

## **Opportunities for inclusion of tropical grasses silage in ruminant total mixed rations**

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## **1 Introduction**

The Brazilian livestock, nowadays, is one of the most powerful, supporting the largest commercial herd in the world. As it occurs commonly all over the globe, Brazil has a strong seasonality period of production in pastures during the year, with an increase in the production in the warm and rainy period, from October to December, followed by a decreasing or almost shortage period of production from the months of April to September, characterized by a dry and cold period and by smaller photoperiod, typical from the South-center region of the country, coincidentally the one which contains the largest bovine herd in the country.

The emphasized seasonality period of production in pastures has an important demand of feed to be used and conserved as silage and/or hay, of agro industry byproducts, differed grazing strategies, of adopting forage crops resistant to the winter conditions and of the irrigation of pastures (Rolim, 1986; Costa et al., 2008), among other resources, to the animal feeding supplementation in the period of the low forage availability.

The ensiling is often applied, overall to the corn silages (*Zea mays* L.) and sorghum (*Sorghum* spp), which are excellent but at a high cost, being the other species also applied, such as sugar cane (*Saccharum* spp.), the pearl millet [*Pennisetum glaucum* (L.) R. Br.] and the tropical perennial forage grasses, specially the ones belonging to the gender *Pennisetum*, *Panicum*, *Brachiaria* and *Cynodon*, among others.

The most applied perennial grass are the cultivars: *Pennisetum purpureum* Schum., *Panicum maximum* Jacq., *Brachiaria brizantha* (Hochst ex A. Rich.) Stapf, *Brachiaria decumbens* Stapf and *Cynodon dactylon* (L) species, and other species and varieties of *Cynodon* gender.

The tropical perennial grasses, or forages, have a high production of green forage, from a reasonable to a good quality, with major concentration in the summer mainly (rainy season), generating almost always a forage surplus which can perfectly harvested and conserved in a silage form, with a low cost, that will drastically reduce the problems coming from the small availability of green forage to the animals in the dry season of the year, if properly produced.

In this review the aim is to present part of the available strategies to the production of tropical perennial grass silages, of a good quality, and the opportunities of its inclusion in the ruminant ration.

## **2 Conditioning factors to the production and usage of tropical grass silages in the ruminant diets**

The dry matter yield (DM) of the tropical grass can reach really high values, once they have the C<sub>4</sub> pathway and if their nutritional requirements were met. The ones from the species mentioned before are really high, except the ones from *Brachiaria decumbens*. Da Silva et al. (1996), approaching the Elephant-grass production potential (*Pennisetum purpureum* Schum.), the most productive among the tropical perennial, said that this grass intensively managed is capable of producing from 80 to 90 t ha<sup>-1</sup> year<sup>-1</sup> of DM. The DM annual production of *P. maximum* grass (cvs. Mombaça, Tanzania 1, Tobiata, etc.), *B. brizantha* (cvs. Marandu, MG-5 Vitória, Xaraés, etc.) and *Cynodon* spp. (cvs. Coastcross 1, Tifton 85, Tifton 68, Florona, etc.) can reach from 20 to 30 t ha<sup>-1</sup>. Values of DM production of these grasses are showed on Tables 1 and 2.

Table 1. Dry matter yield (DM) of *P. purpureum* cv. Napier and *Cynodon* spp. cvs. Coastcross and Florona with different nitrogen (N), Potassium (K<sub>2</sub>O) and phosphorus (P<sub>2</sub>O<sub>5</sub>) fertilization levels.

N + K <sub>2</sub> O (kg ha <sup>-1</sup> )	Napier Ir <sup>1</sup> DM (t ha <sup>-1</sup> )	Napier Ni <sup>1</sup> DM (t ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	Coastcross <sup>2</sup> DM (t ha <sup>-1</sup> )	Florona <sup>2</sup> DM (t ha <sup>-1</sup> )
400 + 320	21.65a	23.65a	0	15.09	14.85
300 + 240	21.38a	20.31a	40	16.07	14.12
200 + 160	17.15a	17.16ab	80	15.90	14.51
100 + 80	14.26b	12.20c	120	16.18	14.26
Average	18.61	18.39	Average	15.81a	14.44b

Adaptation from data by Mistura et al. (2006)<sup>1</sup>, Napier forage irrigated (Ir) and no irrigated (Ni), in 2001 dry period (April until September), Viçosa-MG; Averages with different letters, in column, are statistically different according to Tukey test (P<0.05); Santos (2004)<sup>2</sup>, Average production of three P sources (triple superphosphate, Arad phosphates and Araxá phosphates), for each P<sub>2</sub>O<sub>5</sub> dose, in 2001/02 dry period (October until April), Lavras-MG; Averages with different letters, in line, are statistically different according to Tukey test (P<0.01).

Table 2. Dry matter yield (t ha<sup>-1</sup>) of tropical forages *Cynodon* sp. cv. Tifton 85, *P. maximum* cv. Tanzânia 1 and *B. brizantha* cv. Marandu irrigated and no irrigated and combined analysis of means.

Forage	Water regime		combined analysis (Mean)
	Irrigated	No Irrigated	
Tifton 85	17.96	16.99	17.48a
Tanzânia	17.98	17.58	17.78a
Marandu	16.35	13.98	15.16a
combined analysis (average of harvest)	17.43A	16.18A	

Source: Santos et al. (2008), 2004/05 wet period (November until April), Itapetinga-BA; Averages with the same minuscule letter in column and capital letter in line are not statistically different according Tukey test (P>0.05).

Besides the photosynthetic characteristics, the soil and the climate have a great influence on the growth and development and, consequently, on the forage crops plants production (McKenzie et al., 2002). The climate can be understood as the mean and typical pattern of the weather in a certain region, settling the conditions to the plants growth and its area of distribution, imposing limits to its survival. (Larcher, 2000).

According to Volenec and Nelson (2003), the climate refers to the long term report of temperature, precipitation and radiation for a given region. Light (or radiation), temperature and humidity of the land are the three main environmental factors which affect the adaptation, the vegetative development and the forage crops species reproduction. Understanding how these environmental factors affect the forage crops is fundamental to develop management models and techniques which might help to assure the high productivity of the pastures.

In the Northeastern Brazil, where there is a semi-arid climate, the forage production shows a strong seasonality period due, mainly, to the unequal distribution of rain, limiting the corn production to the ensiling. However, the grass silages have been showing as an opportunity of forage production in the dry period, and due to their vegetative characteristics, these grasses present a high forage productivity of a good nutritive value, with relatively competitive costs.

On the other hand, in many regions during the rainy season, because of a more favorable climate conditions, the plants growth in some months is so intense that exceeds the herd DM feed intake demand, being necessary some stocking adjustments, mainly in the fertilized systems.

This management, varying the animal number for area unit also in the rainy season, sometimes becomes not so practical or not so interesting to the producer. In this context, the conservation of the pasture surplus by the ensiling and/or haylage has been shown as an interesting opportunity in the feed deficit control. This is a widely used technique in Europe, being part of the pasture management. This implicates in the manipulation of the stocking rate in the pasture areas, thus increasing the pasture controlling flexibility. Nevertheless, because part of the total pasture area is applied to the forage conservation and these areas are isolated from the grazing areas for a couple of weeks, the control is not precise (Hodgson, 1990). Furthermore, the forage accumulation to conservation probably reduce the adoption and the potential of future regrowth. On the other hand, if the goals are to reach more elevated levels of animal performance under variable conditions of forage supply, the maintenance of high stocking rates will only be possible by adopting a very flexible herd management and/or a predisposition to the supplemental feed usage.

The forage conservation is a key component in many animal production systems in those regions where in any time of the year the forage crops growth is very slow or almost null. In these conditions, the value of this management practice is incontrovertible.

Intermittent stocking is the grazing of two or more paddocks, in sequence, followed by a resting period to the grazed forage crops recovery. The principal advantages of this method, according to Matches and Burns (1995), are the best plants persistence, more pasture conservation opportunities and more time to use the forage. The intermittent stocking presents a bigger number of modalities than the continuous stocking, all of them involving the integration with the conservation. In the

conventional intermittent stocking the animals stay in the paddocks for a period of time (grazing period), followed by a resting period. In this modality, paddock number and occupation and fixed resting period and similar size paddocks are used, defined previously (Mayne et al., 2000). This method is one of the most found in Brazil when talking about systems of animal production in pastures which adopts the intermittent stocking, probably because it is presented as an easier way of management.

According to da Silva (2004), management recommendations like those are inefficient and inconsistent, causing qualitative and quantitative loss to the animal production. And yet, according to the author, the grazing management strategies must try to find an optimum balance between the growth process, senescence and feed intake, so that a forage production raise of good quality is possible, being these management actions specific for each condition of use and production. This indicates that the stocking rate must be flexible so that it adequate to the ecophysiological limits of the plant, while the paddock number can rise or not, using electric fence. In those situations when the pasture offer exceeds the demand, the forage surplus in the paddock can be conserved as hay or silage, in the beginning of the season, when the growth rates are high.

In Brazil, the pastures management associating grazing with forage conservation is not common. However some studies with silages of tropical forage, integrating grazing and forage conservation, seeking to keep the animal stocking more stable and raised all year long have been led. Corrêa et al. (2001), working with intensive intermittent stocking, checked that as forage surplus occurred, part of the paddocks was being reserved to the silage making. The harvest was made in the 55<sup>th</sup> day of the plant growth of Tanzania-grass and in the 30<sup>th</sup>, 35<sup>th</sup> and 45<sup>th</sup> day to the Coastcross grass. The silage supply started in June, when the produced forage in the pastures was not enough anymore to keep the stocking defined. Each animal fed with Tanzania-grass silage mixed to the silage, 0.5 kg of Soybean meal per day. During the dry climate, the resting periods passed to 60 and 48 days respectively, to the pastures of Tanzania-grass and Coastcross grass, having the animals free access to the pasture and to the silage

According to the authors, the use of the silage in the dry climate, integrated with the grazing, was possible to maintain both systems intensified all year long, with a relatively stable herd, fed practically only with forage from the rotational system. In the Tanzania-grass pasture case (background-finishing) was possible to obtain Canchim beef cattle with slaughter weight around 450 kg of live weight, 19 to 20 months old. In

the rainy season, the feeding consisted only of grazing forage, with an average gain of 850 g animal<sup>-1</sup> day<sup>-1</sup> and, in the dry season, grazing forage added with silage from the forage surplus from the rainy season and 0.5 kg of soybean meal, with an average gain of 440 g animal<sup>-1</sup> day<sup>-1</sup>.

### **3 Indispensable cares to the making of good tropical grass silage**

To obtain good qualities silages of tropical perennial grass, special care are required regarding the restrictions such as the high concentration of humidity and low soluble carbohydrate content and the high buffering capacity presented by the green forage at the best nutritional moment and which must be ensiled. The standard corn silage shows DM contents around 30 and 35%, however for the perennial grass contents higher than 20% are acceptable. Lavezzo (1993), in a review of ensiling of elephant-grass, mentioned that in forages with less than 20% of DM the high humidity will reduce the conservative effects of the primary acid fermentations and the growth of *Clostridium* can be not restricting in pH values from 3.8 to 4.0. To the elephant-grass cultivars, as informed by Lavezzo (1993), several approaches can be used to determine the moment of harvesting to the ensiling such as the age of the plant being around 60 and 90 days (70 days as average); height varying from 1.5 to 1.8 m and the leaf: stem ratio is 1.0. Ávila et al. (2006), when working with cv. Tanzania, say that the tropical perennial grass must be harvested younger, with the age of 60 and 70 days, to obtain of the best nutritional value of silage.

The low soluble carbohydrate contents of the tropical grass, in general, will not provide silages rich in lactic acid. Lavezzo (1993), reviewing several authors, reported that the lactic acid content must be around 10%, preferably around 13 and 16% in DM. Associating the DM concentration to the soluble carbohydrate contents, McCullough (1977) mentioned that the ideal fermentations of the ensiled mass happen when DM is from 28 to 34% and values above 6 to 8% of soluble carbohydrate, since the buffering capacity is not raised. The soluble carbohydrate / buffering capacity ratio is determining in the ensiling process, according to Vilela (1997). The author adds that when this ratio decreases, a minimal increase in the DM content is required to prevent undesirable fermentation in the interior of the silo.

The buffering capacity, the resistance offered to the lower values of pH in ensiling, decreases while the forage crops get older. Lavezzo (1993), revising studies

with elephant grass, quotes values of buffering capacity reducing from 55.26 to 36.81 mg g<sup>-1</sup> of DM when the age of cv. Napier raised from 51 to 121 days, while to other cultivars of elephant grass these values were reduced from 38 to 40 eq. mg of HCl by 100 g of DM, at the age of 37 days de MS, to 13 to 17 eq. mg of HCl by 100 g of DM at the 67<sup>th</sup> day of growth.

Tropical perennial grass restrictions known to the silage production of good quality, techniques such as wilting and the use of different additives establish the tool applied to avoid such limits.

#### **4 Opportunities to the application of byproducts in tropical grass silages**

The tropical grass stands out for being DM high potential production plants and good chemical composition. However, there is a significant decrease in the nutritive value across the maturity. One of the techniques used to the management of these forage crops is the ensiling use of the material to a superior conservation of its nutritive value. This grass, however, presents a low content of soluble carbohydrates and DM contents of around 20%, insufficient to guarantee a good fermentation. An alternative to improve the fermentative standards and, consequently, the nutritive value of the tropical grass silage is the use of additive.

In Brazil, it has been increasing the use of agroindustrial byproducts or co-products as silage additive, mainly in the regions where there is a great availability of these substrates. Its application aims to reduce the ruminant feeding costs and to minimize the environment pollution. Several agroindustrial byproducts are being evaluated and have already been applied as additive in the perennial grass silages. Among these, the fruit byproducts, agricultural byproducts and the like stand out.

#### **4.1 Byproducts from the fruit processing**

##### **4.1.1 Pineapple**

During the pineapple industrialization, hulls, stem, crown and cylinders, considered as rejects and which correspond to, in average, 35% of the processed raw-material weight. The pressing of these rejects results in juice and pie, which are used in

animal rations in an empirical way. From the total pressed rejects, 75 to 85% are juice and 15 to 25% are meal (Py et al., 1984).

About the byproducts use in the pineapple juice production, Oliveira Filho et al. (2002) evaluated the nutritive value of the elephant grass silages containing different levels of pineapple byproducts and observed that the silage DM contents increased progressively with the sub product addition. The minimum level of 30% of DM, considered ideal by Lavezzo (1988), was not reached, but near values were observed with the addition of 20% of pineapple sub product (28.89% of DM). About the values in neutral detergent fiber (NDF), it was observed that with the addition of the pineapple sub product there was a reduction in their contents and for each addition of 1% it was registered a decrease of 0.35% in the NDF in the silages, reaching a minimal of 63.88% of NDF when adding 20% of the sub product.

#### **4.1.2 Cashew**

Ferreira et al (2002) observed that the addition of 36% of cashew bagasse in the elephant-grass silage caused a rising of 63% in the CP contents. While in the pure silages the values were 3.6%, in the ones containing 36% of cashew bagasse, they were 9.6%. The authors observed as well that the cashew sub product addition induced to a decrease in the pH values and in the ammoniacal nitrogen contents, showing this way that the fermentative process was improved.

Teixeira et al. (2003) evaluated the productive performance of ovine fed with elephant-grass silages containing dehydrated cashew bagasse (12% in DM basis) comparing to pure elephant-grass silage. On trial with confined the five months old ovine, approximately, receiving ration supplements concentrated in the proportion of 1.5 and 2.5% of live weight. The researchers observed that when the animals received supplements with the concentrate 1.5% of live weight (about 340 g day<sup>-1</sup>), they showed a bigger weight gain (110 g day<sup>-1</sup>) when the forage was the elephant-grass silage with cashew bagasse. The animals fed with the same quantity of concentrate ration, still with pure elephant-grass silage, presented a weight gain of 66 g day<sup>-1</sup>. The authors also observed the increase in the feed conversion when it was used the pure elephant-grass silage plus concentrate.



### **4.1.3 Guava**

According to Arraes (2000), the guava presents a juice yield of 75%, generating around 25% of waste. This waste can vary according to the methods used in the processing, production purpose (pulp, juice, purée, candies, etc.) the equipments and the efficiency of them. The generated waste can show the following compositions: pure seeds, seeds and rejected fruit, seeds and purée, seeds and purée and rejected fruit.

Neiva et al. (2002) evaluated the elephant-grass silages nutritive value containing different levels of the sub product of guava pulp production. The authors observed that the DM contents increased linearly when the addition of the guava byproduct was made, the way that for every 1% of byproduct addition, it was observed an increase of 0.5 in percentage in the silage DM contents. There was also an increase in the silage CP, NDF and ADF contents with the addition of guava byproduct.

### **4.1.4 Passion Fruit**

The main waste component of the passion fruit is the hull, being that fundamental to the generation of more information about its nutritive value. The passion fruit hull which performs, in average, 50% of the purple variety and 50-60% of the yellow passion fruit, is considered as “loss factor”. However, its chemical composition and nutritive value have been given more attention in the past years.

Aquino et al. (2003) evaluated the fermentative and nutritional characteristics of the elephant-grass silages containing different levels (0.5; 10; 15 e 20%) of passion fruit juice production byproducts. The sub product addition promoted a raise of 0.44 percent units in the DM contents for each 1% of addition. However, the ideal DM content of 30-35% quoted by McDonald (1981) to the occurrence of a good fermentative process was not reached. Now the CP content increased 0.17 percentage unit for each 1% of sub product addition to the silages. It is pointed out that for this variable, the addition of 0.47% of sub product made the CP content reached the ideal level to a good ruminal performance (7%). The addition of passion fruit sub product did not altered ( $P>0.05$ ) the silage pH values, but the observed values were kept within 3.8-4.2.

Reis et al. (2000), in a study performed in 1992, used different levels of passion fruit hull addition in elephant-grass ensiling, concluding that 75 and 50% were the best addition levels.

## **4.2 Agro industry byproducts**

### **4.2.1 Potato**

Approximately, 35% of the produced potato is rejected in the industrialization process. There are different forms of processing the potato for use in animal nutrition, including the potato meal (plant tubercle waste without being processed, dehydrated and floured); moist potato (potato processing waste to the human feed, composed, most of it, by the used potato hull with no dehydration); potato filter meal (representing 20% of the potato total waste resulting from the vacuous percolation); potato flakes (waste obtained from the cooked potato which is mashed and dehydrated) and potato pulp (waste from the leftovers after the starch extraction). The nutritional characteristics of this waste are similar to the ones from the raw potato. (Church, 1991).

Rezende et al (2007), working with elephant-grass silages added with various proportions of potato scraper, verified that as the quantity of potato was increased lower NDF and ADF and higher CP contents were registered, and also higher values of IVDMD were registered related to the testified silage.

Tavares (2009) worked with elephant-grass silages added with potato meal in the proportions of 0; 7 and 14% comparing to the corn silage in the milk cows diet. The addition of potato sub product in the elephant-grass ensiling improved the DM ingestion, as well as the CP, EE and the P element, while there was a reduction of the ADF consumption. The addition of 14% of the potato waste in the elephant-grass silage became similar to the corn silage for the production and composition of milk.

### **4.2.2 Coffee hulls**

The coffee hull, waste from the coffee bean improvement, presenting high DM content and good capacity of humidity absorption has been applied to the tropical perennial grass ensiling.

Bernardino et al. (2005) worked with coffee hull added to the elephant-grass in five levels of inclusion (0, 10, 20, 30 and 40%). The coffee hull addition in the elephant-grass ensiling with 12% of DM improved the silage fermentative characteristics, reducing the pH values and the ammoniacal nitrogen contents. However,

its inclusion increased the NDF, ADIN and lignin concentration, besides the IVDMD reduction.

Carvalho et al. (2007) also worked with the coffee hull added to the elephant-grass, but with different inclusion levels (0, 6, 12, 18 and 24%) compared to the previous study. The authors verified some improvements in the silage fermentative characteristics, with a decrease in the pH values and in the ammoniacal nitrogen contents and in the butyric acid and an increase in the lactic acid contents, promoting this way a better prevention of the ensiled material. Also, the IVDMD values reduced with the increase of coffee hull addition.

#### **4.2.3 Cassava**

The cassava processing involves the making of flour and starch extraction, also called cassava starch. These processing results in a great variety of solid waste such as peels, rejection and bagasse, or liquid waste such as manipueira and the water used to wash the root. When released in the environment they can cause serious problems of pollution because, besides the high organic values, they present a compound which can generate cyanide, toxic compound to most of the aerobic species.

Ferrari Jr. e Lavezzo (2001) worked with elephant-grass silage wilted and added with potato meal, verifying that the withering is a feasible alternative to decrease the humidity, but the cassava meal can raise the DM and soluble carbohydrates contents of the silage. These authors, when evaluating the quality of the wilted elephant-grass silage with an inclusion level of cassava meal up to 12%, observed an increase of 7.5% in the DM contents (28.61%) of the silages with additives which are in higher levels of meal regarding the ones with no additives (26.61%). Though, this increase was not enough to improve the silage quality because there was no significant difference on the pH values, ammoniacal nitrogen and butyric acid.

#### **4.3 Biodiesel production byproducts**

Brazil presents great potentialities to the oil plants cultivation for the biodiesel production because of its climate and ecosystem diversity. The main oleaginous cultivated in Brazil, which could be used in the making of biodiesel, are the soybean (*Glycine max*), the sunflower (*Helianthus annuus*), the castor oil plant (*Ricinus*

*communis*), the palm oil (*Elaeis guineensis*), the jatropha (*Jatropha curcas*), the forage turnip straw (*Raphanus sativus*), the cotton (*Gossypium* spp.), the peanut (*Arachis hypogaea*), the canola (*Brassica napus*), the sesame (*Sesamum orientale*), the babassu (*Orrbignya speciosa*) and the macaúba (*Acrocomia aculeata*) (BiodieselBr.com, 2008).

Most of the oleaginous meals which have been used to the biodiesel production in Brazil are susceptible to use in animal feeding, but each one with their particularities regarding the cares before being supplied to the animals due to the presence of some toxic or anti nutritional factors. As examples, it is mentioned the castor oil plant meal whose application is limited by the ricin and allergenic principles (Castor Bean Alergen – CBA), which can go to the milk of the cattle fed with it (Evangelista et al., 2007). And the jatropha meal which presents a phorbol ester that has carcinogenic activities and inflammatory action. The jatropha and castor oil plant meal have a high CP content and after taking the intoxication out, they can be used in the animal feeding.

Van Cleef (2008), in an essay *in vitro* comparing the jatropha meal and the forage turnip straw addition in elephant-grass silages, verified a reduction in the IVDMD and an increase in the pH values, in the ammoniacal nitrogen and in the lignin, proportional to the addition of the meal increasing levels to the silages. These ones, added with jatropha presented worse quality and IVDMD compared to the testified silages and added with forage turnip straw.

## **5 Economical feasibility of the tropical grass silages**

The usage of tropical grass silages to substitute the traditional corn silage is seen by many technician and producer as a technology capable to increase the efficiency in the pasture use, through the surplus harvesting produced during the rainy season. Also it is capable to minimize the feeding costs in feedlot, the milk cattle as well as the beef cattle, because of the greater possibility of optimize the land factor use, due to the greater productive potential which this forage resource presents regarding the corn and sorghum silages. However, as it was demonstrated by Igarasi et al. (2002), the high tropical grass productivity potential, capable to make them economically competitive forages, is not obtained in most cattle breeding settlements which use them. These authors observed a big variation extent of the production for these crops and very low values of the potential production preconized in literature. (Table 3)

Table 3. Tropical grasses yields

Production (t ha <sup>-1</sup> )	Range		Mean
	Minimum	Maximum	
Original matter harvest <sup>-1</sup>	14	35	23
Dry matter harvest <sup>-1</sup>	2.7	8.1	5.4
Original matter year <sup>-1</sup>	42	105	65
Dry matter year <sup>-1</sup>	8.1	24.3	17

Source: Igarasi et al. (2002)

Once the well managed corn farming produces from 13 to 14 t ha<sup>-1</sup> of DM, able to reach 20 t ha<sup>-1</sup> of DM in optimum conditions (Siqueira et al., 2007), the average productivity observed to the perennial grass silage (17 t ha<sup>-1</sup> year<sup>-1</sup> of DM) become not so attractive, even more considering that, in average, it is necessary to harvest three times so that the forage is produced in an efficient way, increasing the labor force to the silage making.

In the perennial grass silage case, it is believed that one of the principal causes of low productivity is the low fertilization used in the appropriate areas for its production. This way, once the decision is made to the silage production of perennial crop, the fertilization must be conducted to obtain high productions. (Siqueira et al., 2007).

The impact of the Tanzania grass productivity over the bio economic value of the diet formulated with this forage was shown in simulations made with feedlot cattle Muraro et al. (2008). Considering a weight gain of 1.25 kg animal<sup>-1</sup> day<sup>-1</sup>, these authors verified that the liquid profit per produced arroba (15 kg) has only been favorable to the ration containing Tanzania grass silage when this grass presented high production of DM (29 t ha<sup>-1</sup> year<sup>-1</sup>). But, considering the income per area, all the ration containing Tanzania grass silages presented a superior income if compared to that presented to the ration containing corn silage of low productivity (12 t ha<sup>-1</sup> year<sup>-1</sup> of DM) (Table 4), suggesting then being an advantageous strategies to make the use of these silages possible, that is, exploring the production scale to maximize the profit per area and not the performance of the animals individually.

Table 4. Charge and income simulation on finishing beef cattle fed with corn silage or Tanzania silage, estimated gain of 1.25 kg animal<sup>-1</sup> day<sup>-1</sup>

Forage	Corn silage		Tanzania silage			
	DM Yield, t ha <sup>-1</sup> year <sup>-1</sup>					
	12	14	17	21	25	29
Forage, % DM diet	41.9	41.9	26.8	26.8	26.8	26.8
Silage cost, R\$ t <sup>-1</sup> DM	247.50	212.00	305.50	247.00	208.00	179.00
Diet cost, R\$ t <sup>-1</sup> DM	369.54	354.63	409.98	394.28	383.81	376.03
@ (15 kg) Cost, R\$	59.49	57.08	65.99	63.47	61.78	60.53
Liquid profit, R\$ t <sup>-1</sup> diet	89.52	104.43	49.08	64.78	72.25	83.03
Liquid profit, R\$ ha <sup>-1</sup> year <sup>-1</sup>	2563.18	3488.50	3108.76	5068.73	7000.20	8971.68
Liquid profit, R\$ @ <sup>-1</sup>	14.41	16.82	7.91	10.43	12.12	16.82
Relative index, RL ha <sup>-1</sup>	100	-	121	198	273	350
Relative index, RL @ <sup>-1</sup>	100	-	55	72	84	117

Source : Muraro et al. (2008)

Although fundamental, the productivity is not the only factor which might be considered when it is intended to produce tropical grass silages. Another important aspect when choosing the forage is the nutritive value, since this factor determines the degree of its participation in the formulated diet. As the corn silage presents an energetic content higher than the tropical grass silages (10% more of TDN, in average), the TDN kilogram cost of the corn silage is lower than the same TDN kilogram of a perennial grass silage. This way, diets taking as basis corn silage present a bigger forage participation, while diets formulated based on tropical grass silages present the biggest participation of concentrate, because of the lower TDN content (Pereira et al., 2007). Thus, ration made with grass silages reach the cost, in average, 15% higher than the ones obtained with the other forages in the same weight gain rate (Muraro et al., 2008). Although these observations do not make the technology use impossible, they serve to demystify the idea of silage low costs for tropical grass. (Pereira et al., 2007; Muraro et al., 2008).

According to Pereira et al. (2007), the bio economic value of conserved forage diets depend of the concentrate feed price. That is, as the relative price of the energy source is reduced, the bio economic value of the high performance forage crops of DM per area and of a lower production cost, even with a lower nutritive value (lower TDN), as the tropical grass silages, become more attractive than the sorghum and corn silages. This way, the nutritive value loses its importance and increases the weight of the forage profit and the production cost of DM in the conserved forage bio economic value. Now in an opposite situation, where the relative price of the energy source is high, the forage nutritive value is the main factor which determines its bio economic value, even

considering the area, because it permits to minimize the use of the concentrate in the diet.

When simulations of the bio economic value of diets with conserved forage to beef cattle feedlot were made, with live weight starting on 400 kg, weight gain of 1.5 kg animal<sup>-1</sup> day<sup>-1</sup> and ton cost of the energy source feed of R\$ 319.46 Brazilian real, Pereira et al. (2007) noted that the most economically attractive options, under the animal performance aspects or per area, were the corn and sorghum basis diets. (Table 5). The higher energy value of these silages (mainly the corn ones), associated to lower TDN production costs favored them, considering the valid prices of the energy source feed. Regarding the animal performance, the tropical grass silages have shown little attractive with an average cost of diet production, per arroba, being 19% higher than the corn silage, and, in spite of the high revenue of DM per area, the tropical grass silage use resulted in an economical loss, considering the feed analysis only.

Table 5. Simulation of economic values of conserved forages in diets for feed lot cattle

Item	Silage					
	Unit	Corn	Sorghum	Elephant	Tanzania	Braquiarão
TDN	%	65	61	56	56	57
Forage on diet	%	51	42	36	35	35
Cost of forage	R\$ t <sup>-1</sup> DM	189.25	171.90	176.52	186.35	206.59
concentrate <sup>1</sup>	R\$ t <sup>-1</sup> DM	319.46	319.46	319.46	319.46	319.46
@ solded (A)	R\$ @ <sup>-1</sup>	55.00	55.00	55.00	55.00	55.00
Income per animal	R\$ animal/day	2.75	2.75	2.75	2.75	2.75
Income per area (B)	R\$ ha <sup>-1</sup>	7084.80	9553.20	23426.70	16850.30	11787.70
Cost of @ produced (C)	R\$ @ <sup>-1</sup>	53.43	54.30	56.51	56.90	58.30
feedlot animal	R\$ animal/day	2.67	2.71	2.83	2.85	2.92
DM t	R\$ t <sup>-1</sup> DM	283.00	287.60	299.30	301.50	308.82
per area (D)	R\$ ha <sup>-1</sup>	6882.80	9431.50	24068.90	17444.10	12496.00
<b>Feed balance</b>						
@ Produced						
E = (A - C)	R\$ @ <sup>-1</sup>	0.08	0.04	-0.08	-0.10	-0.17
Area F = (B - D)	R\$ ha <sup>-1</sup>	202.00	121.60	-642.20	-593.80	-708.3
<b>Cost-benefit ratio</b>	<b>%</b>	<b>2.9</b>	<b>1.3</b>	<b>-2.7</b>	<b>-3.4</b>	<b>-5.7</b>

Source: Adapted from Pereira et al. (2007)

<sup>1</sup> Corn + citrus pulp (1:1)

Besides, according to the authors, for the gain of live weight of 1.0 kg day<sup>-1</sup>, the difference in the production costs, per arroba, between diets with the sorghum and corn silages and the tropical grass, are higher than for the gain of 1.5 kg day<sup>-1</sup> due to the bigger nutritive value of the sorghum and corn silages, reflecting in a bigger forage participation in the diet to a lower level of performance. Concentrate high price and low levels of performance conditions, the advantages of the sorghum and corn silages when

compared to the tropical grass silages are enlarged because of the lower energy source concentrate, of high cost, in the diet.

In simulations carried out with dairy cattle and with the same prices of the energy source, Pereira et al. (2007) obtained the same conclusions observed to the beef cattle, that is, higher profitability, measured by the benefit-cost ratio in favor of sorghum and corn silages and the difference enlargement against the perennial grass silage, for the lower level of production simulated (30 kg versus 15 kg of milk cow<sup>-1</sup> day<sup>-1</sup>). Of course the price relations simulated by Pereira et al. (2007), of 5.8 @ t<sup>-1</sup> of concentrate or 0.6 kg of milk kg<sup>-1</sup> of concentrate, are not the same ones observed at the moment, however, what is clear is that it is not enough getting high productivities so the tropical grass silages are economically feasible, the energy source cost is a determining factor when deciding to adopt these forages.

Another issue which deserves to be commented is regarded to the ideal level of concentrate inclusion in diets formulated with tropical grass silages. To illustrate the importance of the diet adaptation and the animal performance on the bio economic feasibility of tropical grass silages, Pereira et al. (2008) evaluated the earning cost of the beef cattle carcass, finished in feedlot, from the experimental data obtained by Vieira (2007), with formulated diets with four levels of concentrate (20, 35, 50 and 65%, in DM basis), of which used forage was the silage of Tanzania-grass harvested in the 100<sup>th</sup> day, and they observed that the bio economic levels of concentrate introduction in the diet were located between 50 and 60% of DM. It is important to point out that the bio economic value of the forages is not static because it depends on the animal production level, the availability of feed and its price (Ely, 1992). This way, at the moment of the forage choice, factors like animal production potential, concentrate availability, production area availability, crop regional ability and producer ability are the main aspects to be considered (Nogueira, 2004).

To be able to ally production with quality, the tropical grass can not be ensiled in advanced vegetative stage. Nevertheless, its ensiling in a earlier vegetative stage presents some limits due to DM low contents, high buffering capacity and low contents of soluble carbohydrates, which justify the use of conditioning additives (Coan et al., 2008).

As the bacterial inoculants have not presented consistent results (Pereira et al., 2002), the additive usage which absorbs humidity and, at the same time, supplies carbohydrates represents a potentially important alternative. Since the expectancy of an



improvement of the fermentative standard of ensiled forage, resulting in a better quality silage, also with a higher energy content, and guaranteeing that the loss during the fermentative process are reduced, which would result in a higher efficiency of the ensiled forage. .

The pelleted citrus pulp, possibly, is the best example to characterize this additive group previously mentioned. This additive has the humidity absorption potential of 145% of its weight and besides that the introduction of 10% of pulp (natural matter base) in tropical grass silages can increase the energy content of the forages from 62 to 65% of TDN, making the material similar to good quality corn silage, in energy point of view.

Despite the favorable characteristics of this additive group, most of the studies limits itself to the qualitative aspects of the resulting silages and does not include economical feasibility analysis of adopting technology, which prevents from a more discerning evaluation concerning its use in cattle business on a large scale. (Coan et al., 2008).

The economical evaluation of finishing feedlot beef cattle, comparing to Tanzania and Marandu grass silages, harvested respectively on the 97<sup>th</sup> and 106<sup>th</sup> day, and corn silage, with diets formulated to attend to weight gain of 1.0 or 1.2 kg animal<sup>-1</sup> day<sup>-1</sup>, showed that, in a scenario with R\$ 58.50 arroba price and R\$ 751.67 thin animal price, in spite of the tropical grass silages ensiled with 10% of pelleted citrus pulp (PCP) (natural matter base) have presented satisfactory animal performance, the benefit/cost relation did not justify the substitution of corn silages to silages added with PCP, since the diets composed by Tanzania and Marandu grass silages and PCP presented, in average, 79.5% of the weight gain provided by corn silage, although having a 3.94% higher cost per gained arroba (Coan et al., 2008) (Table 6). Another important observation regarding this study is that the diet formulated with marandu-grass silage without adding PCP was the one which provided the higher return among all the diets formulated with tropical grass silages, showing then that, in the study conditions, even with improvements in the qualitative attributes of the silages using additive, basing on the economic result, its application would not be feasible in the adopted inclusion level.

Table 6. Economic evaluation of feedlot beef experimental diets with 1.0 and 1.2 kg animal<sup>-1</sup> day<sup>-1</sup> of weight gain

Item	Treatment							
	STZ	STZP	SMA1	SMAP1	SMA2	SMAP2	SMI1	SMI2
Forage on the diet (%)	38.35	61.59	35.51	56.69	18.00	28.45	59.01	29.57
Feeding cost, (85%), R\$	174.82	151.20	184.86	183.71	186.00	216.47	129.62	176.82
Other costs (15%), R\$	30.85	26.68	32.62	32.42	32.82	38.20	22.87	31.20
Total cost, R\$ (A)	966.53	938.48	978.46	977.09	979.81	1016.01	912.84	968.91
Total profit, R\$ (B)	1029.60	1017.90	1070.55	1064.70	1041.30	1058.85	1017.90	1076.40
Result R\$ (C = A – B)	63.07	79.42	92.09	87.61	61.49	42.84	105.06	107.49
Capital remuneration (%)a.m.	2.18	2.82	3.14	2.99	2.09	1.41	3.84	3.70
Rate of return, (%) a.m.	<b>6.53%</b>	<b>8.46%</b>	<b>9.41%</b>	<b>8.97%</b>	<b>6.28%</b>	<b>4.22%</b>	<b>11.51%</b>	<b>11.09%</b>

Source: Adapted from Coan et al. (2008)

\* STZ = Tanzânia silage (1.0 kg day<sup>-1</sup>); STZP = Tanzânia silage with 10% of pelletized citrus pulp (PCP) (1.0 kg day<sup>-1</sup>); SMA1 = Marandu silage (1.0 kg day<sup>-1</sup>); SMAP1 = Marandu silage with 10% of PCP (1.0 kg day<sup>-1</sup>); SMA2 = Marandu silage (1.2 kg day<sup>-1</sup>); SMAP2 = Marandu silage with 10% of PCP (1.2 kg day<sup>-1</sup>); SMI1 = corn silage (1.0 kg day<sup>-1</sup>); SMI2 = corn silage (1.2 kg day<sup>-1</sup>).

## 6 Conclusions

Only the high yield is not a guarantee of high bio economic value of diets formulated with tropical grass silages. The opportunities of these forages inclusion in the ruminant feed also depend on the energy source price, price of additives which improve the fermentative standards and their level of inclusion, animal genetic merit, and capacity of resources usage and possibility of agro industry byproducts use, mainly the energy sources such as the additives.

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