In vitro fermentation characteristics of corn and sorghum silages

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ABSTRACT: Aim of the study was to compare corn and sorghum forages, before and after ensiling, in terms of chemical-nutritional characteristics and fermentation kinetics, to substitute corn silage with sorghum silage. The trial was performed using sorghum (*Sorghum vulgare*) and corn (*Zea mais*) incubated *in vitro* at 39°C for 120 h with buffalo (*Bubalus bubalis*) rumen fluid. The *in vitro* gas production technique was used to describe the fermentation kinetics and to estimate the enery value of forages. From chemical composition and *in vitro* fermentation emerged that for corn the ensiling caused more modification compared to sorghum in terms of loss of soluble fractions.

Key words: Sorghum silage, Corn silage, *In vitro* gas production technique, Buffalo.

INTRODUCTION - In the last years corn, the silage which represents the main forage in the diets of buffalo dairy cows in South of Italy, has shown some weak aspects in terms of quantitative and qualitative production (i.e. high contamination with aflatoxins and fumonisins, corn parasites and high cost of irrigation). Therefore, there is an interest for studying the possibility and convenience to substitute totally or partially corn silage with other forages (Colombo *et al*., 2007). Sorghum (*Sorghum vulgare*) has long been used in animal feeding, particularly in dry areas and the silage production has increased due to both increased planting and increased yield. Ensiling proved to be a successful method of preservation of the sorghum and the harvest at early bloom stage guarantee a high quality silage in terms of nutrient digestibility (Black *et al.*, 1980). Aim of this experiment was to compare the chemical and nutritional characteristics of corn and sorghum forages, before and after ensiling. The *in vitro* gas production technique was used to describe the fermentation kinetics and to estimate the energy value of forages. As reported by Hetta *et al*. (2007) the *in vitro* fermentation variables obtained from silage in combination with other feed characteristics can be used to predict the silage dry matter intake in dairy cows. Accurate prediction of voluntary food intake is important in modern feed evaluation systems, especially in silages due to the considerable variation in silage quality, due to crop management and weather impact.

MATERIAL AND METHODS - The trial was performed in a farm sited in Cassino (FR, Italy) using for the sorghum (*Sorghum vulgare*) a forage hybrid (BMR 333) and for

the corn (*Zea mais*) the cultivar CV Kamil (class FAO 400). The crops, seeded in May 2006, were harvested on September, chopped and ensiled in two bunker silos for about 40 d. Before and after ensiling, 3 representative samples were taken for each forage. The samples, pooled, dried at 60°C for 48 h and milled (1.1 mm screen) were analyzed for the chemical composition (AOAC, 1999) and the fibrous carbohydrates were fractioned (Van Soest *et al.*, 1991). Chopped and ensiled samples were analysed for *in vitro* fermentation characteristics with a manual gas recording system (Calabrò *et al.,* 2005). The rumen fluid was sampled at slaughter-house from 2 dry buffalo (*Bubalus bubalis*) cows fed a balanced forage-based diet. About 1 g of organic matter (OM) was incubated in six replications in serum bottles with 76 ml of buffered rumen fluid for 120 h at 39°C. The fermentation residue was filtrated through pre-weighted crucibles (porosity #2) and, of the remaining residues, 3 were treated with NDS boiling for 60 min (Van Soest *et al.*, 1991). After that, all crucibles were dried at 105°C, and then burned at 550°C to determine the OM and NDF degradability (OMD and NDFD, respectively). The data describing the cumulative gas production were fitted to a sigmoid model (Groot *et al*., 1996). The maximum gas production rate (R_{max}) and the time at which it occurs (T_{max}), were calculated according to Bauer *et al.* (2001). The nutritive value, expressed as net energy for lactation, was predicted as follows (Menke and Steingass, 1988): NEl (MJ/kg DM) = 0.54 + 0.0959 GP + 0.038 CP + 0.01733 CP^2 where GP is the 24 h gas production (ml/200 mg DM) and CP is the protein content of feed (g/kg DM). The Tukey's test was used to assesses *statistically* the influence of forage and ensiling on the *in vitro* characteristics using the proc GLM (SAS, 2000).

RESULTS AND CONCLUSIONS - For both silages the chemical composition (Table 1) is comparable to that in other investigations (Tomasoni *et al*., 2006). Sorghum showed slightly higher nutritive value and crude protein content, but a higher NDF content compared to corn. As expected, in both forages the ensiling caused a reduction of NEl and an increasing in structural carbohydrates contents. However, this trend was more marked in corn compared to sorghum.

Table 1. Chemical composition and nutritive value of the chopped and ensiled forages.

	DM	CP	EE	CF	NDF	ADF	ADL	Ash	NDS	NEl
	%				% DM					MJ/kg DM
Sorghum chopped	19.3	9.70	3.10	30.5	58.6	37.2	3.53	10.3	18.4	4.81
Sorghum ensiled	23.0	7.66	3.29	35.1	63.0	40.7	3.61	9.75	16.3	4.50
Corn chopped	33.7	6.34	2.42	24.0	50.8	28.3	2.86	4.69	35.8	4.66
Corn ensiled	28.2	8.60	3.41	32.0	53.1	36.2	4.32	8.79	26.1	4.16

NDS (neutral detergent soluble): 100 – CP – EE NDF – ash.

Concerning the fermentation characteristics (Table 2) the forage and ensiling factors significantly affected most of *in vitro* parameters. Comparing the two forages, a significantly higher (P<0.01) NDF digestibility was observed in sorghum silage, due to the lower ADL

content;, on the other hand a higher OMD and gas production and a faster fermentation process was observed in corn. According to the chemical composition, a different behaviour was observed between sorghum and corn after ensiling. In fact, in the former, OMD and NDFD are similar and not statistically significant between chopped and ensiled (OMD: 66.1 *vs*. 65.5 %; NDFD: 63.4 *vs*. 62.9 %), but for corn this parameters remarkably and significantly decreased (OMD: 73.3 *vs*. 64.1 %; NDFD: 66.0 *vs*. 57.6 %; P<0.01) after preservation. The reduction in OMD after ensiling in sorghum is probably due, as reported by Ciotti (1992), to the low DM content in the chopped sorghum. Is not easy to explain why after ensiling, the real gas production increased in sorghum; the volatile fatty acids produced at the end of incubation, still in course of elaboration, will give a contribute to understand this data.

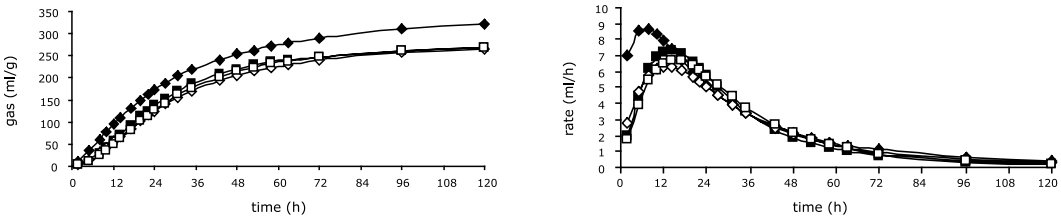
Table 2. *In vitro* fermentation characteristics at 120 h for chopped and ensiled forages.

	OMD	NDFD	OMCV	A	B	C	Tmax	Rmax
	%	%	ml/g	ml/g	h		h	ml/h
Sorghum chopped	66.1	63.4	222	290	28.2	1.69	12.6	6.33
Sorghum silage	65.5	62.9	231	285	27.1	1.94	15.1	6.74
Corn chopped	73.3	66.0	280	361	25.7	1.37	6.55	8.77
Corn silage	64.1	57.6	234	279	24.5	1.97	13.9	7.36
Forage	***	NS	***	***	***	***	***	***
Ensiling	***	***	***	***	NS	***	***	*
Forage*Ensiling	***	***	NS	***	***	***	***	***
MSD[1]	2.35	2.20	4.76	5.30	1.67	0.05	0.93	0.53
MSD[2]	1.59	1.51	3.22	3.65	1.13	0.03	0.63	0.36

OMVC: cumulative gas produced related to the incubated OM.
MSD: Minimum significant differences according to the Tukey test for P<0.01 ([1]) and P<0.05 ([2]).

No relevant differences emerged, in the gas production and the fermentation rate profiles of the chopped and ensiled forages (Figure 1). However corn forages showed a faster fermentative process characterised by a slightly higher fermentation rate. Moreover, as discussed before, ensiling corn caused more modification compared to sorghum in terms of soluble fraction losses (NDS: 18.4 *vs*. 16.2, in sorghum and 35.8 *vs*. 26.1 % DM in corn, chopped and ensiled, respectively); the corn silage curves are consistently higher than the analogous in sorghum. Ensiling sorghum determines only few modifications compared with corn. The *in vitro* results, in combination with other feed characteristics could be used to predict the silages DM intake in dairy buffalo cow.

Figure 1. In vitro gas production and fermentation rate over time in chopped and ensiled forages.



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