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Maize for silage

I. Conservation of whole maize plant for silage with treatment of preservatives and urea before ensiling

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Abstract. Maize was harvested with a precision chopper and ensiled in five plastic tower silos, 1 500 kg fodder/silo. The silages and the ensiling methods were: 0.5 % urea per fresh weight (A), 1.0 % urea per fresh weight + Viher-acid 4 1/1 000 kg of silage (B), 0.5 % urea per fresh weight + Viher-acid 4 1/1 000 kg of silage (C), Viher-acid 4 1/1 000 kg of silage (D) and silage without urea or preservatives (E).

The dry matter content of the whole maize was 21 % and the crude protein content was 10.8 % in DM. The addition of urea increased the crude protein (N × 6.25) content in A- and C-silages to 17.7 percent and in B-silage to 24.9 percent.

The quality of the silages was good, and some marks of butyric acid was found only in the silage ensiled without Viher-acid or urea. The addition of Viher-acid lowered the fermentation rate so that the sugar content of the corresponding silages was higher. The sugar content was higher ($P < 0.01$) and the content of lactic acid lower ($P < 0.001$) in the silage ensiled only with Viher-acid.

Urea increased the content of lactic acid and the content of acetic acid of the silages. In the silages ensiled with urea the use of Viher-acid tended to lower the fermentation rate.

The use of urea increased the NH_3-N ($P < 0.05$) and the soluble N contents ($P < 0.001$) in the silages. In spite of the low dry matter content of the silages some enrichment of the urea in the lower parts of the silos was only found in the silage ensiled with 1 % of urea ($P > 0.05$) and Viher-acid. This was due to the larger effluent amount from the silo.

The fermentation losses of dry matter were smallest in the silage D (3.9 %) and highest in the silage E (11.6 %) ($P < 0.05$). The losses in A-, B- and C-silages were 7.6 %, 4.7 % and 9.2 %, respectively. The use of urea decreased the fermentation losses.

Introduction

Because of the rich content of soluble sugars maize could be ensiled without preservatives. In spite of careful ensiling an intense secondary fermentation was found in sorghum, corn and corn stover silages (SETÄLÄ et al. 1979).

According to MORVARID et al. (1973) and WOOLFORD et al. (1978) secondary fermentation is caused by the great number of yeasts and moulds, which are

typical for maize and sorghum plants. The low dry matter content and the high sugar content form a favourable base for the growth and function of the micro-organisms.

Because of the low content of crude protein in the feeding of ruminants maize silage must be supplemented by some N-source. In this respect urea can be used providing that it is added to the silage before ensiling (HUBER et al. 1968).

In this trial were studied the quality and composition of the silages treated with acid preservatives and urea before ensiling.

Materials and methods

Maize was harvested with a precision chopper and ensiled in plastic tower silos (2.7 m^3). The dry matter content of the raw material was about 21 percent. Exactly 1 500 kg of fresh fodder mass was ensiled in each silo according to an experimental design shown in Table 1. The pressure used was 400 kg/m^2.

The preservative used was a mixture of sulphuric acid, formic acid and formaldehyde (»Viher-acid»). The preservative and urea were added to the fodder in a water solution after each 50 kg of fodder mass ensiled in the towers. The total amounts were 4 litres acid mixture and 500—1 000 grams urea/ 1 000 kg of silage.

Fermentation losses were determined by subtracting the amounts of the silage and the effluent from the amounts of the fodder ensiled in the tower silos. The additions of water solutions when Viher-acid and urea were added to the silages were also considered in the calculations. The amounts of solutions added were about 30, 100, 70 and 50 litres in A-, B, C- and D-silos, respectively.

The samples for the analyses of the raw materials and of the silages were taken from every 50 kilogram lots. In addition to drying the samples in vacuum at +60° C for two days, 100—150 grams of silage was frozen for the quality analyses.

Table 1. Experimental design, crops and their ensiling.

	Silages				
	A	B	C	D	E
Fodder kg/ tower silo	1 500	1 500	1 500	1 500	1 500
Urea, % of the wet weight	0.5	1.0	0.5	—	—
Acid mixture,* l/1 000 kg of fodder	—	4.0	4.0	4.0	—

* Viher-acid: 45 % sulphuric acid, 20 % formic acid, 10 % formaldehyde.

The analycital methods used were those described by SETÄLÄ et al. (1979). Urea was determined colorimetrically (ANON. 1973).

The results were tested statistically by analysis of variance. The significances of the differences between individual means were tested with Tukey's procedure.

Results and discussion

The chemical composition of the raw material and the silages

The dry matter content of the present material was only 21 percent and the grains in the cobs were near milk stage. This growth stage is considered early for making corn silage, because there is always a danger of a faulty fermentation producing acetic acid and alcohols and because the fermentation losses could be very high (NEHRING and HOFFMANN 1960, BECKER and NEHRING 1969, GIARDINI et al. 1976). However, silage of fairly good quality can be made also at this growth stage (SETÄLÄ et al. 1979).

The amounts of sugars and crude protein in raw materials were 16—17 % and 10.5—11.0 % in dry matter, respectively (Table 2). The addition of urea increased the crude protein content 6.5 %-units when 0.5 % of urea in silage fresh weight was included, and 11.3 %-units when 1 % of urea was used.

The sugar content decreased significantly ($P < 0.01$) in silages ensiled with urea, urea + Viher-acid and without preservatives. The silage ensiled only with Viher-acid had the highest content of sugars and there was no statistical difference ($P > 0.01$) in the sugar content between the raw material and this silage.

The content of sugars in silages reflects the strength of the fermentation. In corn silage the fermentation takes place mostly during the first ten days after ensiling. After that the fermentation is finished if no secondary fermentation takes place (SCHAADT and JOHNSON 1969, BRITT and HUBER 1975).

The quality and the fermentation losses of the silages

The quality of all silages was good as judged by colour, odour and analyses (Table 3). The pH values were very low in all silages.

The use of acid preservative decreased the fermentation in the silages (also GROSS and BECK 1970). The content of lactic acid was significantly ($P < 0.001$) higher in silages which were ensiled without acid supplement (also BRITT et al. 1975). The same trend could also be seen in the content of acetic acid (Fig. 1).

The use of urea increased the content of lactic acid and the content of acetic acid in the silages, although the changes were not significant ($P > 0.05$). Changes of this kind after addition of urea before ensiling have been noted also by GROSS et al. (1969) and SHIRLEY et al. (1972).

Urea is hydrolyzed to NH_3 during ensiling. The rate of hydrolysis is the more vigorous the lower is the dry matter content of the silage (POLAN et al. 1967). In spite of differences in the contents of organic acids no statistical differences were found in the pH values of the silages. Ammonia is a strong buffer and affects the pH values so that more organic acids are needed to lower the pH to the desired level (SHIRLEY et al. 1972).

The addition of urea increased the content of NH_3-N and soluble N in the silage (Fig. 2). The content of NH_3-N is higher ($P < 0.05$) in A-silage compared to C-silage, which was supplemented also with Viher-acid. It is possible that the use of preservatives prevents the degradation of urea to NH_3 and the ammonia exists in the form of NH_4^+-ion.

Table 2. Chemical composition of raw material and silages.

	Raw material		Silages A		B		C		D		E		$P < 0.01$
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	
Dry matter, %	20.9	0.26	19.3	0.36	19.4	0.41	19.1	0.87	19.2	0.32	19.0	0.95	ns.
% in DM													
Ash	6.7	0.35	6.5	0.41	6.9	0.24	7.3	0.58	7.1	0.22	6.5	0.71	ns.
Crude protein	10.7	0.20	17.7	0.80	24.9	2.32	17.7	0.99	11.3	0.38	11.3	0.35	R^x—A, B, C
													A—B, D, E
Crude fibre	24.8	0.78	26.3	0.86	26.8	1.33	26.6	0.84	26.0	1.49	26.7	1.34	ns.
Ether extract	1.3	0.10	1.8	0.24	1.5	0.06	1.4	0.07	1.4	0.08	1.6	0.10	R^x—A, E,
													A—B, C, D, E
													D—E
N-free extracts	56.3	1.31	47.6	1.46	39.8	2.85	46.7	1.95	54.3	1.81	53.7	1.51	R^x—A, B, C
													B—A, C
Sugars	16.10	1.09	8.6	1.44	11.2	2.93	10.9	1.21	14.2	0.52	10.4	1.06	R^x—A, B, C, E
													D—A, B, C, E

R^x = raw material
A = 0.5 % urea, no Viher-acid
B = 1.0 % urea, Viher-acid
C = 0.5 % urea, Viher-acid
D = Viher-acid
E = no preservatives

Table 3. Quality of corn silages ensiled without preservatives, with Viher-acid and different amounts of urea.

	Silages											
	A		B		C		D		E			
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	x	s.d.	x	s.d.	$P < 0.001$	$P < 0.05$
Dry matter, %	19.3	0.37	19.4	0.41	19.1	0.87	19.2	0.32	19.0	0.95	—	ns.
pH	3.6	—	3.6	—	3.6	—	3.5	—	3.6	—	—	ns.
% in DM												
Lactic acid	7.98	0.98	4.58	0.63	4.28	0.93	2.98	0.15	7.88	1.08	A—B, C, D E—B, C, D D—A, B, E	—
Acetic acid	0.83	0.07	0.46	0.07	0.45	0.14	0.58	0.18	0.73	0.14	A—B, C E—B, C	—
Propionic acid	0.32	0.06	0.31	0.09	0.29	0.12	0.46	0.05	0.31	0.05	—	ns.
Butyric acid	—	—	—	—	—	—	—	—	0.10	—	—	—
NH_3-N	0.11	0.01	0.14	0.08	0.08	0.01	0.07	0.01	0.08	0.01	—	A—C, D, E B—A, C, D, E
Soluble N	1.85	0.09	2.88	0.18	1.77	0.10	0.79	0.08	0.79	0.12	A—B, D, E C—B, D, E B—D, E	—

A—E see Table 2.

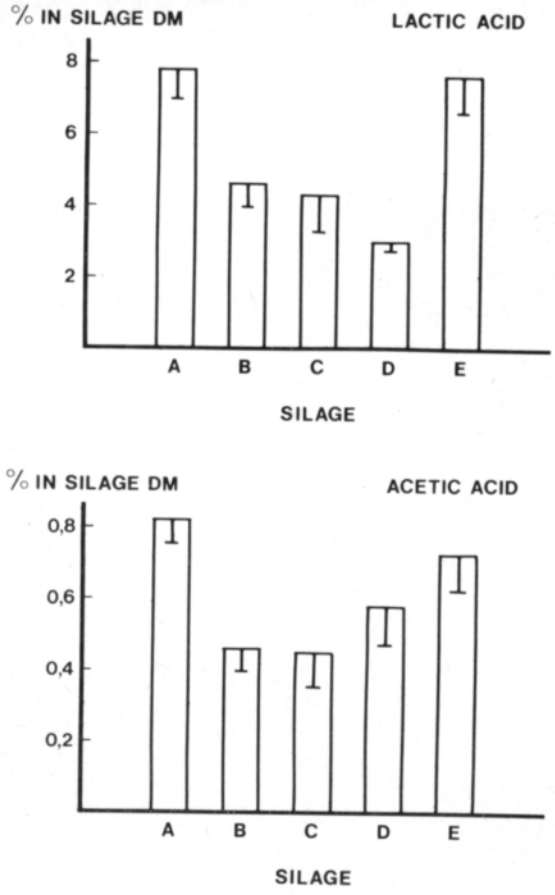

Figure 1. The contents of lactic and acetic acids in the silages. A—E see Table 1.

Some signs of the butyric acid was found in the silage ensiled without preservatives or urea. This is quite unusual for the corn silage (ANDRIEU 1976) and has not been stated earlier (SETÄLÄ et al. 1979).

The fermentation losses in dry matter were smallest ($P < 0.05$) in the silage ensiled with Viher-acid and greatest ($P < 0.05$) in the silage ensiled without any additives. (Table 4). The corresponding losses were 3.9 % and 11.6 %. In the A, B and C silages the fermentation losses were 7.6 %, 4.7 % and 9.2 %, respectively. It seems that urea had lowered the fermentation losses during ensiling (also GROSS etal. 1969).

The urea concentration of the silages in different parts of the silos

In spite of the low dry matter contents particularly urea-rich layers were not found in the silages (Fig. 3). This can be explained by the small effluent amounts flowed from the silos (Table 4). Urea can be easily dissolved in the effluent and then be concentrated in the bottom layers of the fodder in a tower silo. Because of this it has been advised to add urea before ensiling only when the dry matter content of the fodder is over 25 percent (BÖTTGER 1969, KIRCHGESSNER 1973).

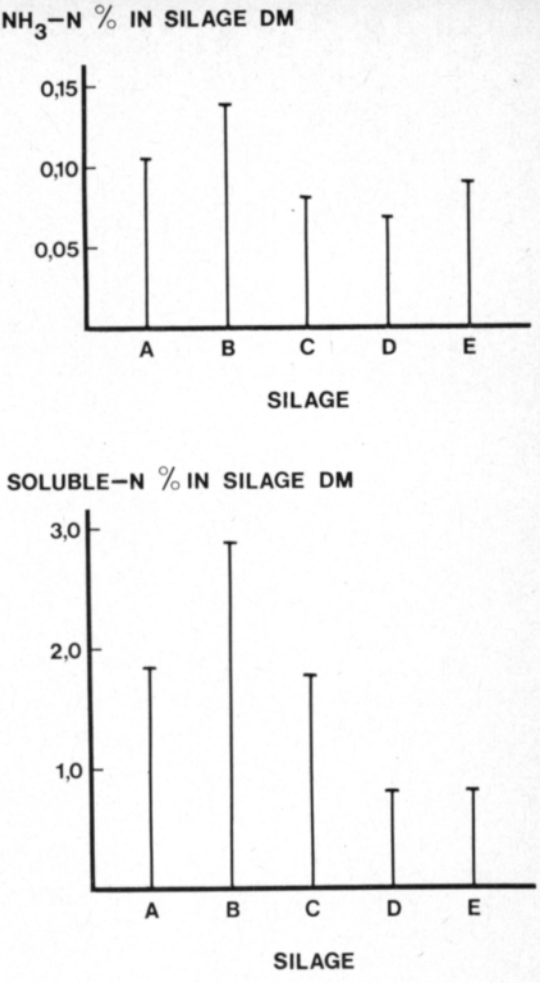

Figure 2. The contents of NH_3-N and soluble N of the silages. A–E see Table 1.

Table 4. The amounts of effluents per 1 500 kg fodder, soluble N content of the effluents and the fermentation losses in dry matter of the corn silages.

	Silages						
	A	B	C	D	E	$P < 0.05$	$P < 0.001$
Silage effluent, kg	1.6	56.0	19.0	1.0	—	C–A, D, E	B–A, C, D, E
Soluble N, % in effluent	1.10	4.30	2.10	0.94	—	C–A, D, E	B–A, C, D, E
Fermentation losses in DM, % in raw material	7.6	4.7	9.2	3.9	11.6	D–A, B, C, E E–A, B, C	

Because of the greater effluent amount from the B-silage, urea concentration was slightly higher in samples taken after 180 fermentation days from the bottom of the silo (Fig. 3). However, the increase was not statistically significant ($P > 0.05$). The greater amounts of effluents in C- and especially in B-silages could be partly explained by the fact that both urea and Viher-acid

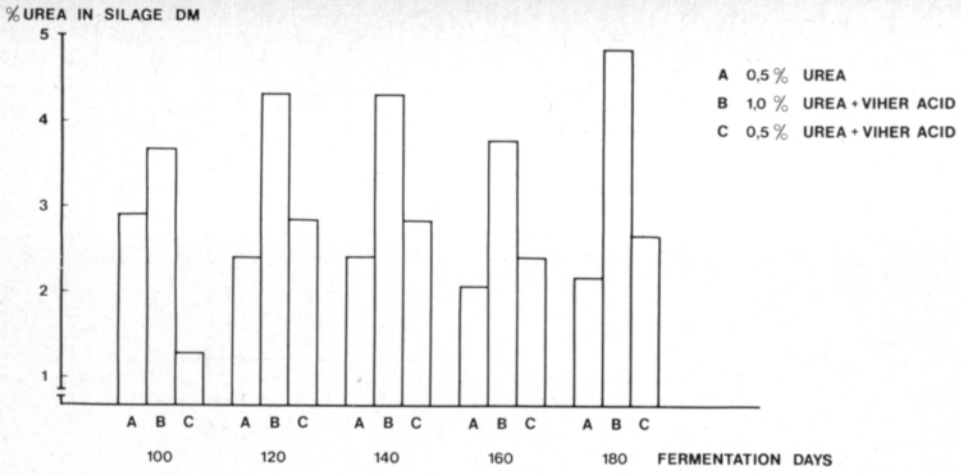

Figure 3. The variability of the urea concentration in the silages ensiled with urea. The samples are taken in the connection of emptying the silos during 100—180 days after ensiling.

were added to the silages in water solutions. The amounts of the solutions were about 100 and 70 litres in the silages of B and C, respectively.

The soluble N content was highest ($P < 0.001$) in the effluent of the silage ensiled with 1 % of urea. The losses of urea in the form of soluble N were, however, quite small. The average urea contents (% in silage DM) were in A-, B- and C-silages 2.4 % (s.d. 0.30), 3.9 % (s.d. 0.67) and 2.2 % (s.d. 0.63) and the highest contents found were 2.9, 4.8, and 2.8 %, respectively.

The use of the greatest amount of urea (1 % per fodder fresh weight) could be too high in practise, if the silage is going to be used for a long time. Moreover the use of 0.5 % of urea already raises the crude protein content of the corn silage at the same level with an ordinary grass silage.

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SELOSTUS

Maissi säilörehun raaka-aineena I. Viherhapon ja urean käyttö maissisäilörehun säilöntäaineena

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Maissia säilörehun raaka-aineena käsittelevän tutkimuksen ensimmäisessä osassa keskityttiin säilönnällisten kysymysten selvittämiseen. Säilörehut tehtiin käyttämällä säilöntäaineena Farmoksen Viherhappoa sekä lisäämällä rehuihin ureaa 0.5 % tai 1.0 % rehun tuorepainosta. Lisäksi valmistettiin painorehua ilman säilöntäaineita.

Vaikka säilörehut tehtiin hieman liian varhaisella kasvuasteella olevasta raaka-aineesta (ka-% 21), rehut olivat hyvälaatuisia. Merkkejä voihappokäymisestä esiintyi vain painorehussa. Säilöntäaineen käyttö alensi rehuissa tapahtuvaa käymistä ja käymistappioita. Käyminen oli kuitenkin voimakas kaikissa rehuissa ja säilörehujen pH oli hyvin alhainen.

Urean lisääminen rehuun nosti NH_3-typen ja liukoisen typen määrää säilörehussa. Koska urea liukenee helposti puristenesteeseen, sitä saattaa kerääntyä haitallisia määriä alimpiin rehukerroksiin. Kun ureaa käytettiin 1 % rehun tuorepainosta, urean kerääntymistä havaittiin, mutta se ei ollut tilastollisesti merkitsevää. Puristemehun merkitys kerrostumisriskiä lisäävänä tekijänä tuli selvästi esille. Urean lisäys säilönnän yhteydessä pienensi käymistappioita.