Rev. Bras. Saúde Prod. An., Salvador, v.12, n.2, p.286-295 abr/jun, 2011 http://www.rbspa.ufba.br
ISSN 1519 9940

Quality and nutritional value of pearl millet genotypes silage produced with and without inoculants

Qualidade e valor nutritivo de silagem de genótipos de milheto produzidas com e sem inoculante bacteriano

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SUMMARY

The objective was to evaluate the quality of silage produced from millet genotypes with and without inoculants. The experiment was conducted on the campus of the Agronomy Faculty of Rio Verde University. The experimental design was a randomized block design with four replications in a factorial 5 x 2, with five pearl millet genotypes: ADR 500, ADR 7010, LAB 0730, LAB 0731 and LAB 0732 and two treatments: with and without addition of inoculants. The results showed that the silage produced from new genotypes of pearl millet can be considered of good quality. However, the addition of the inoculant had no consistent effect on the silage quality, considering dry matter, crude protein, hemicellulose and pH values. Only the fibrous fractions were modified with the addition of the inoculant in pearl millet genotypes.

Key words: crude protein, fibrous fractions, pH, total digestible nutrients

RESUMO

Objetivou-se avaliar a qualidade de silagem de genótipos de milheto produzidas com e sem inoculante bacteriano. O experimento foi conduzido no Campus da Faculdade de Agronomia da Universidade de Rio Verde. O delineamento experimental utilizado foi de blocos ao acaso, com quatro repetições, em esquema fatorial 5 x 2, sendo, cinco genótipos de milheto: ADR 500, ADR 7010, LAB 0730, LAB 0731 e LAB 0732 e dois tratamentos: com e sem adição de inoculante bacteriano. Os resultados demonstraram que as silagens produzidas com os novos genótipos de milheto, podem ser consideradas de boa qualidade. Contudo, a adição do inoculante bacteriano não teve efeito consistente sobre a qualidade das silagens, no que diz respeito aos teores de matéria seca, proteína bruta, hemicelulose e valores de pH. Apenas as frações fibrosas sofreram alterações com a adição do inoculante nos genótipos de milheto.

Palavras-chave: frações fibrosas, nutrientes digestíveis totais, proteína bruta, pH

INTRODUCTION

The diversification of crops for the annual summer forage production is highly desirable, since the cost of maize and sorghum silage production is quite high. Accordingly, alternative crops of annual grasses have been successfully used in many tropical regions. Among them stands out the millet, which are being explored as an alternative for that period by presenting agronomic characteristics of high drought resistance, low soil fertility adaptation, rapid growth, characterized by its earliness and high yield potential of dry mass (GUIMARÃES JÚNIOR et al., 2008).

The use of silage becomes an option to circumvent the problem of seasonal fluctuation of pasture production and therefore the livestock production decrease in winter. The use of millet in the ensiling process has grown significantly, with positive results due to the silage quality (GUIMARÃES JÚNIOR et al., 2005b; AMARAL et al., 2008).

The number of pearl millet genotypes launched in the market has increased lately, which necessitates better nutritional assessment of these materials as silage. In Brazil, the studies on this species have been developed through the breeding program, aiming to produce earlier pearl millet genotypes with high yield and nutritional value. In 2003 the ADR 500 variety was released and in 2007 the ADR 7010 was considered the first hybrid millet of Brazil (BENEDETTI, 2009). Thus, it is important to obtain technical information, supported by scientific studies on the behavior of these new genotypes.

Although millet have good nutritional characteristics there has been used some additives on silage fermentation. The use of inoculant is indicated in order to promote more efficient fermentation production of lactic acid, accelerating the pH drop and inhibit undesirable fermentation processes that spoil the silage. There are numerous studies on the additive, however, the results related to improvements of the fermentation and nutritional value are still contradictory (AVILA et al., 2009). Thus, studies are needed to evaluate the efficacy of bacterial inoculants sold in Brazil, within our terms of production. The objective of this research was to evaluate the quality of pearl millet genotypes silage with and without bacterial inoculants.

MATERIAL AND METHODS

The experiment was conducted on the campus of the Faculty of Agronomy University of Rio Verde which is located on the farm sources of knowledge, at 748 m of altitude, 17° 48' south latitude and 50°55' west longitude. The soil was classified as distroferric red latossol, which physical and chemical characteristics at a depth of 0-20 cm, are presented in Table 1.

Table 1. Results of chemical and physical analysis of soil.

pH	Ca	Mg	Al	H + Al	P	K	Cu	Zn
Water	cmolc/dm^3				mg/dm^3			
4.8	1.11	0.39	0.10	5.0	8.17	70.2	3.7	1.8
CEC	V	MO	Clay		Silty		Sand	
cmolc/dm^3	%	g/kg	g/kg					
6.6	25.1	31.2	600		50		350	

The area preparation was done by eliminating invasive plants, applying glyphosate at a dosage of 1.458 g/ha. Fifteen days after desiccation it was used 1.0 tons of lime, with 95% PRNT, and it was subsequently made a harrowing, followed by leveling. The pearl millet [*Pennisetum glaucum* (L.) R. Br] genotypes were established on 20 february, 2009, where they were manually sown on ground already furrowed and fertilized with 250kg/ha with the formulation of 2-20-19 (NPK). There were used 6 lines of 10m for each genotype, spaced 0.5m between rows. The quantities of seed used were 12kg/ha, to achieve a density of 250.000 plants/ha. The nitrogen (80kg N/ha) was performed 30 days after seeding, topdressing, using as source the ammonium sulfate.

The experimental design was randomized blocks with four replications in a factorial 5 x 2 being five genotypes of pearl millet: ADR 500 (commercial variety), ADR 7010 (commercial hybrid), LAB 0730, LAB 0731 and LAB 0732 (experimental hybrids) and two treatments: with and without inoculants addition.

For the fermentation process, the pearl millet genotypes were harvested in April in the soft dough growth stage, 60 days after sowing, with average levels of dry matter of 27.5%. The materials were collected with a knife, close to the ground. Subsequently were minced, in particles of 10 to 30mm. For the treatments receiving inoculant there were used 2g (400 g referring to 10 tons of material) of Bacto Silo®, diluted in 80 mL of distilled water and sprayed on 3kg of forage to be ensiled in a homogeneous way. Then the materials were stored in silos of PVC, measuring 10cm in diameter and 40cm in length. The ensiled material was packed with iron pendulum and the silos were sealed with PVC caps, fitted with Bunsen valves and sealed with tape. Once closed, the silos were placed in a tilted position, to facilitate the exit of effluents by Bunsen valve, simulating a trench silo.

After 60 days of fermentation, the silos were opened, discarding the top and bottom portion of each. The central portion of the silo was homogenized and placed in plastic trays. After opening the silos, it was analyzed the pH values, using a pot Expandomatic Beckman SS-2. Later these materials were weigthed and taken to a forced ventilation oven to 60-65°C for 48 hours for pre-dried matter determination. The samples were ground in a Willey-type mill with a mesh sieve of 1mm, for further analysis.

The chemical analyzes were performed to determine the levels of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, cellulose and hemicellulose by the method described by Silva e Queiroz (2002). The total digestible nutrient (TDN) was obtained through the NDF content, using the formula: % TDN = 105.2 - 0.68 (% NDF), proposed by Chandler (1990).

The results were subjected to analysis of variance by the statistical program SISVAR 4.6 (Ferreira, 2000) and means were compared by Tukey test at a significance level of 5%.

RESULTS AND DISCUSSION

Analysis of variance showed no significant effect (P> 0.05) in DM of pearl millet genotypes silage, treatments with and without addition of inoculant and interaction of these factors (Table 2), showing that the addition of inoculum did not influenced the results. Avila et al. (2009), working with mombaça grass silage, found that the inoculants addition did not affect the DM content of silage, that was around 28.2%. However, Rodrigues et al. (2002), found that the addition of commercial inoculants for silage sorghum decreased DM content of silage.

The protein levels were not affected (P>0.05) by treatments with and without inoculant and by the interaction of genotype and treatment (Table 3). Similar results were also obtained by Pereira et al. (2007) that working with different additives for silage of forage sorghum hybrid, found that the use of inoculant did not affect crude protein content of silage. The authors reported that inoculant application had no consistent effect on fermentation profile and quality of silage. However, Rocha et al. (2006) studied the nutritive value of corn silage with enzyme-bacterial inoculants, found that the crude protein content of the inoculated silages was higher than the non inoculated. This suggests a reduced proteolysis in the silage treated with inoculant, thus resulting in better conservation of the protein content of these silages, a fact not observed in this study.

Table 2. Dry matter (DM) of pearl millet genotypes ensiled with and without inoculant

Pearl millet genotypes	With inoculant	Without inoculant	Average
	DM (%)		
ADR 500	29.06	28.66	28.86[a]
ADR 7010	28.12	29.63	28.87[a]
LAB 0730	31.67	30.10	30.88[a]
LAB 0731	28.57	29.17	28.87[a]
LAB 0732	30.01	29.61	29.81[a]
Average	29.48[A]	29.43[A]	-
CV (%)	8.51		-

Averages follow by distinct letter differs by Tukey test (P<0.05).

Table 3. Crude protein (CP) of pearl millet genotypes ensiled with and without inoculant

Pearl millet genotypes	With inoculant	Without inoculant	Average
	CP (%)		
ADR 500	13.45	12.96	13.20[A]
ADR 7010	13.06	11.30	12.18[AB]
LAB 0730	9.60	10.03	9.81[B]
LAB 0731	10.30	12.10	11.20[AB]
LAB 0732	11.76	11.43	11.59[AB]
Average	11.63	11.56	-
CV (%)	13.86		-

Average follows by distinct letters, capital letter in column (genotypes), difers by Tukey Test (P<0.05).

There was significance (P<0.05) only in the crude protein of silage of pearl millet genotypes (Table 3). The greatest amount of silage was obtained in ADR 500 genotype, differing only from genotype LAB 0730. Considering that crude protein levels below 7% are limiting for ruminant production, by requiring a lower intake, digestibility and reduction in negative nitrogen balance (VAN SOEST, 1994), notes that even the silage of LAB 0730 genotype, which had the lowest crude protein content, showed levels above the critical level, serving well the minimum protein requirements of ruminants, due to silage quality. These results are due to genetic improvement process that seeks at each selection cycle, higher genotypes to those already on the market. Guimarães Júnior et al. (2008) reported that although the energy content of pearl millet grain is lower than the maize and sorghum, it has high protein content, which explains the millet recommendation as an interesting option for the ensiling process.

Another important variable that expresses the forage quality is the NDF, comprising the structural carbohydrates that are mostly utilized by ruminants, mainly cellulose and hemicellulose (VAN SOEST, 1994).There were significant effects (P<0.05) among pearl millet genotypes, treatments with and without inoculant and interaction of these factors for the NDF and TDN (Table 4).

Table 4. Levels of neutral detergent fiber (NDF) and total digestible nutrients (TDN) of pearl millet genotypes ensiled with and without inoculant

Pearl millet genotypes	With inoculant	Without inoculant	Average
	NDF (%)		
ADR 500	54.66^{ABa}	51.73^{Ba}	53.19
ADR 7010	59.03^{Aa}	61.33^{Aa}	60.18
LAB 0730	58.33^{Aa}	59.33^{Aa}	58.83
LAB 0731	51.00^{Bb}	60.33^{Aa}	55.66
LAB 0732	57.66^{Aa}	59.73^{Aa}	58.69
Average	56.13	58.49	-
CV (%)	3.67		-
	TDN (%)		
ADR 500	57.13^{ABa}	54.07^{Bb}	55.60
ADR 7010	61.70^{Aa}	64.10^{Aa}	62.90
LAB 0730	60.97^{Aa}	62.01^{Aa}	61.49
LAB 0731	53.30^{Bb}	63.06^{Aa}	58.18
LAB 0732	60.27^{Aa}	62.43^{Aa}	61.35
Average	58.67	61.13	-
CV (%)	3.76		-

Average follows by distinct letters, capital letter in column (genotypes) and lower in line (treatment) differs by Tukey test (P<0.05).

Evaluating the genotypes, it is observed that the addition of the inoculant in silage of LAB 0731 and ADR 500 genotypes had the lowest NDF content differing from other genotypes, showing the best results (Table 4). However, without addition of the inoculant at ensiling process, the lowest NDF content was obtained for ADR 500 cultivar. Guimarães Júnior et al. (2005a) evaluated the fibrous fractions of silages of three pearl millet genotypes, and observed NDF content of 52.94, 46.96 and 55.51% at 56 days of fermentation for the CMS-1, BRS-1501 and BN-2 genotypes, respectively. These levels were below our study for the pearl millet genotypes.

Comparing the treatments with and without inoculation, only LAB 0731 cultivar was affected, showing that the addition of the inoculant reduced the NDF content of 18.30% over the non-application of this additive (Table 4). This lower fiber content is desirable because, according to Van Soest (1994), the reduction in forage fiber enables improvements in the consumption and digestibility.

The highest levels of NDT for silages with inoculant were observed in genotype ADR 7010 and LAB 0730 and 0732, differentiating from silage of LAB 0731, which showed the lowest value of TDN. Already without the addition of inoculant, only ADR 500 differed from other genotypes, having the lowest levels of TDN (Table 4). This difference between genotypes may be due to genetic improvement through the varieties, obtaining with this, new hybrids, which have certain superiority over nutritional value. This is known as genetic gain due to the selection of superior individuals in the process of improvement.

Cappelle et al. (2001) reported that estimates of energy values of foods and diets are important for animals with high production, especially for dairy cows, which require large amounts of energy. Diets deficient in energy reduces the milk production, causing excessive weight loss, reproductive problems and may reduce resistance to disease.

Comparing treatments, it was observed that inoculant addition increased by 5.37% TDN content of cultivar ADR500, compared with the non-application of this additive in the ensiling process (Table 4). However, for silage of LAB 0731 adding the inoculant reduced the TDN content of 18.16%. The silage genotypes ADR 7010, LAB 0730 and 0732, were not affected by the addition of this additive.

There was no significant effect (P>0.05) of interaction between treatment and pearl millet genotypes with and without inoculation, however, ADF, lignin and cellulose were influenced (P<0.05) by treatments (Table 5).

The addition of the inoculant in silage regardless of genotypes reduced ADF by 13.2% when compared with no addition of this additive. This decrease is considered important because the ADF content is correlated with digestibility of food. High levels of ADF in forage crops reduce the digestibility of dry matter, affecting the performance of the animals (VAN SOEST, 1994). Studying the quality and nutritive value of three pearl millet genotypes, Amaral et al. (2008) found that ADF of 38.43, 38.71 and 41.38% when harvested 70 days after sowing, for the genotypes BRS 1501; BN1 and Policy, respectively. These levels were similar to those found in this study, in silages of different pearl millet genotypes.

The lower levels of lignin were obtained with the addition of the inoculant in the silage of LAB 0731 and 0732 genotypes, with reductions of 45.1 and 37.0% when compared with those who did not receive this additive (Table 5). This reduction is considered relevant to improving the nutritional value of forage and increasing silage consumption by animals, because the lignin is associated with indigestible food. Low concentrations of lignin allow better use of the fiber by microorganisms in the rumen (RIBEIRO et al., 2008). As for the other silages of pearl millet genotypes, the addition of the inoculant did not affect the levels of lignin, showing similar levels (Table 4).

The addition of the inoculant at ensiling process of ADR 500 and 0731 LAB genotypes showed significantly lower levels of cellulose, with a reduction of 25.6 and 37.5% respectively, compared to the silages of these genotypes that have not received the additive (Table 5).

Table 5. Levels of acid detergent fiber (ADF), lignin and cellulose of pearl millet genotypes ensiled with and without inoculant

Pearl millet genotypes	With inoculant	Without inoculant	Average
	ADF (%)		
ADR 500	32.66^{b}	40.66^{a}	36.65^{A}
ADR 7010	38.66^{a}	40.67^{a}	39.66^{A}
LAB 0730	35.20^{a}	38.00^{a}	36.60^{A}
LAB 0731	34,06^{b}	41.56^{a}	37.81^{A}
LAB 0732	40.03^{a}	43.73^{a}	41.88^{A}
Average	36.12^{b}	40.92^{a}	-
CV (%)	10.54		-
	Lignin (%)		
ADR 500	5.66^{a}	6.57^{a}	6.12^{A}
ADR 7010	5.33^{a}	6.66^{a}	5.99^{A}
LAB 0730	6.40^{a}	6.56^{a}	6.48^{A}
LAB 0731	5.05^{b}	7.33^{a}	6.19^{A}
LAB 0732	5.34^{b}	7.32^{a}	6.33^{A}
Average	5.56^{b}	6.88^{a}	--
CV (%)	14.29		--
	Cellulose (%)		
ADR 500	27.07^{b}	34.00^{a}	30.53^{A}
ADR 7010	33.33^{a}	34.06^{a}	33.69^{A}
LAB 0730	28.80^{a}	31.32^{a}	30.06^{A}
LAB 0731	26.65^{b}	36.66^{a}	31.65^{A}
LAB 0732	34.63^{a}	36.40^{a}	35.51^{A}
Average	30.09^{b}	34.48^{a}	-
CV (%)	12.98		-

Average follows by distinct letters, capital letter in column (genotypes) and lower in line (treatment) differs by Tukey test ($P< 0.05$).

Guimarães Júnior et al. (2005a) studying with different genotypes of pearl millet in the process of fermentation, found levels of cellulose of 28.20, 24.52 and 30.26% at 56 days of fermentation, for CMS-1, BRS-1501 and BN-2 genotypes, respectively. These levels were similar to those found in this study for pearl millet genotypes.

The hemicellulose is known as a reserve carbohydrate and a potential source of energy for microorganisms in the rumen. It is considered the main source of additional substrate for the silage fermentation and could be consumed, between 40% to 50%, by microorganisms in the ensilage process (HENDERSON, 1993). The hemicellulose and pH values

Rev. Bras. Saúde Prod. An., Salvador, v.12, n.2, p.286-295 abr/jun, 2011 http://www.rbspa.ufba.br
ISSN 1519 9940

were not affected (P> 0.05) by pearl millet genotypes, treatment with and without inoculants and interaction of these factors (Table 6). The averages of hemicellulose were between 20.65 and 20.00% with the addition of inoculant and without addition of inoculant, respectively, for the silage of pearl millet genotypes.

Table 6. Hemicellulose and pH values of pearl millet genotypes ensiled with and without inoculant

Pearl millet genotypes	With inoculant	Without inoculant	Average
	Hemicellulose (%)		
ADR 500	22.00	21.45	21.75[a]
ADR 7010	20.36	20.66	20.51[a]
LAB 0730	23.13	21.33	22.23[a]
LAB 0731	19.10	18.66	18.88[a]
LAB 0732	18.67	17.94	18.30[a]
Average	20.65[A]	20.00[A]	-
CV (%)	15.01		-
	pH values		
ADR 500	3.67	3.96	3.81[a]
ADR 7010	3.80	3.86	3.83[a]
LAB 0730	3.83	3.53	3.68[a]
LAB 0731	3.73	3.83	3.78[a]
LAB 0732	3.74	3.86	3.80[a]
Average	3.75[A]	3.80[A]	-
CV (%)	5.88		-

Average follows by distinct letters, capital letter in column (genotypes) and lower in line (treatment) differs by Tukey test (P<0.05).

According to Pazian et al. (2006), the use of enzymes at ensiling aims to increase the availability of carbohydrates to lactic acid bacteria, with consequent decrease in pH, and raising the OM digestibility. However, the addition of inoculant was not effective in changing the profile of fermentation in the silo, providing silage with a pH statistically equal to silage without additive addition. The pH values of the silages of pearl millet genotypes were between 3.75 and 3.80 with the addition of inoculant and without addition of inoculant, respectively. These pH values are within the proper range (3.8 to 4.2), which did not turn possible undesirable secondary fermentations (JAYME et al., 2009). Rodrigues et al. (2002), evaluating sorghum silage quality found that the use of bacterial enzyme additive had no influence on silage pH. Similar results were also obtained by Pazian et al. (2006), evaluating inoculated Tanzania grass silage.

McDonald et al. (1991) reported that the final pH of silage is an indicative of the quality of the fermentation process, and its value inside the silo must become, as

quickly as possible, low enough to inhibit the growth of undesirable bacteria, such as those from Clostridium gender.
The silage produced by new genotypes of pearl millet can be considered of good quality. However, the addition of the inoculant had no consistent effect on the quality of silage, with respect to DM, CP, hemicellulose and pH values.
Only the fibrous fractions were modified with the addition of the inoculant in pearl millet genotypes silage.

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Data de recebimento: 25/05/2010
Data de aprovação: 10/03/2011