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In vitro fermentation of ten cultivars of barley silage

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ABSTRACT - The fermentation characteristics of whole-crop barley silages from ten different cultivars were evaluated by the *in vitro* gas production technique**.** The organic matter degradability of barley silage (62.9% in average) was comparable to those reported in our previous trials for oat (59.7%) and sorghum silages (65.5%); while the maximum gas production rate (5.38 ml/h in average) was slightly lower respect to oat (6.71 ml/h) and sorghum silage (6.74 ml/h). The mean nutritive value (4.00 MJ/kg DM) calculated on the basis of both chemical composition and *in vitro* fermentation data was comparable to that (4.16 MJ/kg DM) obtained in our previous research performed on corn silage, from crop sowed in the same area.

*Key words***:** Barley, *In vitro* gas production technique, Ensilage.

Introduction – Harvesting whole-crop cereal silage arouses increasingly interest because it enables crop rotation and manure utilization in the fields and reduces feed production costs (Manninen *et al.*, 2005). In south of Italy, whole-crop barley *(Hordeum vulgare* L.*)* harvested at milky-waxy maturation of grain (32-34 %DM) yields 10.5-12.5t of dry matter/hectare (Gianinetti and Stanca, 2006) and it has also been thought as possible and convenient substitute of corn silage which shows some weak aspects like high contamination with aflatoxins and fumonisins, parasites and high cost of irrigation. However, nutritive value of whole-crop barley silage is strongly influenced by several factors like cultivar, soil characteristics, water availability, weather conditions and stage of maturity. Aim of present work is to evaluate the chemical composition and the fermentation characteristics of whole-crop silages from 10 different cultivars of barley by means of the *in vitro* gas production technique (Theodorou *et al.*, 1994).

Material and methods – The trial was performed in a farm sited in Cassino (FR, Italy) using ten cultivars of barley, chosen for productive and morphologic characteristics and disease resistance, which were sowed (November 2007) in plots of 10 m^2 each and harvested (May 2008) at milky-waxy maturation of grain. The forage was chopped to 2 cm length using a cutter, and was well pressed in the microsilos. After ensiling (2 months), 3 representative samples of each cultivar were taken from each microsilos. The samples, pooled, dried at 60°C for 48 h and milled (1.1 mm screen) were analyzed for the chemical composition (AOAC, 2000), the fibrous carbohydrates were fractioned (Van Soest *et al.*, 1991) and pH was measured. The *in vitro* fermentation characteristics were studied (Calabrò *et al.,* 2005) incubating at 39°C about 1 g sample in three replications in serum bottles buffered rumen fluid. The rumen fluid was sampled at slaughter-house from 2 dry buffalo (*Bubalus bubalis*) cows fed a

standard diet. The gas production was recorded at 2 and 24h intervals using a manual system (Theodorou *et al.*, 1994). At 120 h the fermentation was stopped, pH was measured and the fermentation residue was filtered through pre-weighted crucibles (porosity #2), dried at 105°C, and then burned at 550°C to determine the OM degradability (OMD). The data describing the cumulative gas production were fitted to a sigmoid model (Groot *et al.*, 1996). The maximum gas production rate (Rmax) and the time at which it occurs (tmax), were calculated according to Bauer *et al.* (2001). The nutritive value (net energy for lactation) was predicted as follows (Menke and Steingass, 1988): NEl (MJ/kg DM)=0.54+0.0959GP+0.0038CP+0.0001733CP^2 where GP is the 24h gas production (ml/200 mg DM) and CP is the protein content of feed (g/kg DM). The influence of cultivar on the *in vitro* characteristics was statistically assesses using the proc GLM (SAS, 2000).

Table 1. Chemical composition (% DM), pH and nutritive value (MJ/kg DM) of barley silages.

Cultivar	DM	CP	NDF	ADF	ADL	pH	NEl
Alce	26.5	9.6	65.7	40.2	6.0	5.13	3.91
Aldebaran	27.3	9.8	65.1	45.7	5.6	5.36	4.06
Amilis	25.5	8.2	69.1	43.7	6.7	5.42	3.67
Boreale	25.6	9.0	66.1	41.2	4.1	5.26	4.33
Estival	28.4	8.5	67.5	45.3	5.3	4.58	3.58
Ketos	27.0	8.2	69.4	46.8	5.8	5.19	3.89
Lutece	27.7	9.0	65.2	44.5	6.0	5.33	4.14
Ninfa	24.3	9.5	68.5	42.5	5.7	5.07	4.03
Nute	24.6	9.7	62.1	43.0	5.2	4.77	4.18
Sixtine	24.9	9.5	67.6	44.6	4.7	5.08	4.25

Table 2. In vitro fermentation characteristics of barley silages.

Cultivar	pH	OMD	OMCV	A	B	tmax	Rmax
		%	ml/g	ml/g	h	h	ml/h
Alce	6.64	63.7B	228CD	271B	32.6B	15.2	5.15B
Aldebaral	6.65	61.3C	236BC	273B	33.1A	17.9	5.25C
Amilis	6.68	60.7C	223D	261B	32.2B	16.5	5.10B
Boreale	6.65	67.1A	250A	285A	28.6C	15.3	6.35A
Estival	6.69	63.6B	236BC	286A	35.3A	16.0	5.01C
Ketos	6.67	63.5C	245AB	289A	32.2B	15.3	5.56B
Lutece	6.69	61.5C	242BC	284A	32.6B	16.4	5.44B
Ninfa	6.65	63.8B	231CD	276A	34.0A	16.6	5.07C
Nute	6.65	61.3C	234C	281A	32.6B	14.3	5.30B
Sixtine	6.73	63.0BC	237BC	271B	30.9B	16.3	5.56B
MSE	0.0035	0.785	16.34	33.02	0.909	1.47	0.0376

OMD: organic matter degradability; OMCV: cumulative gas production of incubated OM; Rmax: maximum gas production rate; tmax: time at which Rmax occurs; A (ml/g): asymptotic gas production; B (h): time after incubation at which A/2 was formed. In the same column, A,B,C,D: P<0.01; MSE: mean square error.

Results and discussion – DM ranged between 24.3% and 28.4% (table 1) and was slightly lower than that reported by Manninen *et al.* (2005). These authors found on whole-crop barley silage also higher percentage of crude proteins (11.0% DM) and lower NDF (46.5% DM) than our results (CP% DM between 8.2 and 9.8; NDF% DM between 62.1 and 69.1) probably due to the early stage of harvesting (dough stage). The nutritive value calculated on the basis of both chemical composition and *in vitro* fermentation, ranged between 3.58 and 4.25 MJ/kg DM. It has to be underlined that the mean value is comparable to those (4.16 MJ/kg DM) obtained in our previous research (Calabrò *et al.*, 2007) performed on corn silage, from crop sowed in the same area.

As regards the fermentation characteristics (table 2), the values of pH was in each case higher than 6.4, useful to guarantee the activity of cellulolytic microrganisms (Doane *et al.*, 1997). All the cultivars show values of OMD (62.9% in average) comparable to those obtained *in vitro* with whole crop oat (59.7%, Calabrò *et al.*, 2005) and sorghum silages (65.5%, Calabrò *et al.*, 2007). The mean values of tmax

Figure 1. In vitro gas production over time.

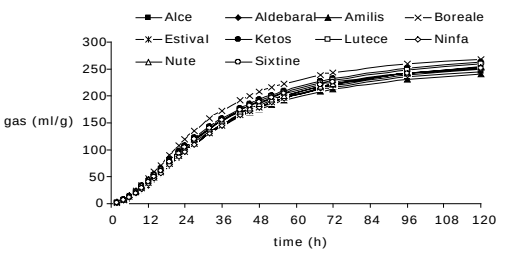
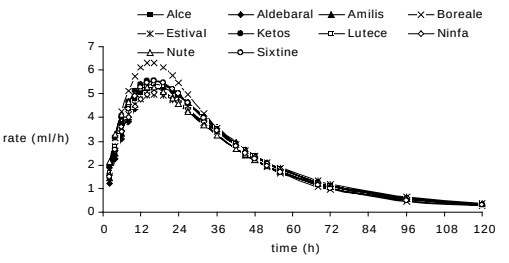


Figure 2. Fermentation rate over time.



for barley silage (16.0h) were similar to those obtained with sorghum silage (15.1h) but higher compared to oat silage (8.3h). Besides the mean values of Rmax (5.38 ml/h) were slightly lower that those obtained with oat (6.71 ml/h) and sorghum silage (6.74 ml/h). In present trial, the behaviour of the different cultivars for all the fermentation parameters (figure 1) was similar excepted for the "Boreale" which showed significantly ($P<0.01$) higher OMD and OMCV and faster fermentation kinetics. These last results are probably due to the lower lignin content (table 1). In conclusion, all the tested whole-crop barley silages showed a good fermentative behaviour and a nutritive value comparable to other cereal silages. However, a complete judgement on the tested barley silages will be possible from the elaboration in progress of their other qualitative characteristics.

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