パニックグラスおよびローズグラスサイレージの発酵品質と飼料価値

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Fermentation Quality and Feeding Value of Panic Grasses and Rhodesgrass Silages.

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Synopsis

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The fermentation quality and feeding value of guineagrass (*Panicum maximum* JACQ var. *natsukaze*), green panic (*P. maximum* var. *trichoglume* EYLES), colored guineagrass (*P. coloratum* L.) and rhodesgrass (*Chloris gayana* KUNTH var. *katambora*), under a silage cutting regime of three harvest per growing season were evaluated. The first and second cuttings were field wilted before ensiling but the third was not wilted due to poor weather conditions. In digestion trails the silages were fed to four wethers.

The pH values of all silages were high, ranging from 4.6 to 5.8. The lowest pH values were consistently obtained from silages made from unwilted herbage of the third cutting. The silages were well preserved as indicated by the low contents of butyric acid and volatile basic nitrogen as a percentage of total nitrogen (VBN/T-N). Most of the silages contained more lactic acid than acetic acid. However, the second and third cuttings of green panic and second cutting of colored guineagrass produced acetate-type silages.

With the exception of silage prepared from the first cutting of guineagrass, differences among and within the species in digestibilities of DM and other constituents were small. The mean DCP content was in the ranking order green panic (6.6%) > colored guineagrass (5.9%) = rhodesgrass (5.9%) > guineagrass (5.3%). The mean TDN content was in the increasing order of guineagrass (51.8%), green panic (51.9%), colored guineagrass (52.1%), rhodesgrass (53.3%), with only slight differences among species. Relative to rhodesgrass, which was used as a comparison species, the DCP yields of guineagrass, green panic and colored guineagrass were 142, 130, and 102%, respectively. The respective TDN yields of guineagrass, green panic and colored guineagrass were 146, 106, and 91% of that of rhodesgrass. Guineagrass and green panic showed the considerable potential of DCP and TDN yields and compared favorably with rhodesgrass.

Key words : Colored guineagrass, DCP yield, Digestibility, Green panic, Guineagrass, TDN yield.

Introduction

The genus *Panicum* contains many species, sub-species and varieties cultivated which are widely in the tropics, sub-tropical and even in temperate regions[9,17]. Guineagrass, green

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panic and colored guineagrass are some of the important grasses belonging to the genus Panicum. Despite their importance, there is limited information on the fermentation quality and nutritive value of these grasses. This is partly due to the fact that silage making is not a popular practice among farmers in the tropics. Lack of good quality pasture throughout the year *per se* is a major factor hindering the expansion of ruminant production in tropical countries. The seasonality in forage production resulting from the seasonal rainfall emphasizes the need for conservation of forage for periods of short supply. Frequently, the vagaries of the weather, especially in the tropics, does not enable hay making at the correct time to give maximum yield of digestible nutrients. The ensiling of excess forage produced during inclement weather of the wet season could be a better alternative for 'ironing out' the fluctuations in forage supply.

The objectives of this study were to evaluate the fermentation quality and feeding value of silages of three panic grasses, under a 3-cut harvest system. Comparisons were made with rhodesgrass, an improved tropical grass species.

Materials and methods

Silage making

The following four grass species, under a three cuts system was used in this study : guineagrass (*Panicum maximum* JACQ var. *natsukaze*), green panic (*P. maximum* var. *trichoglume* EYLES), colored guineagrass (*P. coloratum* L.) and rhodesgrass (*Chloris gayana* KUNTH var. *katambora*). Seeding was done on 14 May 1991. Fertilizer application, stage of cutting and other cultural practices were already reported[1]. The primary growth (cut-1), first (cut-2) and second (cut-3) regrowths were hand-harvested, using sickles, on 25 July, 28 August and 29 October 1991, respectively. The cut herbage were wilted in the field (except in the third cut) to a dry matter content of approximately 29.2–37.5%, chopped into about 2 cm length with a chop machine, thoroughly mixed and ensiled in 200 l polyethylene silos. The materials were compacted by tramping as the silos were filled and the tops of the silos were sealed with vinyl film to prevent aeration. The ensiling period was about 60 days.

The recovery of dry matter of silage was determined by the buried bag method. Two plastic screen bags each filled with 2 kg silage material were evenly buried in each silo. The bags were removed from the silos as they appeared on the surface of the silage, weighed and sampled for dry matter determination.

Digestion trial

Three to five years old Japanese corriedale wethers, weighing 41 to 56 kg, were used for the conventional sheep digestion trial. The animals were housed in separate metabolic cages. In each trial, a 7-day total collection period was preceded by a 7-day preliminary feeding period with four sheep for each experimental silage.

Analytical methods

Dry matter content (DM) of herbage was determined by oven-drying method at 80 ℃ for 24 h. Silage DM content was determined by distillation with toluene[5]. The proximate fractions were determined by the conventional method[16]. Neutral detergent fiber (NDF) and acid detergent fiber (ADF), were estimated according to the methods of new feed analysis method[14], and nitrogen by the Kjeldahl technique. Volatile basic nitrogen was measured by micro-diffusion method, and pH of silage was carried out with a glass electrode meter. Water soluble carbohydrates (WSC) was estimated colorimetrically using anthrone and organic acids by the Flieg's method[16]. Statistical analysis was performed using the analysis of variance and Duncan's multiple range test was used to test for differences between means.

Results and discussion

The chemical compositions of the silage materials at ensiling are shown in Table 1. Within each species, the DM contents were higher in the first and second cuttings. The low DM contents of third cuttings were due to the inclement weather conditions which prevented the wilting of the silage materials. The DM contents of wilted colored guineagrass and rhodesgrass were greater than those of guineagrass and green panic. However, the DM contents of unwilted silage materials were almost the same among species.

The amounts of WSC in the silage materials ranged from 4.3 to 6.9%. These values were lower than those reported for temperate grasses[7], but were within the range of those reported for tropical grasses[3,4]. Within each species, no vast differences were noted among cuttings in WSC content. On the average, WSC contents of colored guineagrass and rhodesgrass silage materials were slightly higher than those of guineagrass and green panic.

Crude protein content of the silage materials ranged from 7.2 to 14.2%. The crude protein content of the third cutting of each species was the highest and those of colored guineagrass were highest at each cutting.

The NDF and ADF contents of the first and second cuttings of colored guineagrass were slightly lower than those of other species. In guineagrass and rhodesgrass, the NDF and ADF contents of the first and second cuttings were slightly higher than those of the third cuttings. The higher NDF and ADF contents of the first and second cuttings may be associated with the

Table 1. Chemical composition of silage materials at ensiling (% DM).

Species	Cut	Dry matter	Organic matter	Crude protein	Crude fat	Crude fiber	NFE[1]	Crude ash	NDF	ADF	WSC
Guineagrass	1st	31.8	87.2	7.2	3.5	32.6	43.9	12.8	68.8	43.2	5.1
	2nd	29.2	87.0	8.1	3.5	32.5	42.9	13.0	68.8	41.2	5.1
	3rd	18.1	87.1	13.1	2.8	30.1	41.1	12.9	66.4	37.1	5.3
Green panic	1st	33.4	89.4	9.0	2.1	31.6	46.7	10.6	67.0	42.0	5.6
	2nd	30.5	87.7	9.9	2.1	33.8	41.9	12.3	71.3	43.6	4.3
	3rd	20.4	87.1	13.8	2.0	32.4	38.9	12.9	71.2	38.0	5.0
Colored guineagrass	1st	37.9	86.7	9.2	3.5	26.5	47.5	13.3	59.4	35.1	6.9
	2nd	34.9	85.9	11.7	3.5	28.7	42.0	14.1	63.4	35.9	5.2
	3rd	18.3	87.4	14.2	3.1	26.9	43.2	12.6	66.1	33.8	5.9
Rhodesgrass	1st	38.5	89.2	8.5	3.0	31.3	46.4	10.8	72.4	39.4	5.9
	2nd	37.7	87.4	9.0	4.0	32.2	42.2	12.6	71.5	39.2	5.8
	3rd	17.4	86.5	13.0	2.7	29.6	41.2	13.5	71.2	32.9	6.3

[1] NFE : nitrogen free extracts ; NDF : neutral detergent fiber ; ADF : acid detergent fiber ; WSC : water soluble carbohydrates.

higher temperatures[1)] during growth which promote more rapid physiological development and accumulation of structural matter[23)].

As shown in Table 2, the silages obtained from the third cutting of all species had lower DM content, reflecting the dry matter content of the herbage at ensiling. Generally, the contents of crude protein and NDF of the silages closely resembled those of the materials at ensiling.

Table 3 shows the fermentation quality of the silages. The recovery of dry matter varied from 90.1 to 96.8% DM. The contents of residual WSC were lower in the silages than the corresponding silage materials, indicating a net use of sugars during ensiling.

Table 2. Chemical composition of silages (% DM).

Species	Cut	Dry matter	Organic matter	Crude protein	Crude fat	Crude fiber	NFE[1)]	Crude ash	NDF	ADF
Guineagrass	1st	29.1	88.0	6.1	4.3	38.1	39.5	12.0	70.1	44.4
	2nd	27.1	86.9	7.6	3.5	38.2	37.6	13.1	71.2	46.4
	3rd	15.5	85.3	11.5	4.0	30.3	39.5	14.7	55.9	29.7
Green panic	1st	31.6	88.2	6.8	3.0	35.2	43.2	11.8	70.3	44.5
	2nd	28.9	86.8	9.9	4.0	37.4	35.5	13.2	60.6	44.0
	3rd	18.1	86.9	12.7	3.5	28.9	41.8	13.1	58.8	35.6
Colored guineagrass	1st	35.3	85.9	8.2	4.0	30.3	43.4	14.1	62.1	35.6
	2nd	32.9	85.3	9.1	4.5	31.4	40.3	14.7	60.7	36.1
	3rd	16.1	85.8	11.1	3.5	34.7	36.5	14.2	62.0	40.4
Rhodesgrass	1st	36.5	88.9	7.7	3.4	36.2	41.6	11.1	72.1	43.2
	2nd	35.2	87.7	8.5	5.9	33.2	40.1	12.3	72.0	40.5
	3rd	15.9	86.8	12.4	5.0	31.1	38.3	13.2	59.3	34.2

1) Refer to Table 1. for NFE, NDF, ADF.

Table 3. Recovery of dry matter and fermentation quality of silages.

Species	Cut	Recovery of DM (%)	WSC	pH	Organic acids (% fresh weight)				Lactic/ acetic ratio	Flieg's score	VBN[1)]
					Acetic	Butyric	Lactic	Total			T-N (%)
Guineagrass	1st	91.0	2.7	5.8	0.77	0.25	0.95	1.97	1.23	45	7.10
	2nd	90.1	1.7	5.7	0.55	0.00	0.81	1.36	1.47	70	4.48
	3rd	91.5	2.5	4.6	0.77	0.05	0.83	1.65	1.08	55	4.58
Green panic	1st	96.8	2.8	5.8	0.74	0.00	1.30	2.04	1.76	80	3.36
	2nd	95.8	3.2	5.3	1.19	0.00	0.26	1.45	0.22	50	5.09
	3rd	94.1	3.0	4.7	0.80	0.05	0.52	1.37	0.65	40	3.83
Colored guineagrass	1st	96.2	3.8	5.6	0.95	0.00	1.59	2.54	1.67	80	3.92
	2nd	90.1	2.2	5.1	1.02	0.00	0.68	1.70	0.67	60	5.03
	3rd	93.7	2.5	4.6	0.63	0.00	0.84	1.47	1.33	70	4.48
Rhodesgrass	1st	91.0	2.4	4.9	1.01	0.00	1.85	2.86	1.83	80	4.31
	2nd	93.6	2.3	5.4	0.78	0.01	2.74	3.53	2.62	88	2.31
	3rd	93.7	2.1	4.5	0.69	0.05	0.92	1.66	1.33	55	3.86

1) VBN/T-N : Volatile basic nitrogen/total nitrogen.

The pH of the silages were generally high, ranging from 4.6 to 5.8. The high pH value of all silages agreed with those reported for tropical grass silages[2,3,4,7,20,22]. The pH values of the unwilted silages (third cutting) were lower than those of the wilted silages (first and second cuttings), is in accordance with the findings of other workers[6,10,18,19,24].

The total acid content (DM basis) of the unwilted silages of the third cutting was higher than those of the wilted silages (first and second cuttings). Thus, wilting by increasing dry matter content of the ensiled herbage restricted fermentation. At each cutting, the lactic acid and total acid contents of rhodesgrass silages were higher than those of the panic grasses. Guineagrass and rhodesgrass silages consistently produced more lactic acid than acetic acid. A similar trend was observed in silages of green panic and colored guineagrass, except that the silages obtained from the second and third cuttings of green panic and second cutting of colored guineagrass, tended to produce more acetic acid than lactic acid. The consensus of opinion has been that acetic acid rather than lactic acid was the main preservative in tropical grass silages[2,3,4,7,20]. In the present study, however, only the second and third cuttings of green panic and second cutting of colored guineagrass produced typical acetate-type silages. On the contrary, WOODWARD et al[25]. reported that lactic acid was the major fermentation end-product in most of the silages of elephantgrass, except in silages of immature dwarf elephantgrass where both lactic and acetic acids were major fermentation end-products. It was also reported, by TANAKA et al.[21], that in guineagrass silages, lactic, acetic and succinic acids were the major fermentation acids. In this study, most of the silages fall in the category of the aforementioned authors[21,25]. Admittedly, because the microflora and fermentation pathways of the silages were not elucidated in this study, it is difficult to offer a satisfactory explanation for the variation in lactic/acetic ratio. Nevertheless, the low lactic/acetic ratio in the silages of the second and third cuttings of green panic, and second cutting of colored guineagrass reflects fermentation of lactic acid to acetic[8,26] and heterolactic acid fermentation[12,13,26]. Also, a high acetic acid level was indicative of saccharolytic clostridia or enterobacteria activity[13,24]. Further studies are needed to clarify factors which influence the production of acetate-type silages and microbial composition of tropical grass silages.

The fermentation quality of the silages were evaluated according to the Flieg's score which is based upon the relative proportions of acetic, butyric and lactic acids[11,26]. In the silages of the first cutting, the Flieg's scores of green panic, colored guineagrass and rhodesgrass were remarkably higher than those of guineagrass. Rhodesgrass silages, especially those obtained from the second cutting, were of better quality. The silages prepared from the second cuttings of green panic and colored guineagrass had Flieg's scores of 50 and 60, respectively, denoted medium or average quality. Majority of the silages had Flieg's scores between 68–85, denoted good or very good silage quality. However, it is noteworthy that according to CATCHPOOLE and HENZEL[3], chemical standards which indicate the nature and extent of anaerobic changes in silage based on lactic acid content should be used with caution when assessing the fermentation quality of tropical herbage species if their preservation is not due to lactic acid fermentation.

With the exception of the silages derived from the first cutting of guineagrass, the silages produced trace amounts of butyric acid. According to the criteria developed to assess the efficiency of fermentation and preservation of silages based on butyric acid and VBN as a ratio of total nitrogen[11,26], the silages were considered to be well preserved.

The apparent digestibility of dry matter (DM) of the silages varied from 49.2% to 58.6% (Table 4). The DM digestibility of silages of the first cutting, especially guineagrass, which was remarkably lower than those of other silages. The low DM digestibility of the silage of the first cutting may be partly attributed to the low crude protein content and the high fiber content except for colored guineagrass. The DM intake of silage of the first cutting of guineagrass (1.1% per liveweight) was on the average 27% lower than those of other silages (1.5% per liveweight). The correlation between DM intake and digestibility was significant ($r = 0.78$). There were no significant correlations between intake and the concentrations of VBN, acetic acid, butyric acid and lactic acid. Therefore, the depression in intake of the silage obtained from the first cutting of guineagrass could not be linked with either the products of clostridial fermentation or higher concentrations of free acids in the silage.

Apparent digestibility of crude protein varied from 51.3 to 72.4% and were within the range reported for tropical grasses[15]. Crude protein and crude fat digestibility of silages made from first cutting of guineagrass and green panic were lower than those of other cuttings. Digestibility of crude protein and crude fat were not very great for the silages of colored guineagrass. Within silages of rhodesgrass, crude protein and crude fat digestibility of the third cutting were higher than those of the first and second cuttings. Crude fiber digestibility of silages of the first cutting of guineagrass, green panic and rhodesgrass were lower than those of the second and third cuttings. The NFE digestibility of silages of the first

Table 4. Digestibility, digestible nutrients (% DM), DCP and TDN yields of silages.

Species	Cut	Dry matter	Organic matter	Crude protein	Crude fat	Crude fiber	NFE[1]	NDF	ADF	DCP	TDN	DCP yield[2] (kg/a)	TDN yield (kg/a)
Guinea-grass	1st	49.2	50.3	51.3	50.2	57.1	43.6	48.2	50.6	3.1	47.0	3.2^b	48.8^b
	2nd	57.0	57.6	63.8	72.0	64.5	48.3	59.3	61.2	4.9	53.3	6.3^a	68.7^a
	3rd	57.1	60.0	69.4	76.9	65.8	51.1	53.1	54.6	8.0	55.0	5.3^a	36.7^{bc}
	Total (Mean)									(5.3)	(51.8)	14.8^A	154.2^A
Green panic	1st	52.8	53.7	53.1	51.7	55.5	52.4	58.2	58.2	3.6	49.3	3.0^b	41.5^b
	2nd	58.6	58.9	72.4	78.2	69.3	40.0	65.7	65.7	7.2	54.3	5.3^a	40.1^b
	3rd	54.8	56.9	72.0	64.3	57.0	51.6	51.9	51.9	9.1	52.2	5.3^a	30.5^c
	Total (Mean)									(6.6)	(51.9)	13.6^B	112.1^B
Colored guinea-grass	1st	53.2	55.5	56.8	62.6	55.6	54.6	51.2	53.1	4.7	50.8	3.2^b	34.7^{bc}
	2nd	56.6	58.2	62.5	58.0	61.1	56.2	57.1	63.6	5.7	53.4	3.6^b	33.7^{bc}
	3rd	56.9	57.9	64.4	59.3	54.3	59.1	55.2	59.2	7.2	52.2	3.8^b	27.4^{cd}
	Total (Mean)									(5.9)	(52.1)	10.6^C	95.8^D
Rhodes-grass	1st	49.8	51.6	56.4	51.8	56.4	46.4	50.8	51.6	4.3	47.8	4.1^b	45.7^b
	2nd	56.5	58.6	53.7	57.3	62.4	56.7	59.8	63.0	4.6	55.6	3.5^b	42.2^b
	3rd	57.1	60.3	71.8	72.9	68.5	47.6	56.1	59.5	8.9	56.6	2.8^b	17.5^d
	Total (Mean)									(5.9)	(53.3)	10.4^C	105.4^C

[1] Refer to Table 1. for NFE, NDF, ADF.
[2] Means in the same column with different superscripts are significantly different ($P < .01$).

cutting of guineagrass, colored guineagrass and rhodesgrass were lower than those of the second and third cuttings. Generally, the NDF and ADF digestibility of the first cutting, especially guineagrass, was low.

Digestible crude protein (DCP) content of the silages ranged from 3.1 to 9.1%. The DCP contents in the silages of the third cutting of all species were higher than those of other silages. The ranking order of the mean DCP content was : green panic (6.6%)>rhodesgrass (5.9%)= colored guineagrass (5.9%)>guineagrass (5.3%).

The DCP yield was calculated by multiplying DM yield[1] by DCP content and DM recovery. Total DCP yield was in the ranking order : guineagrass (14.8 kg/*are*)>green panic (13.6 kg/*are*)>colored guineagrass (10.6 kg/*are*)>rhodesgrass (10.4 kg/*are*). Relative to rhodesgrass, which was used as a reference, the DCP yield of guineagrass, green panic and colored guineagrass were 142, 130, and 102%, respectively. Within guineagrass and green panic, DCP yields of second and third cuttings were greater than those of the first cutting. Within rhodesgrass, DCP yield of the first cutting tended to be greater than those of the second and third cuttings. On the other hand, within colored guineagrass, DCP yield did not differ significantly among cuttings.

The total digestible nutrients (TDN) varied from 47.0 to 56.6%. The TDN content of silages made from the first cuttings of guineagrass, green panic and rhodesgrass were lower than those of other silages. Within colored guineagrass, TDN contents of silages were not significantly different, although those of the first cuttings tended to be low. The ranking for mean TDN content was: rhodesgrass (53.3%)>colored guineagrass (52.1%)>green panic (51.9%)>guineagrass (51.3%), with small differences among species.

The TDN yield, calculated as for DCP yield, was in the ranking order : guineagrass (154.2 kg/*are*)>green panic (112.1 kg/*are*)>rhodesgrass (105.4 kg/*are*)>colored guineagrass (95.8 kg/*are*). The respective TDN yields of guineagrass, green panic and colored guineagrass were 146, 106, and 91% of that of rhodesgrass. Comparing cuttings, TDN yield of the second cutting of guineagrass was significantly greater than those of first and third cuttings. Within green panic and rhodesgrass, TDN yields of the first and second cuttings were significantly greater than those of third cutting. Within colored guineagrass, TDN yields did not vary significantly among cuttings.

Although the DCP and TDN contents of guineagrass silages were slightly lower than those of other species, guineagrass was the highest yielding species, therefore, the yields of total digestible nutrients of this species were significantly greater than those of other species. It was concluded that these panic grasses, especially guineagrass, offer considerable potential for silage DM production, and where ensiling conditions are satisfactory, ensiling would be useful method of conserving surplus forage for supplementary feeding of ruminants.

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* : In Japanese with English summary.

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パニックグラスおよびローズグラスサイレージの発酵品質と飼料価値

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要　約

3回刈したギニアグラス，グリーンパニック，カラードギニアグラスとローズグラスでサイレージを調製し，それらの発酵品質と飼料価値を評価した。1番草と2番草は圃場で予乾したが，3番草は天候が悪く予乾せずにサイレージを調製した。これらサイレージの消化試験は4頭の去勢羊を供試して実施した。

サイレージのpH価は4.6～5.8の範囲で高く最低のpH価は無予乾の3番草サイレージで得られた。これらサイレージは酪酸含量とVBN/T-N比がともに低く，良く保蔵されていた。サイレージの多くは乳酸含量が酢酸含量より高かったが，グリーンパニックの2, 3番草とカラードギニアグラスの2番草では酢酸含量が乳酸含量より高い酢酸サイレージとなった。

消化率はギニアグラスの1番草サイレージを除き，供試サイレージ間で差がなかった。サイレージの平均DCP含量はグリーンパニック6.6%カラードギニアグラス＝ローズグラス5.9%＞ギニアグラス5.3%の順であった。また，平均TDN含量はギニアグラス51.8，カラードギニアグラス52.1，グリーンパニック51.9およびローズグラス53.3%を示し，種間差は小さかった。対照牧草のローズグラスのDCP収量を100とした場合，ギニアグラス，グリーンパニックおよびカラードギニアグラスのそれは146，130および102であり，同じくTDN収量についてはギニアグラス，グリーンパニックおよびカラードギニアグラスはそれぞれ146，106および91であった。ギニアグラスおよびグリーンパニックはローズグラスに比較してDCPおよびTDNの生産能力が相当高くサイレージ利用上，ローズグラスより有利であった。

キーワード：カラードギニアグラス，ギニアグラス，グリーンパニック，消化率，TDN収量，DCP収量.

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