EFFECT OF THE STORAGE TIME AND SEVERAL SILAGE INOCULANTS ON THE AEROBIC STABILITY OF SORGHUM SILAGES

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ABSTRACT - Effect of the storage time and several silage inoculants on the aerobic stability of sorghum silages
Aerobic stability of silages has great importance in practice. When the silo is opened, yeasts and moulds can grow due to exposure to the air. The process cause significant loss of nutrients and harmful silage will be produced. There are lot of published results on the fermentability, the nutritive value and digestibility of sorghum silages, but we have only limited knowledge about their aerobic stability. The aerobic stability is affected by several factors. As the sugar content is high one of the most important fact is the amount of easily fermented carbohydrate remaining after the fermentation – in case of sorghum silage.
In this paper we report the aerobic stability of sorghum silages changing in the function of storage time, using inoculants *Lactobacillus buchneri* (NCIMB 40788), *Propionibacterium acidipropionici* (MA 26/4U) and the preservative product Lalsil Fresh.
Four treatments were used (T1 untreated control, T2 treated with *Lactobacillus buchneri* $3x10^5$ CFU/g FM, T3 treated with *Propionibacterium propionici* $3x10^5$ CFU/g FM, T4 treated with 0.005 g/kg Lalsil Fresh). The Lallemand inoculant "Lalsil Fresh" contained selected strain of *Lactobacillus buchneri* (NCIMB 40788 $6x10^{10}$ CFU/g). Sorghum (Róna 1) was ensiled immediately after harvest, chopped to about 1-1.5 cm size, mixed with additives and ensiled in 4.2 L jars. The jars were incubated at 20+/-2 °C. Five jars per treatment were sampled on day 14, 28, 42, 56 and after 140 of storage. The aerobic stability, chemical and microbiological parameters were analysed from the silages.
Strong correlation was observed between the aerobic stability and the storage time of silages. At the beginning of fermentation the aerobic stability was still low but changed better with the progress of time. After complete fermentation, from the eight week of ensilaging stable silages could be observed. The aerobic stability of silages opened on the twentieth week was more than one week. Positive effect of the heterolactic bacteria was established. The aerobic stability was increased moderately by *Propionibacterium propionici*, and significantly *Lactobacillus buchneri*. Lalsil Fresh had the best effect on aerobic stability. All the treated silages opened on the twentieth week had better aerobic stability than the untreated.
Keywords: sorghum silages, aerobic stability, storage time, microbial inoculants

INTRODUCTION

Due to the climate changes caused by global warming, the numbers of droughty years are increasing, and that is while the cultivation of xerotolerant plants becomes important. It is well known that sorghum (*Sorghum bicolor L.*) belongs to drought resistant plants. Sorghum – as a forage-plant – has numerous advantages and some disadvantages properties. The sorghum is able to produce (depending on the drought weather) 10-30% more yield than silo maize. Due to the high sugar content of sorghum fermentation starts more rapidly, the pH decreases and the interval of auto-oxidation shortens. These conditions are favourable to lactic acid bacteria for fermentation (AVASI ET AL., 1997,

2001). Aerobic stability of silages has great importance in practice. When the silo is opened, yeasts and moulds can grow due to exposure to the air. The process cause significant loss of nutrients and harmful silage is produced (URIARTE ET AL. 2001). The aerobic stability is affected by several factors (initial microbial populations, density of the silage, exposure to air, exposure time, stage of maturity, DM content, ambient temperature, residual water soluble carbohydrate) (OHYAMA ET AL., 1975; WOOLFORD, 1978). As the sugar content is high one of the most important fact is the amount of easily fermented carbohydrate remaining after the fermentation – in case of sorghum silage. The residual WSC content is also relatively high and because of this the silage can spoil easier (WOOLFORD, 1990). Due to the fairly high carbohydrate content the aerobic stability of sorghum silage has been intensively studied. Supplementation with lactic acid bacteria during ensiling sorghum improved the fermentation process, but reduced the aerobic stability of the silage (MEESKE ET AL., 1993). The effect of heterofermentative bacterium *L. buchneri* has been investigated on the aerobic stability of sorghum silage. The bacterium decreased the growth intensity of yeasts and moulds, and it was established the aerobic stability of silages improved (FROETSCHEL ET AL., 1995; FILYA ET AL. 2002; WEINBERG ET AL., 2002).

MATERIAL AND METHOD

Four treatments were used (**T1**= untreated control, **T2**= treated with *Lactobacillus buchneri* $3x10^5$ cfu/g FM, **T3**= treated with *Propionibacterium acidipropionici* $3x10^5$ cfu/g FM, **T4**= treated with Lalsil Fresh 0.005 g/kg → $3x10^5$ cfu/g FM). The Lallemand inoculant „Lalsil Fresh" contained selected strain of *L. buchneri* (NCIMB 40788, $6x10^{10}$ cfu/g).

The sorghum (varieties Róna 1 from the research station of the Cereal Research Ltd. Szeged) was harvested at the doughty stages of maturity, and was ensiled immediately after harvest, chopped to about 1-1.5 cm size, mixed with additives and ensiled in 4.2 L jars. Silage density was 210 kg DM/m^3 +/-3%. The jars were stored at ambient temperature 20+/-2 ^oC.

Five jars per treatment were sampled on day 14, 28, 42, 56 and after 140 of storage.

The chemical and microbiological parameters and the aerobic stability were analysed from the silages. Dry matter content and crude nutrients (crude protein, crude fibre, crude fat, ash, nitrogen-free extract) were measured according to the Hungarian National Standards. The WSC (water soluble carbohydrate) was determined according to Mac Donald and Henderson, using anthron reagent and sulphuric acid, applying spectrophotometer. The content of lactic acid and volatile fatty acids was examined with ACME Joung Lin 6100 gas chromatograph device. The ammonia content from watery extract was measured with OP246/1 NH_3 measuring device. The number of yeast and mould colonies was determined on the basis of the Hungarian standard (MSZ ISO 7954).

The silages were tested for aerobic stability by HONIG (1986) method. For this purpose, 500 g of silage was put into an isolating box, and stored at environmental temperature of 20-22 ^oC. The temperature was measured in every hour. The rise of silages temperature was measured through 10 days. Aerobic stability was defined as the time passed until the temperature increased 3 ^oC above ambient temperature.

RESULTS AND DISCUSSION

The dry matter content of the fresh crops sorghum was 34.2 %. The chemical composition of sorghum on the basis of dry matter was: crude protein 64.3 $g.kg^{-1}$, crude fat 31.1 $g.kg^{-1}$, crude fibre 270.6 $g.kg^{-1}$, ash 64.9 $g.kg^{-1}$, WSC 424,8 $g.kg^{-1}$ (mean value, n=3).
The fermentation parameters of the silages after 2,4,6,8 and 20 week storage time are shown in *Table 1*.

Table 1. Fermentation parameters of sorghum silages on fresh basis

Storage time	Parameters		Treatments			
			T1	T2	T3	T4
2 weeks	Lactic acid	%	0.97	2.14	2.41	2.21
	Acetic acid	%	0.34	0.64	0.71	0.72
	Butyric acid	%	0.00	0.00	0.00	0.00
	Propionic acid	%	0.000	0.000	0.02	0.000
	pH		4.53	4.26	4.16	4.10
	NH_3-N	% of TN	9.16	10.98	9.08	9.18
4 weeks	Lactic acid	%	1.13	1.89	2.26	2.00
	Acetic acid	%	0.55	1.24	0.83	1.36
	Butyric acid	%	0.04	0.00	0.00	0.00
	Propionic acid	%	0.004	0.000	0.01	0.000
	pH		4.66	4.17	4.15	4.10
	NH_3-N	% of TN	10.37	9.68	8.15	8.23
6 weeks	Lactic acid	%	1.25	1.72	1.77	1.82
	Acetic acid	%	0.48	1.32	0.74	1.14
	Butyric acid	%	0.06	0.00	0.00	0.00
	Propionic acid	%	0.000	0.000	0.03	0.000
	pH		4.94	4.19	4.22	4.22
	NH_3-N	% of TN	8.02	7.61	6.68	6.27
8 weeks	Lactic acid	%	1.06	1.75	1.33	1.98
	Acetic acid	%	0.43	1.21	0.87	1.33
	Butyric acid	%	0.04	0.00	0.00	0.00
	Propionic acid	%	0.000	0.000	0.03	0.000
	pH		5.29	4.20	4.35	4.46
	NH_3-N	% of TN	11.64	8.94	8.28	8.77
20 weeks	Lactic acid	%	1.28	1.62	1.48	1.72
	Acetic acid	%	0.55	1.31	1.18	1.36
	Ratio LA:AA		2.33:1	1.24:1	1.25:1	1.26:1
	Butyric acid	%	0.06	0.00	0.00	0.00
	Propionic acid	%	0.000	0.000	0.06	0.000
	pH		5.29	4.35	4.44	4.47
	NH_3-N	% of TN	13.94	10.24	10.15	9.75

It can be seen that intensive fermentation was going on in the treated silages (T2, T3, T4) already in the first two weeks, and the lactic acid, acetic acid content was higher, the pH was lower than in the untreated control silages (T1).
Further fermentation resulted in lower lactic acid but more acetic acid amount in the treated silages. After the 20 weeks storage time the ratio of lactic acid: acetic acid was about 1,25:1.
The pH and ammonium content of treated silages were significantly lower than in the control.
Data concerning the aerobic stability and dry matter loss are shown in *Table 2.*
Comparing the aerobic stability of the treated silages with the control the treated samples can be considered much better after 2 weeks storage time and the dry matter loss is much lower in these treated silages. That is positive correlation was observed between the storage time and the aerobic stability, and negative correlation between the storage time and the dry matter loss. After 20 weeks storage the aerobic stability of treated silages was more than 300 hours (*Fig.1*), and during exposition to air lasting 10 days resulted in less than 1% dry matter loss.

Table 2. Aerobic stability of silages and dry matter loss after 10 day exposition to air

Storage time	Parameters		Treatments			
			T1	**T2**	**T3**	**T4**
2 weeks	**Aerobic stability**	**hour**	69	93	85	127
	Dry matter loss	**%**	12.0	11.0	11.2	6.7
4 weeks	**Aerobic stability**	**hour**	89	85	84	120
	Dry matter loss	**%**	11.1	10.2	10.0	8.6
6 weeks	**Aerobic stability**	**hour**	93	195	127	>240
	Dry matter loss	**%**	6.2	3.0	6.9	<1
8 weeks	**Aerobic stability**	**hour**	170	169	>190	>190
	Dry matter loss	**%**	4.8	4.9	4.1	3.0
20 weeks	**Aerobic stability**	**hour**	200	>300	>300	>300
	Dry matter loss	**%**	6.6	<1	<1	<1

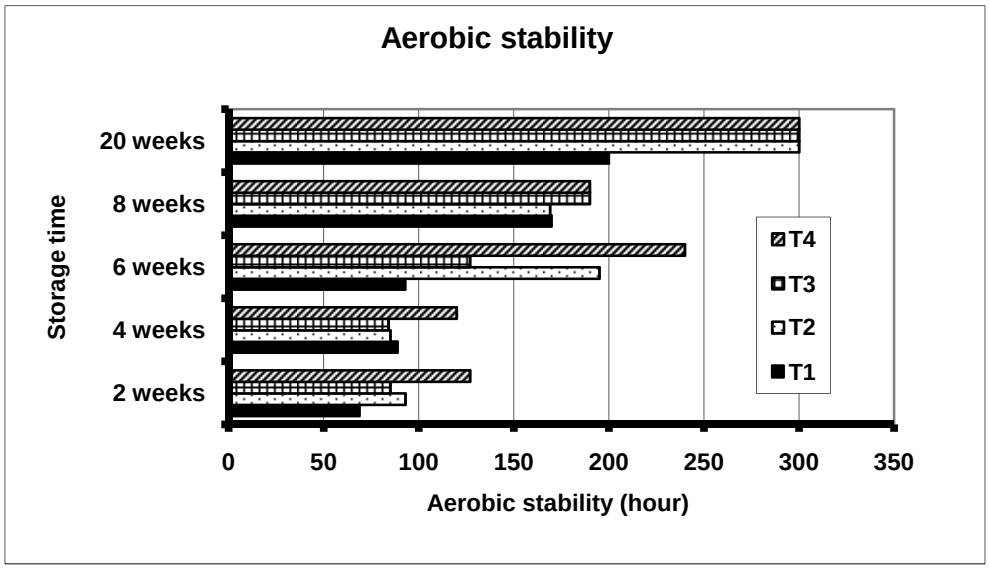

Fig.1. Aerobic stability of the control and treated silages

The results of microbiological experiments verified the positive effects of inoculant on the aerobic stability of silages (*Table 3*). In the presence of *L. buchneri* bacteria (T2, T4) the number of moulds was 1-2 order of magnitude lower than in the control after 10 days exposure to air.

Table 3. Number of mould and yeast cells at opening of silos (after 20 weeks storage time) and after 10 days exposure to air

Treatment	Number of cells (yeasts and moulds) log_{10} cfu/ g fresh matter			
	At opening		After 10 days exposure to air	
	Yeasts	Moulds	Yeasts	Moulds
T1	<1	<1	<1	8.2
T2	<1	<1	<1	6.7
T3	<1	<1	<1	7.4
T4	<1	<1	<1	5.7

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