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Chemical composition and fermentative characteristics of old man saltbush silage supplemented with energy concentrates

Composição química e características fermentativas de silagem de erva sal aditivadas com concentrados energéticos

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Abstract

The objective of this study was to evaluate the fermentation profile and chemical composition of old man saltbush (*Atriplex nummularia* Lindl.) silage supplemented with cassava (*Manihot esculenta* Crantz) scraps or grain sorghum (*Sorghum bicolor*) in the proportion of 10% based on natural matter. The experimental design was completely randomized, in a 3 x 7 factorial arrangement (3 treatments and 7 opening days), with three replications. The treatments consisted of three silages: old man saltbush silage, old man saltbush silage + cassava scrap, and old man saltbush silage + grain sorghum. The experiment was conducted at the EMBRAPA Semiarid Animal Nutrition Laboratory, located in the city of Petrolina-PE. Twenty-one experimental silos were used for each treatment; these silos were opened after 1, 3, 5, 7, 14, 28, and 56 days in ensiling. The pH, ammoniacal nitrogen and total nitrogen ratio, dry matter, crude protein, ether extract, mineral matter, organic matter, neutral detergent fiber, acid detergent fiber, total carbohydrates, non-fibrous carbohydrate, and dry matter in vitro digestibility. The additives grain sorghum and cassava scrap increased the dry matter content and reduced pH values. $N\text{-}NH_3\ NT^{-1}$ values increased as the fermentation processes progressed, and after 56 fermentation days were close to 11%. Silages were classified as excellent in the fermentation process. The addition of cassava scrap and grain sorghum favors the ensiling process of the old man saltbush, providing improvements in the silage nutritive value. During the storage period, the use of these additives promoted a reduction of total losses, inhibition of alcoholic fermentation, and greater carbohydrates recovery, resulting in silage with a nutritive value similar to that of fresh forage, representing an alternative source of additives.
Key words: Foodstuffs. Forage conservation. Semi-arid. Supplementation.

Resumo

Objetivou-se com este trabalho avaliar o perfil fermentativo e a composição química da silagem de erva sal (*Atriplex nummularia* Lindl.) aditivada com raspa de mandioca (*Manihot esculenta* Crantz) ou sorgo grão (*Sorghum bicolor*) na proporção de 10% com base na matéria natural. O delineamento experimental

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foi o inteiramente casualizado, em arranjo fatorial 3 x 7, (3 tratamentos e 7 dias de aberturas), com três repetições. Os tratamentos constituíram-se de três silagens: silagem de erva sal, silagem de erva sal + raspa de mandioca e silagem de erva sal + sorgo grão moído. O experimento foi conduzido no laboratório de Nutrição Animal da Embrapa Semiárido, localizada no município de Petrolina-PE. Para cada tratamento foram utilizados 21 silos experimentais que foram abertos aos 1, 3, 5, 7, 14, 28 e 56 dias de ensilagem. Foram determinados o pH, nitrogênio amoniacal em relação ao nitrogênio total, matéria seca, proteína bruta, extrato etéreo, matéria mineral, matéria orgânica, fibra em detergente neutro, fibra em detergente ácido, carboidratos totais, carboidrato não fibroso e digestibilidade *in vitro* da matéria seca. Os aditivos: sorgo grão e raspa de mandioca elevaram o teor de matéria seca e reduziram os valores de pH. Os valores de $N\text{-}NH_3$ NT^{-1} aumentaram com o decorrer dos processos fermentativos e após 56 dias de fermentação foram próximos a 11%. No processo fermentativo as silagens foram classificadas como excelentes. A adição da raspa de mandioca e do sorgo grão favorece o processo de ensilagem da erva sal proporcionando melhorias no valor nutritivo da silagem. Durante o período de conservação, a utilização desses aditivos promove redução das perdas totais, inibição da fermentação alcoólica e maior recuperação de carboidratos, resultando em silagem com valor nutritivo semelhante ao de forragem fresca, caracterizando assim como uma fonte alternativa de aditivos.
Palavras-chave: Alimentos. Conservação de forragem. Semiárido. Suplementação.

Introduction

In the semi-arid regions of northeastern Brazil, the scarcity of food and its low nutritional value, mainly due to rainfall irregularities, are some of the problems that compromise the development of animal production. Small farms in the semi-arid region obtain water through cisterns, wells, underground dams or small dams. About 100,000 wells have been drilled to meet the diverse needs of the human and animal populations (MARTINS; NOGUEIRA, 2015).

The use of groundwater is often unfeasible because of a large amount of salts dissolved by the weathering of crystalline rocks, requiring desalination to make the spring viable, providing good quality water. However, this technology generates residues with high salt concentration, because to obtain a certain volume of desalinated water, another volume of saline waste is produced. This residue can be placed in evaporation basins to obtain salt, used in the production of aquatic animals, and for the irrigation of halophytes with forage potential which, besides serving as livestock feed, can help to preserve the regional environmental balance (SANTOS et al., 2010a).

Halophytes are adapted to elevated levels of soil salinity and have the capacity to accumulate high amounts of salts in their tissues through the process of phytoextraction of salts in sodium soils. To do so, the plant must be tolerant to salt excess and high biomass production in this condition. In addition, it must accumulate high salt levels in the aerial part, so that salts can be removed with the plant harvest (PEDROTTI et al., 2015). Because the old man saltbush has high salt content, it can be a reliable source of minerals to meet the demands of ruminants in semi-arid conditions (VALE; AZEVEDO, 2013). The high digestibility coefficient and protein content in its leaves make it a potential resource of nutrient supply, especially during the forage shortage period, and these nutrients can be converted into noble products such as meat, milk, and skin.

The use of preserved forages, especially in the form of silage, is a viable alternative to ensure the provision of high-quality forage during the feed shortage period. The process is based on the fermentation and concomitant production of organic acids responsible for pH reduction and food preservation (COUTINHO et al., 2015). However, the fermentation process is complex, involving chemical and microbiological variations in the ensiled mass, which can result in good or poor-quality silage (MOUSQUER et al., 2013).

The use of additives can improve the quality of legume silages, providing conditions for good fermentation. Thus, cassava (*Manihot esculenta* Crantz) is a viable alternative because it is traditionally grown in most of the country. The roots stand out as an energy source, which is the most important component of food rations for different animal species. Sorghum (*Sorghum bicolor* [L.] Moench) has also been widely used in silage production due to its biomass production potential under water deficit conditions and poor soils, because it is tolerant to diseases and pests, easy to cultivate and preserve, has good nutritional value, is a source of digestible fiber and starch, besides being excellent for animal consumption.

The objective of this study was to evaluate the chemical composition and fermentative characteristics of old man saltbush silage supplemented with energy concentrates.

Material and Methods

The experiment was carried out at an experimental field in the Caatinga biome located in the Animal Metabolism research center, Brazilian Agricultural Research Corporation (EMBRAPA), in the city of Petrolina (PE), Brazil. The area has an average annual rainfall of 578 mm and average maximum and minimum temperatures of 33. 46 and 20.87ºC, respectively (EMBRAPA, 2011).

The experimental design was completely randomized, in a factorial arrangement 3 x 7, (treatments and opening days), with three replications. The treatments (T) consisted of three silages: T1- old man saltbush silage (SS), T2-SS + cassava scrap (10% of green weight), T3-SS + milled grain sorghum (10% of green weight). The old man saltbush used for silage production was harvested in the experimental field of EMBRAPA Semiarid, when in full vegetative stage. Forage cutting was done manually, and the material was chopped in a forage machine, obtaining particles of sizes ranging from 2 to 10 centimeters. The chopped material was homogenized and sampled as non-ensiled material (original material), and then ensiled in experimental silos made from "PVC" tubes of 10 cm in diameter and 50 cm in length. Table 1 shows the chemical composition of the old man saltbush and additives.

Table 1. Average content of dry matter (DM), organic matter (OM), mineral matter (MM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), total carbohydrates (TC), and non-fibrous carbohydrate (NFC) of the food used to make the silages.

Variables	Food		
	Old man saltbush	Cassava scrap	Grain sorghum
DM	41.58	84.19	86.28
OM	82.82	96.49	94.07
MM	17.18	3.51	5.93
CP	6.82	3.49	7.27
EE	1.09	0.74	3.21
NDF	64.37	21.28	15.41
ADF	37.00	13.20	12.00
CHOT	77.42	90.33	75.93
NFC	10.45	15.10	59.05
IVDMD	47.59	81.23	70.34

Sixty-three silos were made in PVC tube to store the chopped forage. The silos were weighed before and after forage deposition to determine the density of the ensiled mass, and silo volume and weight. The silos were opened on different days (1, 3, 5, 7, 14, 28, and 56 days), and the ensiled material at up to 10 cm from the edges of the silos was discarded. The remaining material was homogenized and sampled to determine the bromatological composition and fermentation profile, together with the forage sample before being ensiled.

Samples of the *in natura* material and the silage after silo opening were pre-dried in a forced ventilation oven at 55ºC for 72 hours and processed in mills with screen sieves of 1mm in diameter. The samples were conditioned in polyethylene bottles to determine the contents of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (AFD), and ether extract (EE), according to the recommendations of Silva and Queiroz (2002). In vitro dry matter digestibility (IVDMD) was also determined according to the two-step method of Tilley and Terry (1963), described by Silva and Queiroz (2002). Total carbohydrates (TC) and non-fibrous carbohydrates (NFC) were obtained according to Sniffen et al. (1992), by means of the equations: TC = 100 - (% CP +% EE +% MM), and NFC = 100 - (% CP +% EE +% NDF + MM).

An aliquot of 25 g of wet silage sample was taken and placed in a container with 100 mL distilled water and then mixed. After one-hour resting, pH was read using a potentiometer as proposed by Silva and Queiroz (2002). The content of ammoniacal N ($N\text{-}NH_3$) was determined as technique proposed by Fenner (1965) and adapted by Vieira (1980). Another aliquot of 25 g of wet silage was placed in a vessel containing 200 mL H_2SO_4 (0.2 N), stirred, and allowed to stand for 48 hours under refrigeration. Afterward, the material was filtrated through a fine mesh plastic sieve, lined with gauze. Then, an aliquot of 5 mL of the filtrate + 10 mL of potassium hydroxide (2N) was filtered and titrated with an HCl solution, and the readings were noted. The ratio between $N\text{-}NH_3$ and total N (TN) was calculated using the equation: $N\text{-}NH_3$ = (N ammoniacal*100) NT^{-1}. The value of TN was obtained by dividing the CP values by the factor 6.25 (SILVA; QUEIROZ, 2002).

The recommendations of Kung Junior and Ranjit (2001) were adopted for the analysis of organic acids. 1mL of metaphosphoric acid 20% v v-1 was added to 2mL of the filtrate, and the sample was centrifuged. Analyses of organic acids (lactic acid, acetic acid, and butyric acid) were carried out by high-performance liquid chromatography (HPLC) at the Animal Nutrition Laboratory of the Federal University of Minas Gerais (UFMG).

The silages produced had their fermentation processes classified as excellent (90 - 100 points), good (70 - 89 points), regular (50 - 69 points), bad (30 - 49 points), and very bad (<30 points) according to the method proposed by Tomich et al. (2004). This method qualifies silage fermentation process regarding the relationship between pH and DM content, the concentration of $N\text{-}NH_3$ NT^{-1}, and butyric and acetic acid contents.

The data were submitted to analysis of variance (ANOVA) and the means were compared by the Tukey test at the 5% probability level ($P < 0.05$), using the statistical analysis software SAS (SAS, 2009).

Results and Discussion

Table 2 shows the mean values for dry matter, mineral matter, organic matter, crude protein, and ether extract of the old man saltbush silages submitted to different treatments and silo-opening times. There was no significant interaction ($P>0.05$) for fermentation time and treatment for DM concentrations. DM contents are observed to have been similar at day 56 after ensiling for all silage types evaluated ($P>0.05$), with values of 29.66%; 35.76%; 35.94%, for SS, SS+C, SS+S, respectively.

No changes were observed in the DM values of silages in the different opening periods (0 to 56 days), that is, the dry matter remained stable. However, the DM contents of SS+C and SS+S were similar

(P>0.05) and higher than those of SS (P<0.05). The DM increase with the addition of cassava scrap and grain sorghum was due to the higher DM content of these additives in relation to old man saltbush.

Table 2. Average contents of dry matter (DM), mineral matter (MM), organic matter (OM), crude protein (CP), and ether extract (EE) of salt grass silages supplemented with energetic concentrates as a function of fermentation days.

	Fermentation Days							
Treatments	P0	1st	3rd	5th	7th	14th	28th	56th
				Dry Matter				
SS	29.44aB	28.28aB	29.50aB	28.32aB	31.65aB	28.90aB	29.76aB	29.66aB
SS + C	34.24aA	33.34aA	36.05aA	33.59aA	37.44aA	34.05aA	34.51aA	35.76aA
SS + S	35.37aA	33.66aA	35.45aA	33.44aA	37.60aA	34.91abA	33.60abA	35.94aA
				Mineral Matter (% DM)				
SS	14.91bA	13.91bA	14.71abA	16.33abA	15.50abA	14.12abA	16.22aA	15.79abA
SS + C	13.40bB	12.33bB	12.77abB	13.46abB	12.47abB	13.11abB	13.78aB	13.11abB
SS + S	15.27bA	13.19bA	15.19abA	15.01abA	14.34abA	14.54abA	15.44aA	13.79abA
				Organic Matter (% DM)				
SS	85.09aB	86.08aB	85.28abB	83.66abB	84.50abB	85.87abB	83.77bB	84.20abB
SS + C	86.60aA	87.66aA	87.22abA	86.53abA	87.52abA	86.88abA	86.21bA	86.88abA
SS + S	84.75aB	86.80aB	84.80abB	84.99abB	85.65abB	85.45abB	84.55bB	86.20abB
				Crude protein (% DM)				
SS	6.82aB	6.85aB	7.18aB	6.93aB	6.73aB	7.28aB	6.83aB	7.36aB
SS + C	6.05aC	6.10aC	6.07aC	6.21aC	5.91aC	6.17aC	6.08aC	5.50aC
SS + S	7.27aA	7.59aA	7.49aA	7.56aA	7.53aA	7.61aA	7.87aA	7.58aA
				Ether extract (% DM)				
SS	1.09bA	1.98bA	2.01bA	1.96bA	2.13bA	2.14bA	1.82bA	2.28bA
SS + C	1.06bA	1.65bA	1.20bA	1.80bA	1.67bA	2.04bA	1.65bA	1.27bA
SS + S	1.95aA	2.24aA	2.87aA	2.92aA	2.85aA	3.54aA	2.92aA	3.37aA

SS= Oldman saltbush Silage; SS+C= Old man saltbush Silage + Cassava Scrap; SS+S= Old man saltbush Silage + Grain Sorghum; P0= Pre-ensiled material; Upper case letters in the same column and lower case in the lines do not differ by Tukey's test (P<0.05).

The DM values found in this study for SS+C and SS+S ranged from 33.34 to 37.44% and 33.44 to 37.60%, respectively. They are close to the range considered adequate according to McDonald et al. (1991), who state that a dry matter content of 20% or more associated with an adequate soluble carbohydrate content would be sufficient to produce good quality silage. For the variable MM, no significant interaction (P<0.05) was observed between the treatments and the different fermentation days. The treatments SS and SS+S did not differ from each other (P>0.05), but were higher (P<0.05) than SS+C. This difference can be explained by the fact that old man saltbush and grain sorghum have higher MM contents than cassava scrap. There was no interaction between the different opening times for the OM variable. However, the addition of cassava scrap was observed to promote an increase in OM contents for the SS+C treatment, which was higher than the others were (P>0.05). This behavior can be explained by the low ash contents in the cassava scrap compared to the old man saltbush, which led to an increase in OM content.

No interaction (P<0.05) was observed for CP between treatments as a function of fermentation days. The silage added with grain sorghum was superior to the others (P>0.05), ranging from 7.27 to 7.87%. The silages were observed to present CP levels close to the minimum requirements for ruminal functioning, which according to Church

(1988) are of at least 7% CP so that the nitrogen supply is sufficient for effective microbial fermentation in the rumen. However, the old man saltbush silages showed CP values similar to that of silages supplemented with grain sorghum at 30 (7.18%), 14 (7.28%), and 56 (7.36%) days.

According to McDonald et al. (1991), the CP levels remain stable, but their nature changes due to the intense proteolysis. In this study, CP remained stable during silage from the 1st to the 56th day (P>0.05), with differences only when comparing CP contents of the original material (6.82%) to the silage on the 56th day (7.36%) (P<0.05). The increase in CP content in the silage supplemented with sorghum reflects the higher percentage of this fraction in the additive compared to the other treatments.

No interaction (P>0.05) was observed between the treatments for the EE variable and silo opening days. However, significant differences (P<0.05) were observed between treatments. Silage added with grain sorghum presented higher values than the other treatments (P>0.05). This behavior was expected because the EE content of this additive is higher than are the others. Oliveira et al. (2012) observed a reduction of 0.02 percentage units for each unit of cassava meal added in elephant grass silage. The author attributes these reductions to the probable low EE levels of the residue used, as well as to the low values of this constituent in elephant grass.

Table 3 shows the levels of total carbohydrate (TC), non-fibrous carbohydrate (NFC), and in vitro dry matter digestibility (IVDMD). No interaction (P>0.05) was observed between the treatments and the different fermentation days for the variable TC. However, the treatments presented significant differences (P<0.05). The silage added with cassava scrap showed higher TC contents than the other silages, which did not differ (P>0.05). This difference can be explained by the higher percentage of this fraction in this additive when compared to old man saltbush, and the cassava scrap stands out, with 90.33% in its composition. Carbohydrate levels are strongly influenced by CP and EE values, considering the use of these variables for TC determination.

An interaction (P<0.05) was observed between the treatments and fermentation days for NFC values. The highest NFC contents can be observed in the pre-ensiled material and in the first day of silo opening (P<0.05). The stabilization of the drop in NFC contents occurred from the 14th fermentation day on. The mean values of the other fermentation times presented a similar behavior (P>0.05). Cassava scrap promoted an increase in NFC contents in the SS+C treatment, which was higher than the SS and SS+S treatments. These increases in the FCN fraction may be justified by the fact that cassava meal is very rich in starch. As this fraction consists of soluble sugars and starch, that is, the difference between CHOs and NDF (FERRAZ et al., 2011), probably the residue high starch values increased the fraction contents.

The in vitro digestibility of DM (IVDMD) presented significant interaction (P<0.05). The oldman saltbush silage and the one supplemented with cassava scrap in the pre-ensiled material did not differ (P>0.05) in the first opening day, being superior to the silage supplemented with sorghum. As the fermentation days passed, the silages added with cassava scrap were observed to present higher averages than the other treatments (49.06%, 49.35%, 49.99%, 49.44%, 50.01%; 50.18%, and 48.93%). Probably, the increase in IVDMD is due to the high digestibility of the used additive (81.23%) when compared to the others.

The NDF contents interacted (P<0.05) between the treatments as a function of fermentation days. NDF contents are observed to increase up to 50 fermentation days with 64.73%, which is higher than the others are (P<0.05), and the additive promoted alterations in the cell wall fraction content. However, as fermentation time increases, contents decrease. NDF reductions may indicate the action of enzymes on carbohydrates in the cell wall and may increase substrate availability for bacteria. However, Santos et al. (2010b) report that the concentration of cell wall constituents generally increases with the ensiling process due to the loss of soluble nutrients in the gas or effluent form, or according to Van Soest (1994) due to the loss of volatiles during material drying in the greenhouse.

Table 3. Mean values of total carbohydrates (TC) and non-fibrous carbohydrates (NFC), in vitro digestibility of DM (IVDMD), neutral detergent fiber (NDF), and acid detergent fiber (ADF) of herb old man saltbush supplemented with energy concentrates, as a function of fermentation days.

	Fermentation Days							
Treatments	P0	1st	3rd	5th	7th	14th	28th	56th
	Total Carbohydrates (% DM)							
SS	77.42bA	77.25bA	76.08bA	74.76bA	75.62bA	76.44bA	76.18bA	74.54bA
SS + C	81.81aA	79.90aA	79.94aA	78.51aA	79.93aA	78.66aA	78.46aA	80.10aA
SS + S	69.00bA	76.96bA	74.42aA	74.49bA	74.49bA	75.25bA	74.29aA	75.34bA
	Non-fibrous carbohydrates							
SS	14.42bA	14.64bA	13.66bAB	11.20bAB	11.25bAB	13.50bAB	12.22bAB	12.45bAB
SS + C	20.52aA	17.72aA	15.41aAB	13.22aAB	13.02aB	14.08aAB	16.43aAB	15.77bAB
SS + S	19.27bA	15.72bA	12.74bAB	12.94bAB	14.45bAB	12.03bAB	12.71bAB	14.77aAB
	In vitro digestibility of DM							
SS	47.59cA	48.88aA	47.98abB	47.34abB	48.37abB	48.28abB	48.72abB	47.81bB
SS + C	50.45bA	49.06bA	49.35abA	49.99abA	49.44abA	50.01abA	50.18aA	48.93bA
SS + S	48.79bA	47.75bA	47.78bB	48.59abB	48.29abB	48.68abB	48.89aB	47.76bB
	Neutral detergent fiber (% DM)							
SS	62.32cC	61.73cC	62.42cB	63.56cA	62.09cC	62.47cB	61.69cC	61.77cC
SS + C	62.54bC	61.94bC	63.03bB	64.00bA	62.25bC	63.05bB	62.21bC	62.42bC
SS + S	63.80aC	62.87aC	63.82aB	64.73aA	63.41aC	64.16aB	63.17aC	62.86aC
	Acid detergent fiber (% DM)							
SS	37.21abA	36.97abA	37.05abA	37.79abA	38.32abA	38.48abA	38.27abA	37.83abA
SS + C	37.92aA	38.24aA	38.10aA	38.27aA	38.18aA	37.86aA	37.78aA	37.64aA
SS + S	38.12aA	38.09aA	37.94aA	38.02aA	38.16aA	37.86aA	37.31aA	37.27aA

SS= Old man saltbush Silage; SS+C= Old man saltbush Silage + Cassava Scrap; SS+S= Old man saltbush Silage + Grain Sorghum; P0= Pre-ensiled material; Upper case letters in the same column and lower case in the lines do not differ by Tukey's test (P<0.05).

Silages added with grain sorghum (64.73%) had higher NDF contents, differing significantly (P<0.05) from the other treatments. In contrast, no interaction (P>0.05) was observed between the treatments and fermentation days for ADF. The values presented were similar (P>0.05) in all treatments evaluated, remaining stable throughout the fermentation period. There was an interaction (P<0.05) between the treatments and the different fermentation days for silage pH (Table 4). The first fermentation day had pH of 4.43; 4.30; 4.40 for the treatments, which were considered superior to the other treatments in the different fermentation days. Silages did not show any differences for the different fermentation days on days 3, 5, 7, 14, 28, and 56 (P> 0.05). Their values ranged from 3.56 to 4.10, and from 3.80 to 4.06, respectively, which is within the pH range considered normal (3.6 to 4.2) for silages to be considered of good quality (McDONALD et al., 1991).

Table 4. Mean pH and ammoniacal nitrogen content (N-NH_3 NT^{-1}), and organic acids concentration of the old man saltbush silages supplemented with energy concentrates, as a function of fermentation days.

	Fermentation Days						
Treatments	1st	3rd	5th	7th	14th	28th	56th
			pH				
SS	4.43aB	3.56aA	4.10aA	3.90aA	3.96aA	3.93aA	3.90aA
SS + C	4.30aB	4.00aA	4.06aA	3.96aA	3.80aA	4.00aA	4.06aA
SS + S	4.40aB	4.03aA	4.10aA	3.90aA	3.83aA	4.00aA	4.00aA
			Ammoniacal nitrogen (% of total nitrogen)				
SS	4.64cB	7.24cB	8.51cA	8.75cA	9.08bA	9.33bA	11.53aA
SS + C	4.75cB	7.70cB	8.86cA	8.86cA	9.14bA	9.29bA	11.74aA
SS + S	4.93cA	7.98cA	8.63cA	8.92cA	9.10bA	9.31bA	11.87aA
			Lactic acid (% DM)				
SS	3.90abcB	4.71abcA	5.29abcA	5.86abA	6.27aA	3.73abA	4.53bcB
SS + C	3.46abA	4.63aA	5.54aA	4.76aA	5.00aA	4.28aA	4.55aA
SS + S	3.09abcB	4.69abcA	5.08abA	4.75abA	4.40abA	4.00abA	5.88aA
			Acetic acid (% DM)				
SS	0.78bcB	2.30bcA	0.94bcA	0.86bA	2.93aA	1.19aA	1.99aA
SS + C	2.03bB	2.05bA	0.76bA	0.93bA	0.95bB	1.23bA	2.28bA
SS + S	2.30bA	0.69cB	0.86cA	0.81aA	1.07cB	1.85bcA	2.88bcA
			Butyric Acid (% DM)				
SS	0.02aA	0.02aA	0.04aA	0.02aA	0.02aA	0.02aA	0.03aA
SS + C	0.02aA	0.02aA	0.03aA	0.03aA	0.02aA	0.02aA	0.02aA
SS + S	0.02aA	0.02aA	0.03aA	0.03aA	0.02aA	0.03aA	0.03aA

SS= Old man saltbush Silage; SS+C= Old man saltbush Silage + Cassava Scrap; SS+S= Old man saltbush Silage + Grain Sorghum; Upper case letters in the same column and lower case in the lines do not differ by Tukey's test ($P<0.05$).

Concerning N-NH_3 NT^{-1}, there was an interaction ($P<0.05$) between treatments and the different fermentation days (Table 4). The oldman saltbush silages and silage supplemented with cassava scrap at days 10 and 30 of fermentation were similar ($P>0.05$), but different from the silage added with grain sorghum, which was superior ($P<0.05$). However, an increase of N-NH_3 NT^{-1} was observed as early as the third day after ensiling, and it continued to increase until the 56th fermentation day. In addition, no differences were observed among silages from day 5 to 56 of fermentation ($P>0.05$), which were superior to those of day 1 to 3.

Thus, the silages that are inserted within the first to the 28th days of fermentation presented ammoniacal nitrogen values below 10%, except on the 56th day. A low N-NH_3 NT^{-1} content with less than 10% NT indicates that the storage process did not result in excessive protein breakdown in ammonia. However, a value greater than 15% means that protein breakage was considerable, silages may be less accepted by animals, and there may be low consumption (FARIA et al., 2007).

The concentration of lactic acid underwent interaction ($P<0.05$) between the treatments and the different fermentation days (Table 4). A significant difference ($P<0.05$) was observed for the first fermentation day when the cassava scrap promoted an increase in lactic acid concentrations. This difference is also observed on the 56th day when sorghum promotes an increase in lactic acid contents when added to the silages. Lactic acid has a higher dissociation constant and is, therefore, the strongest and single most important agent for lowering pH (LEONEL et al., 2009).

Based on the classification criteria used by Breirem and Ulvesli (1960), silages with lactic acid values in the range of 1.5 to 2.5% are considered of good quality. In this study, the values determined presented a variation of 1.41 to 2.29% of dry matter, which allows classifying them as "good quality", not only in function of the lactic acid values but also mainly due to the other parameters evaluated, except butyric acid.

There was an interaction (P<0.05) between treatments and fermentation days (Table 4) for the acetic acid concentration. On the first opening day, the silage supplemented with sorghum appeared better than the other treatments, however on the 3rd day an inversion occurred, and the old man saltbush silages supplemented with cassava scrap had higher results than the silage supplemented with sorghum. The treatments were similar to each other (P<0.05) for the 5th, 7th, 14th, 28th, and 56th fermentation days.

The presence of moderate concentrations of acetic acid is an important factor in fermentation. The values found in the experiment ranged from 0.69 to 4.30%, and according to Carvalho et al. (2007), a good preservation of ensiled mass should be found below 0.8% since, above this level, it is considered critical.

The presence of butyric acid in the ensiled mass is always accompanied by changes in product quality. There was no interaction (P>0.05) between the treatments and the different fermentation days for the butyric acid variable (Table 4). The values found in this study were low, close to zero, indicating a little incidence of the *Clostridium* bacteria, which are the main producers of butyric acid and have their development stimulated under conditions of high humidity in the silage material, evidencing quality of the silage material.

The density of the ensiled material showed no interaction (P>0.05) between treatments and fermentation the days (Table 5). Higher density (P<0.05) was observed for the 56th fermentation day, followed by the 1st, 3rd, and 28th. They were not different from each other (P>0.05). These results can be explained by the better fermentation at higher densities due to the absence of air, and the lower loss of effluent in the silages. Lower values were observed for the 5th; 7th; and 14th opening days.

Table 5. Average contents (%) of dry matter loss and density for old man saltbush silages supplemented with energy concentrates, as a function of fermentation days.

	Fermentation Days						
Treatments	1st	3rd	5th	7th	14th	28th	56th
			Density (kg/m$_3$)				
SS	943aA	891aA	804aA	870aA	850aA	831aA	910aA
SS + C	910aA	900aA	911aA	882aA	840aA	841aA	930aA
SS + S	979aA	961aA	971aA	918aA	918aA	841aA	911aA
			DM losses (%)				
SS	0.01bA	0.01bA	0.01bA	0.01bA	0.08aA	0.05abB	0.03aA
SS + C	0.02aA	0.01aA	0.01bA	0.01bA	0.03bB	0.03aA	0.03aA
SS + S	0.01aA	0.01aA	0.02aA	0.01aA	0.05aB	0.03aB	0.02aA

SS= Old man saltbush Silage; SS+C= Old man saltbush Silage + Cassava Scrap; SS+S= Old man saltbush Silage + Grain Sorghum; Upper case letters in the same column and lower case in the lines do not differ by Tukey's test (P<0.05).

All the silages were well compacted, presenting a desirable density, as recommended by Nussio (1997), who states that silage density in the range between 600 and 900 kg/m3 is adequate compaction for the ensiling process. Although high values were obtained for the ensiled material density, this fact did not guarantee a better fermentation process or lower DM losses. In other words, the density of the silage material cannot be considered as a determinant of silage quality, and all the forage bromatological and fermentative characteristics must be analyzed.

As for dry matter losses, there was an interaction (P>0.05) between the treatments and fermentation days. Days 1st; 3rd; 5th; 7th, and 56th were observed to present similar averages (P>0.05) and were different from the other periods (P<0.05). Low values were observed for dry matter losses, with averages varying from 0.01 to 0.32%. Possibly, dry matter losses in low percentages are related to the low proteolysis of the ensiled material during fermentation.

According to Edvan et al. (2013), pH values between 3.8 and 4.2 are desirable for silage considered to be well conserved. However, pH alone cannot be considered as a safe criterion for the evaluation of silages, because its inhibitory effect on plant bacteria and enzymes depends on the decline rate of the ionic concentration and the humidity level of the medium.

When the fermentation process of the silages was analyzed through the model proposed by Tomich et al. (2004) for pH and ammoniacal nitrogen, silages of all treatments (SS, SS+C, SS+S), were observed to present scores (100 points) to be classified as excellent, as seen in Table 6. This classification reveals that old man saltbush can be conserved in the form of silage and is equivalent to or even superior to the silages of other tropical forages already used in the feeding of ruminants in other Brazilian regions.

Table 6. Qualification of silage fermentation as a function of dry matter content, pH, and ammoniacal nitrogen as a proportion of the total nitrogen (N-NH_3 NT^{-1}) of old man saltbush silages supplemented with energy concentrates.

Treatments	Average DM	Average pH	Average NH_3 NT^{-1} (%)	Score
SS	29.44B	3.96A	8.44A	100/Excellent
SS + C	34.87A	4.02A	8.62A	100/Excellent
SS + S	34.99A	4.03A	8.67A	100/Excellent

SS= Old man saltbush Silage; SS+C= Old man saltbush Silage + Cassava Scrap; SS+S= Old man saltbush Silage + Grain Sorghum; Upper case letters in the same column and lower case in the lines do not differ by Tukey's test (P<0.05).

Conclusion

The addition of cassava scrap and grain sorghum favors the old man saltbush ensiling process, providing improvements in the silage nutritional value.

Using these supplements during the storage period promotes a reduction of total losses, inhibition of alcoholic fermentation, and recovery of carbohydrates, resulting in silage with a nutritional value similar to that of fresh forage, characterizing it as an alternative supplement source.

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