Effects of the use of EM-silage in corn silage

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1. INTRODUCTION AND BACKGROUND

Roughage is the most important ingredient of the rations of dairy cows. In The Netherlands and Europe mainly grass and corn are ensiled. Within this process a good preservation is necessary to achieve a high-quality ration for dairy cows and young cattle.
In The Netherlands, ensilage agents (inoculants) are mainly used when the circumstances to achieve a good silage preservation are not very good, for example in case of insufficient pre-drying due to bad weather circumstances. Lactic acid bacteria are often used as ensilage agent.
In the literature data is available on the effect of the use of bacterial inoculants in grass silage on the silage fermentation. For corn silage such data is very rare.
Both a literature study and a practical search were carried out in order to determine the effect of EM-silage on the silage characteristics of corn silage.

2. THE USE OF FERMENTATION ENHANCERS IN CORN SILAGE

The main conditions for achieving a well fermented silage are the absence of oxygen and a fermentation process which is dominated by lactic acid bacteria. In practice, exposure to oxygen can never be completely prevented. In that case decay can be caused by the growth of (optionally) aerobic micro organisms. The aerobic decay is caused by acid tolerant yeasts and, in corn silage, sometimes by acetic acid bacteria. These micro organisms break down the fermentation products in the silage, resulting in an increase of the pH and growth of other aerobic micro organisms and finally, decay.
Measures directed at improving the aerobic stability of the silage mainly focus on controlling the growth of the micro organisms that are responsible for this process, particularly yeasts. It appeared from research that the presence of non dissociated acetic acid is the main inhibiting factor for yeast growth in silages. Beside this, also other volatile acids like propionic acid and butyric acid decrease the growth of fungi and yeasts (Driehuis et al., 1999).
Additives for silages usually consist of one or more kinds of homofermentative lactic acid bacteria that (in comparison with heterofermentative lactic acid bacteria) produce lactic acid in a fast and efficient manner. Examples are Lactobacillus Plantarum, Pediococcus acidilactici and Enterococcus faecium. However, from research it appeared that homofermentative lactic acid bacteria can decrease the aerobic stability. There are strong indications that in contrast with homo fermentative lactic acid bacteria, heterofermentative lactic acid bacteria are (in an anaerobic environment) able to transform lactic acid into acetic acid and 1.2-propanediol. This can inhibit the yeast growth which results in an increase of the aerobic stability. Research by Driehuis et al. (1999) showed that an ensilage agent consisting of a Lactobacillus buchneri stem promotes the aerobic stability of corn silage. The acetic acid content of the silage treated with the ensilage agent was higher, whereas the lactic acid content was lower.
Danner et al. (1993) also concluded from research that in contrast with homofermentative lactic acid bacteria the adding of heterofermentative lactic acid bacteria (such as Lactobacillus brevis or Lactobacillus buchneri) has a positive effect on the aerobic stability of corn silage. It was concluded that acetic acid was responsible for the positive effect on the aerobic stability.

Driehuis et al. (1999) investigated the effect of adding different concentrations of Lactobacillus buchneri bacteria to corn silage. The results are shown in the following table.

Table 1 Compound and dry matter (d.m.) loss of silages treated with different dosages Of Lactobacillus buchneri after 92 days storage in preserving bottles

	Concentration Lactobacillus buchneri				
	-	1 x 10^3	1 x 10^4	1 x 10^5	1 x 10^6
PH	3.64	3.67	3.70	4.04	4.28
DS loss (g/kg d.m.)	13.7	13.9	15.2	24.5	38.7
NH_3-N (g/kg total N)	90	92	92	99	112
Lactic acid (mmol / kg d.m.)	880	831	716	358	126
Acetic acid (mmol / kg d.m.)	260	272	348	591	726
Propionic acid (mmol / kg d.m.)	9	0	10	43	106
Ethanol (mmol / kg d.m.)	180	177	179	193	151
1-propanol (mmol / kg d.m.)	21	28	63	200	236

It is clearly demonstrated that the pH increases as a result of adding Lactobacillus buchneri bacteria. The content of lactic acid highly decreases at an increasing concentration of inoculant, whereas the acetic acid content increases. These results are in conformity with the expectations. Hetero fermentative bacteria such as Lactobacillus buchneri are able to transform lactic acid into acetic acid and 1.2-propanediol. According to Driehuis, the higher content of acetic acid mainly has a positive effect on the aerobic stability of the silage due to a decrease of yeast growth. In literature, data on the effects of silages treated with Lactobacillus buchneri on the rumen fermentation are not available.

Corn contains a relatively high percentage fermentable carbohydrates and has a low content of protein and minerals. That makes it in general easier to ensile corn in comparison to grass. However, it must be noted that the corn species and the stage of harvesting have a great influence on the preservation of the corn silage. The effect of an ensilage agent based on micro organisms with corn silage will generally be less compared to grass silage.
In the experiments that have been described in literature no large effects of the use of homo fermentative bacteria mixtures have been found on the preservation of the corn silage. Shepherd and Kung (1996) concluded from research that soluble sugars are no limiting factor at the preservation of corn. Both in research on corn with a dry matter content of 32% (Hunt et al., 1993) to which a mixture of lactic acid bacteria was added, and a study on corn with a dry matter content between 21 and 23% to which a bacteria mixture with propionate and lactic acid bacteria was added (Higginbotham et al., 1998), no differences in preservation were found.
In the following table the effect of adding a mixture of lactic acid bacteria on the pH and the content of organic acids is demonstrated (Hunt et al., 1993).

Table 2 The effect of an additive based on lactic acid bacteria on the pH and organic acids concentration of corn silage

	Additive	
	-	+
PH	3.55	3.49
Organic acids (% in the dry matter)		
Lactic acid	5.45	6.59
Acetic acid	1.85	1.72
Propionic acid	0.03	0.02
Butyric acid	0.06	0.08

Kung et al. (1993) studied the effect of two inoculants; Ecosyl (Lactobacillus plantarum) and Pioneer 1174 (Lactobacillus plantarum and Streptococcus faecium). The composition of the silages are shown in the following table.

Table 3 Compound of silage (on dry matter basis)

	Control	Ecosyl	Pioneer 1174
Dry matter %	34.7	32.9	33.3
Crude protein %	7.71	7.60	7.57
ADF %	22.7	24.0	24.5
NDF %	44.1	43.1	43.8
PH	3.70	3.69	3.81
Lactic acid %	4.71	5.28	4.48
Acetic acid %	1.82	2.36	1.65
Ammonia N %	0.062	0.072	0.056
D.m. recovery	94.3	92.8	90.7

Meeske et al. (1998) also studied the effect of an inoculant on the ensilage characteristics of corn silage. The ensilage agent was a mixture of Lactobacillus plantarum, L. bulgaricus and L. acidophilus and the enzymes amylase and cellulase. The compound of the silages is presented in the following table.

Table 4 Compound (% in the dry matter) of corn silages (Meeske et al., 1998)

	Corn without additive	Corn with inoculant
Dry matter	27.6	27.6
Organic matter	89.5	88.8
NDF	49.6	49.2
Crude protein	9.3	9.4
NH_3-N	5.3	5.2
PH	3.7	3.9
Water-soluble carbohydrates	7.1	5.2
Lactic acid	6.9	6.4
Acetic acid	1.1	1.4
Butyric acid	-	-
Propionic acid	-	-

In the study of Meeske et al. (1998) the use of an inoculant in corn silage did not result in large differences in the silage compostion.
From literature studies it appeared that the adding of microbial inoculants to corn silages had variable effects.

3. EFFECT OF THE USE OF EM-SILAGE IN CORN SILAGE

In this Chapter the set-up, carrying out and results of the technical analysis of the use of EM-silage in corn silage are described. The results are also compared with the literature.

1.1 Set-up of the study

As a base sample 10 kilogram freshly chopped corn without additive was used. This sample was divided in two parts of 5 kg each. Then EM-silage was added to one corn sample.

A. 5 kg control corn
   125 ml water was added by means of a plant spray and this was thoroughly mixed
B. 5 kg EM-silage corn
   0.4 ml EM-silage and 124.6 ml lukewarm water were thoroughly mixed and then fogged on the corn by means of a plant spray. Then it was thoroughly mixed.

Of each treatment four airtight bottles of 1 litre were filled (about 550 gram per preserving bottle). On 22 September the preserving bottles were stored in a dark environment at ca. 20 ^{o}C. The incubation period was 6 months.

1.2 Results and discussion

In the following table the composition of the two silages is given.

Table 5 Corn silage fermentation characteristics of corn ensiled without additive (Control) and corn ensiled with EM-silage (EMS)

		Control	EMS
Moisture	%	65.2	66.7
Yeasts	kve/g	2600	630000
Fungi	kve/g	200	< 10
PH		3.68	3.66
Ammonia	mg/kg d.m.	615	592
Ethanol	g / kg d.m.	20.95	23.7
Acetic acid	g / kg d.m.	11.2	16.2
Lactic acid	g / kg d.m.	46	51
Propionic acid	g / kg d.m.	< 0.3	0.6
Propylene glycol	g / kg d.m.	< 0.3	< 0.3
Formic acid	g / kg d.m.	< 0.3	< 0.3
Butyric acid	g / kg d.m.	< 0.3	< 0.3

The effects of the use of EM-silage in corn silage are less prominent than as to the use in grass silage (Wikselaar, 2000). However, in general the same trends at the use of EM-silage in grass and corn silage are perceptible. The main similarities are:

- Increased number of yeasts at the use of EM-silage
- Lowering of the pH

- Increase of lactic acid and acetic acid content
- Increase of ethanol content

The smaller effects of the use of EM-silage in corn silage in comparison with grass silage are in accordance with the results from the literature. Because of the fact that corn has a relatively high content of rapidly degrading carbohydrates and a low content of protein and minerals corn can relatively easily be ensiled. The time period of harvesting and the corn species will, however, play a big part in the preservation of corn.
More detailed research on the effect of the use of EM-silage with both different stages of maturation of corn and different corn species will be necessary.