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Short communication

A comparison of the yield, nutritional value and predicted production potential of different maize hybrids for silage production

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Abstract

The yield, nutritional value and production potential of silage made from twenty one maize hybrids was compared. The digestibility of organic matter and predicted intake, mean retention time and milk production potential were found to differ between hybrids ($p < 0.05$). Acid detergent fibre content could not be used to accurately predict the metabolizable energy content of silage.

Keywords: Milk production, intake, mean retention time, silage, yield.
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Introduction

Maize silage is used extensively in diets for beef and dairy cattle in South Africa. Large differences in nutritional value may exist between silage made from different maize hybrids (Hunt *et al*., 1993). Givens *et al.* (1995) have shown that substantial variation exists in respect of the proportions of starch and cell-wall components in maize silage, and that these are not closely related to differences in digestibility. Methods used to characterize the nutritional value of maize silage should take differences in the rates and extent of rumen degradation of starch and cell-wall components into account (Givens *et al*., 1995). Aufrère *et al.* (1992) evaluated 12 maize hybrids and found that crude protein content varied from 5.8 to 13% and organic matter digestibility from 62.8 to 77.4%. This variation is influenced by the hybrid used, stage of growth, location and season. The aim of the present study was to compare yield, nutritional value, rate and extent of digestion, predicted intake and milk production potential of silage made from 21 different maize hybrids.

Materials and methods

Twenty one maize hybrids were planted using a randomized block design. Three adjacent blocks, each containing a 5 m row of each hybrid, were planted at a density of 22 000 plants/ha at Oberholzer, South Africa (26° 08' S, 27° 35' E; altitude 1725 m). Rows were 91cm apart. The soil was a sandy loam Hutton type with a pH(KCl) of 4.8; the concentrations of P, K, Ca, Mg, Zn and Na were 45, 75, 520, 87, 5.2 and 12 mg/kg respectively. The total rainfall from October to May was 482 mm, the monthly precipitation (mm) being 58, 35, 145, 79, 28, 81, 40 and 16 for October, November, December, January, February, March, April and May respectively. The long-term average rainfall for the area is 561 mm per year. Fertilizer (2:3:4(33)) was applied at the time of planting at a rate of 75 kg/ha. One hundred kg KAN (28) was applied six weeks after planting, when plants had reached the 6-8 leaf stage. All maize hybrids were harvested at the three-quarter milkline stage: when the kernels were dented and the lower leaves of the plants had started to dry off.

Plants were counted and weighed to determine yield. All plants were passed through a commercial silage chopper, and a representative sample of the fresh chopped material was taken. The plant-material was ensiled in mini-silos, which consisted of 1.5 litre glass jars equipped with lids that allowed gas release (J. WECK, GmbH, Wehr-Oflingen, Germany). Dry matter (DM) content was determined by drying at 60 °C for 72 hours. *In vitro* organic matter digestibility (IVOMD) of oven-dried samples and rate of digestion were determined as described by

Tilley & Terry (1963) and modified by Pienaar & Kühn (1991) to include measurement of gas production. Metabolizable energy (ME) content was estimated using IVOMD and fat content as follows:

Total digestible nutrients (TDN) = 48 h IVOMD + ((% fat-2)/100) x 1.91

ME (MJ/kg DM) = TDN x 20.66 x 0.82 x %OM / %DM

Intake was calculated by dividing the predicted rumen organic matter (OM) content by the predicted retention time of OM in the rumen as described by Pienaar & Roux (1989). The predicted milk production potential of hybrids for a 600 kg cow was calculated from the estimated ME value and intake, assuming that no other nutrient was limiting (Pienaar & Roux, 1989). Neutral detergent fibre (NDF) was determined according to Robertson & Van Soest (1981), and acid detergent fibre (ADF) according to Goering & Van Soest (1970). Nitrogen (Kjeldahl) and fat content were determined according to AOAC (1984). Analysis of variance was done using the Statgraphics (1988) statistical package for least significant differences.

Results and discussion

The composition of silage made from the different maize hybrids is given in Table 1. All silage samples had a low pH and were well preserved. There were no differences in NDF or ADF content between hybrids. Mean NDF and ADF values were 46.7±1.9% and 25.2±1.1% respectively, and are comparable with the values of 47.7±3.6% for NDF and 23.3±2.6% for ADF reported by Aufrère *et al.* (1992) for French cultivars**.**

Table 1 Nutritional value and pH of silage made from different maize hybrids (DM basis)

Hybrid	DM (%)	pH	CP (%)	IVOMD (%)	ME (MJ/kgDM)	NDF (%)	ADF (%)
NS9100	35.0^{abcd}	3.53^{a}	6.6^{ab}	72.4^{a}	10.20^{a}	46.3	23.6
PAN6364	39.7^{a}	3.60^{abcd}	6.7^{ab}	65.9^{bc}	10.00^{ab}	45.7	23.9
PAN6140	33.0^{abcd}	3.66^{abcdef}	7.4^{a}	63.3^{ab}	9.80^{abcd}	46.3	25.3
CAR3414	31.5^{cd}	3.66^{abcdef}	6.3^{ab}	64.0^{ab}	9.87^{abc}	49.4	25.5
PHB3253	33.6^{bcd}	3.65^{abcde}	6.7^{ab}	62.0^{abc}	9.73^{abcd}	44.3	22.9
SNK2266	34.1^{bcd}	3.81^{efghi}	6.7^{ab}	61.7^{abcd}	9.50^{abcde}	48.1	25.4
CAR3852	35.3^{abcd}	3.62^{abcd}	7.2^{ab}	62.7^{abc}	9.70^{abcde}	44.1	24.3
SNK2888	36.0^{abc}	$3.74^{cdefghi}$	7.2^{a}	63.7^{ab}	9.70^{abcdef}	45.0	23.8
A1598	37.5^{ab}	$3.75^{cdefghi}$	7.2^{ab}	62.3^{abc}	9.63^{abcdef}	46.3	24.9
SNK2154	35.5^{abc}	3.91^{i}	6.7^{ab}	60.7^{abcd}	9.37^{abcdef}	46.4	25.8
NS5122	30.5^{d}	3.65^{abcde}	7.1^{ab}	61.7^{abcd}	9.30^{abcde}	48.2	25.4
PHB3442	33.0^{bcd}	3.87^{hi}	7.2^{a}	60.3^{abcd}	9.33^{abcdef}	49.5	26.6
PAN6146	34.8^{bcd}	3.76^{defghi}	6.6^{ab}	60.7^{abcd}	9.40^{abcdef}	50.1	26.1
PAN6479	31.4^{cd}	3.58^{abc}	5.7^{b}	61.0^{abcd}	9.50^{abcdef}	45.7	23.4
PHB3412	31.5^{cd}	3.70^{bcdef}	7.2^{a}	59.3^{bcd}	9.13^{bcdef}	45.3	24.9
SNK2255	34.9^{bcd}	3.83^{ghi}	7.1^{ab}	59.0^{bcd}	9.13^{bcde}	46.2	25.6
CAR4526	33.7^{bcd}	3.71^{cdefgh}	7.1^{ab}	62.0^{abcd}	9.23^{bcdef}	45.8	26.5
SNK2665	31.3^{cd}	3.53^{ab}	7.7^{a}	61.0^{abcd}	9.17^{bcdef}	48.1	26.6
A1539	32.5^{cd}	3.83^{fghi}	7.3^{a}	58.0^{cd}	8.93^{cdef}	48.0	26.1
SNK2265	33.1^{bcd}	$3.67^{abcdefg}$	6.4^{ab}	58.0^{cd}	8.90^{def}	48.4	26.3
PAN6255	33.7^{bcd}	3.86^{hi}	6.9^{ab}	56.7^{d}	8.73^{f}	43.0	25.4
PAN6043	34.0^{bcd}	3.83^{fghi}	7.0^{ab}	57.7^{cd}	8.83^{ef}	47.8	26.0
Mean	33.9	3.72	6.9	61.1	9.41	46.7	25.2
SD	2.2	0.11	0.4	2.3	0.43	1.9	1.1
SEM	1.7	0.06	0.3	1.8	0.33	2.7	1.4

^{abcdef}Means within columns without common superscripts differ ($p < 0.05$); SD: standard deviation; SEM: standard error of the mean

The estimated ME values of silage differed between cultivars ($p < 0.05$), and varied from 8.83 to 10.20 MJ ME/kg DM. De Boever *et al*. (1988) reported that the ME content of 50 maize silages in Belgium varied between 9.75 and 12.21 MJ ME/kg DM. The crude protein content (Table 1) of maize silage varied between 5.7 and 7.7%, which was lower than values (8.2-11.4%) reported by De Boever *et al*. (1988). The relationship ($p < 0.05$; $R^2 = 0.48$; n = 66) between ME and ADF content was best described by the equation:

ME (MJ/kg) = 14.0501 - 0.18421 ADF (%)

The standard error of the constant was 0.6001, and the standard error of the factor was 0.023737.

Givens *et al*. (1995) compared the use of different laboratory analyses to predict the *in vivo* digestibility of maize silage, and found that ADF concentration accounted for 42.6% of the variation in organic matter *in vivo* digestibility. Prediction of the energy value of maize silage from ADF concentration may result in under or over estimation because the digestibility of cellulose or hemicellulose may vary, depending on the degree of crystallinity, acetylation or interlinking with lignin and silica (Giger-Reverdin, 1995). Silage yield, predicted intake, mean retention time and milk production potential is shown in Table 2. The predicted intake of SNK2154, i.e. 13.8 kg DM, was greater ($p < 0.05$) than that of PAN 6364, SNK2888, PAN6146, CAR4526, SNK2665 or SNK2265.

Table 2 Yield and predicted intake, mean retention time and milk production potential of silage made from different maize hybrids

Hybrid	DM Yield (ton/ha)	DM intake (kg/day)	Mean retention retention time (h)	Milk production (kg/d)
NS9100	14.7^{a}	13.4^{bcd}	24.9^{abc}	14.9^{cde}
PAN6364	13.2^{ab}	12.4^{ab}	27.0^{bcd}	14.2^{abcd}
PAN6140	12.0^{ab}	13.1^{bcd}	25.7^{abc}	14.0^{bcd}
CAR3414	14.7^{a}	12.8^{abcd}	26.1^{abc}	13.5^{abcd}
PHB3253	11.3^{ab}	12.8^{abcd}	26.1^{abc}	13.1^{abcd}
SNK2266	9.7^{b}	13.5^{cd}	24.6^{ab}	15.3^{bcd}
CAR3852	10.1^{b}	12.8^{abcd}	26.0^{abc}	13.3^{abcd}
SNK2888	12.1^{ab}	12.4^{abc}	26.8^{bcd}	12.3^{abcd}
A1598	11.5^{ab}	12.9^{abcd}	25.8^{abc}	14.1^{bcd}
SNK2154	11.1^{ab}	13.8^{d}	24.3^{a}	15.9^{bcd}
NS5122	10.7^{ab}	12.9^{abcd}	26.1^{abc}	13.4^{abcd}
PHB3442	11.1^{ab}	13.0^{bcd}	25.7^{abc}	13.3^{abcd}
PAN6146	13.0^{ab}	12.6^{abc}	26.7^{abcd}	11.7^{abc}
PAN6479	12.9^{ab}	13.0^{bcd}	25.4^{abc}	15.0^{bcd}
PHB3412	12.2^{ab}	12.8^{abcd}	26.1^{abc}	13.2^{abcd}
SNK2255	10.7^{ab}	13.1^{bcd}	25.3^{abc}	14.6^{bcd}
CAR4526	10.8^{ab}	11.8^{a}	28.6^{cde}	9.5^{a}
SNK2665	10.4^{ab}	12.5^{abc}	27.0^{abcd}	11.6^{ab}
A1539	10.9^{ab}	13.5^{cd}	24.6^{abc}	16.2^{bcd}
SNK2265	10.4^{b}	12.3^{ab}	27.0^{cd}	11.6^{abc}
PAN6255	10.6^{ab}	13.1^{bcd}	25.4^{abc}	13.2^{abcd}
PAN6043	11.6^{ab}	13.0^{bcd}	25.6^{abc}	13.6^{abcd}
Means	11.7	12.9	25.9	13.6
SD	1.3	0.45	1.0	1.6
SEM	1.4	0.4	0.8	1.5

^{abcdef}Means within columns without common superscripts differ ($p < 0.05$); SD: standard deviation; SEM: standard error of the mean

The DM yield of NS9100 and CAR3414 was higher than that of SNK2266, CAR3852 or SNK2265 ($p < 0.05$). Variation in the number of plants per row was the main cause of yield differences between hybrids. There were eight plants per five metre row for SNK2266, CAR3852 and SNK2265, which was less ($p < 0.05$) than that for NS9100 or PAN6043 (10 plants/5m). An average of 9.67 plants/5m was recorded for CAR3414. Differences between predicted dry matter intakes were due to differences between predicted mean retention times. Maize hybrid SNK2154 had a shorter predicted mean retention time (24.3 h) than that of PAN6364, SNK2888, CAR4526 or SNK2255 (Table 2). The estimate of mean retention time (MRT) combines the effects of digestibility and rate of digestion (Pienaar & Roux 1989). A shorter predicted MRT implies a higher digestibility and/or a faster rate of digestion. Predicted milk production varied from 9.5 to 16.2 kg/d. Differences in predicted milk production potential between hybrids were caused by differences in digestibility, predicted mean retention time and predicted intake. The production potential of maize hybrids should be considered when choosing a maize hybrid for silage production.

It was concluded that maize hybrids differ in ME content, rate of digestion, predicted intake and predicted milk production potential. The content of NDF and ADF did not differ between the maize cultivars used in this study and could therefore not be used to predict nutritional value or production potential.

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