elephant grass (26.21 g/kg DM)

The nutritional composition of elephant grass silage was improved with the inclusion of forage peanut due to the higher concentration of CP in this forage plant (214.39 g / kg DM; Table 1). This association provided the silages with crude protein values above the minimum necessary to ensure adequate rumen fermentation, which is 7% according to Pereira et al (24), reinforcing the positive contributions of the presence of forage peanut in the chemical composition of elephant grass silages. Gomes et al (25) also reported linear increases in CP content in *Urochloa brizantha* cv. Marandu with addition of forage peanuts to the silages. Also, the protein amount preservation associates with the silage pH: the faster the pH was reduced and reached below 4.0 levels, the better the silage protein and carbohydrates content preservation (39).

On the other side, the fibrous silage fraction reduced as increasing the forage peanut. Lima et al (40) evaluating peanut cake concentrations in masai grass silage also observed that the increase in peanut cake levels in silages reduced NDF, ADF, cellulose and hemicellulose contents in relation to silage containing 100% Masai grass (0% peanut cake). The reduction of these components is associated with the organic acids produced during fermentation, hydrolyzing the more digestible cell wall during silage.

The LIG content increase is an undesirable nutritional feature, affecting the lignocellulose biodegradation (41). The increase in LIG contents corroborates the increases observed by Gomes et al. (25) when including forage peanut levels in the composition of *U. brizantha* cv. Marandu (palisade grass).

The TC content was reduced with the increase of forage peanut contents in the silages. Chen et al (38) observed a similar behavior to the present study with a reduction in TC (770.1 to 370.5 g kg DM) in a study of mixed silages with alfalfa and sweet sorghum (0, 25, 50.75 and 100%). The TC reduction may have occurred due to the cell wall catabolism process. This conversion aims to provide more substrate with fermentative potential (such as glucose) for the lactic acid bacteria (42), which also causes a NFC increase.

The increase in the NFC content of elephant grass silages with the addition of forage peanut levels is due to the high NFC content in the composition of forage peanut (160.11 g/kg DM) compared to elephant grass (81.54 g/kg DM) (Table 1). According to Serra-Ferreira et al (43), NFCs are considered soluble and highly digestible, contributing to the increase in the nutritional value of silages. When the NFC content is high, it means that there is a high amount of starch and sugars. This fact is relevant because they are nutrients that make the food rich in energy (44). However, according to Serra-Ferreira et al (43) this increase in nutritional value will still depend on the action of homo or heterofermentative microorganisms and the products generated during fermentation (water, heat, CO_2, alcohol, lactic, acetic, propionic and butyric acids).

The increase in TDN content is associated with the presence of forage peanut in the composition of elephant grass silages. These values are lower than those found by Zhang et al (45) with a reduction from 730.35 to 664.62 g/kg DM and reported by Chen et al (38) with an increase from 659.3 to 753.8 g/kg DM of TDN, both authors using levels of alfalfa added to sorghum silage.

In conclusion, under the experimental conditions, recommend the inclusion of up to 40% *Arachis pintoi* combined with *Pennisetum purpureum* to compose mixed silages, due to the better fermentative dynamic, nutritional profile, and aerobic stability.

Conflict of interest

The author declares that he has no competing financial interests or personal relationships that could have influenced the work reported in this document.

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