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Preliminary studies on the conservation of whole sorghum and corn plant and sugar corn stover for silage

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Abstract. The whole corn plant and sugar corn stover were ensiled in stacks covered with plastics and soil. Sorghum was ensiled in tower silo. The amounts of fodder ensiled were 2 500 kg, 3 100 kg and 1 400 kg, respectively. All silages were chopped with a precision chopper and ensiled without preservatives. The feeding values of the silages were determined with sheep according to 2 × 3 × 3 Latin square design. Urea (0.3 % of the fresh weight) was added to the silages before feeding.

An intense secondary fermentation was found in all silages. The possible causes for this were the soil contamination of the fodder during harvesting and the effluent remained in the stack silages. The secondary fermentation decreased the sugar content of the silages and increased the fermentation losses especially in the corn silage. However, the quality of the silages was fairly good.

Urea decreased the palatability of the silages and it would be better to add the urea to the silages before the ensiling.

The energy and DCP values of the silages were quite modest. There were 0.63, 0.72 and 0.69 f.u./kg silage DM in sorghum, corn and corn stover silages, respectively The corresponding values for DCP were 75, 62 and 86 g/kg silage DM (urea included)

Introduction

Maize and sorghum are regarded as the best raw materials for silage, becauce the DM yields per hectare are high (5—16 tons) and the rich content of soluble sugars makes it possible to ensile the fodder mass without preservatives (GROSS and RIEBE 1974). Corn stover can also be ensiled and used as a feed for cattle in the same way (BIGGS and STEWART 1970).

The maize or sorghum varieties do not attain the proper growth stage in Finland. When it is not possible to get cobs or grains at dent stage, the whole plant has to be used for silage.

In Finland, the Maize Committee started in 1976 a preliminary experiment in which the ensiling problems were studied. The raw materials ensiled were Grazer sorghum, fodder corn (several varieties) and sugar corn stover.

Materials and methods

All the raw materials used were harvested with a precision chopper.

Sorghum (1 400 kg) was ensiled without preservatives into a small plastic tower silo (2.7 m^3). The pressure used was 400 kg/m^2. Corn and sugar corn stover (after the harvesting of ears) were ensiled also without preservatives into two horizontal stacks, covered with polyethene sheet and soil. The method described by LANCASTER (1966) was used. The fresh masses ensiled were 2 500 and 3 500 kg respectively.

The fermentation losses were determined in the tower silo by weighing the amount of the raw material, the amount of the silage taken off, and the amount of effluent coming from the silo. In the stacks losses were determined with the method of jute sacks (ETTALA 1973). There were four sacks per one stack each containing 10 kg of the fodder.

For analyses the samples of the raw material were taken before ensiling. The samples of silages were taken every week, when silages were fed in the digestibility trial. Because the digestibility trial started six weeks after the ensiling of the silages, the samples were taken from 6 to 15 weeks after ensiling.

The digestibilities and the feeding values of the silages were determined according to $2 \times 3 \times 3$ Latin-square design with six Finnish Landrace rams. Each period lasted 21 days of which the collection period covered seven days. The lots of silages taken every week were freezed and melted doses for each animal were weighed daily. The animals were fed twice/day.

The crude protein content of the silages was quite low for the purpose of cattle feeding. Because there are large amounts of soluble carbohydrates available as an energy source for rumen microbes, the silages were supplemented by urea (0.3 % per fresh weight) before feeding so that the desired crude protein levels in the diets were maintained.

The chemical composition of the raw materials and silages as well as the faeces from the digestibility trial were determined according to standard methods. Water-soluble carbohydrates were determined by the method of SALO (1965).

The quality criteria of silages were determined so that the VFA were determined by the gas chromatographic method (HUIDA 1973), the lactic acid according to the method described by BARKER and SUMMERSON (1941), the ammonia nitrogen by the method of MCCULLOUGH (1967) and the soluble nitrogen by the Kjeldahl method.

The dry matter content of the silages was corrected after the VFA determination according to ULVESLI and BREIREM (1960).

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

Results and discussion

The fermentation losses and the quality of the silages

Because of the fermentation the amounts of the sugars had reduced severely (Table 1). The silages contained on an average only 50 percent of the amount of sugars found in raw materials. The crude ash content of the corn stover

Table 1. The average chemical composition of the raw materials and silages (% in dry matter).

	Raw materials			Silages		
	Sorghum	Corn plant	Sugar corn stover	Sorghum	Corn plant	Sugar corn stover
Dry matter %	19.2	20.7	20.9	18.9	19.0	17.3
% in DM						
Ash	8.7	7.4	12.5	8.9	9.3	16.5
Crude protein*)	9.9	9.6	10.4	11.2	10.3	12.5
Crude fiber	27.3	24.1	19.7	30.8	24.4	23.3
Ether extract	2.5	2.2	2.1	3.1	2.3	3.1
N-free extracts	51.6	56.7	55.4	46.1	53.9	44.5
Sugars	22.0	25.5	25.6	10.6	11.1	9.6

*) Urea is not included.

Table 2. The sugar content and fermentation losses in the jute sacks in the stacks of corn plant and sugar corn stover silages.

	Corn silage		Sugar corn stover silage	
	after 6 weeks	after 15 weeks	after 6 weeks	after 15 weeks
Sugars, % in dry matter	16.05[a]	4.83[c]	18.8[a]	9.11[d]
Fermentation losses % in raw material				
— wet weight	7.75[a]	5.85[c]	9.60[b]	9.87[d]
— dry matter	4.05[a]	16.82[d]	15.51[b]	19.49[d]
— organic matter	3.25[a]	18.75[d]	15.49[b]	22.52[d]

$P < 0.01$ a—b after 6 weeks of fermentation between corn and sugar corn stover silages.
$P < 0.01$ c—d after 15 weeks of fermentation between corn and sugar corn stover silages.

silage was quite high, the main reason being the soil contamination of the raw material. This applies also to the other silages. Because of the deficient harvesting techniques it was difficult to get the fodder harvested without soil contamination.

When silages were taken for the digestibility trial the stacks and the silo were opened every week. Although the silages were covered each time carefully with plastics and stones some air remained in the silages. The stacks were made on an inclined plane but the effluents could not be taken out and the dry matter content of the stack silages decreased 1.7—3.6 %-units during fermentation. The effluents remained and the high content of sugars in the silages made an excellent growth base for moulds and yeasts (also Morvarid et al. 1973) and an intense secondary fermentation was found.

The effects of the secondary fermentation can be seen in the fermentation losses and in the changes of the sugar contents in the jute sacks that have been in the stacks (Table 2). The quality and the chemical composition of the silages in the sacks were in close agreement with the samples taken from other parts of the silages.

The contents of the sugars in the sacks were after six weeks about 70 % of the sugar content of raw material in both stack silages. After 15 weeks the sugar content was significantly ($P < 0.01$) lower in the corn silage compared to the corn stover silage. Only 30 % and 50 % of the sugars found in raw materials were left in the corn and corn stover silages, respectively.

The fermentation losses have increased in the corn silage during 6 to 15 weeks after ensiling. No statistical differences ($P > 0.01$) were found in the losses (except in wet weigh) between the stack silages after 15 weeks (Table 2). Because the stacks were covered with plastics and stones on the same way, it seems, that the corn silage has been more sensitive to the secondary fermentation that can cause fermentation losses in dry matter even 2.5 %/day (Gross and Riebe 1974).

The secondary fermentation was found also in the sorghum silage although the effluent was taken out from the silo. However, the fermentation was not so intensive as in the stack silages. The fermentation losses in wet weight, in dry matter and in organic matter were 6, 7 and 7 percent of the raw material, respectively.

In spite of the secondary fermentation the quality of the silages was good according to the standards used for grass silage (Table 3). The amount of lactic acid was high in all silages tending to increase during 6 to 15 weeks after ensiling. Because the dry matter content of the raw material was low, there was a danger of a faulty fermentation producing much acetic and butyric acids and alcohols. The amounts of acetic and propionic acids were quite high, but no butyric acid was found in the silages. The contents of organic acids were quite normal for this kind of silages (Owens et al. 1970, Andrieu 1976, Wilkinson et al. 1976).

The palatability of the silages

When compared to the dry matter consumption (Table 4) which has been found in experiments made with grass silage and different carbohydrates (Syrjälä 1972), the consumption was lower with all silages. One reason for

Table 3. The quality of sorghum, corn and sugar corn stover silages (The average values of 12 samples).

Silages	pH	lactic acid	acetic acid	propionic acid	butyric acid	valeric acid	isovaleric acid	total N	soluble N	NH_3-N
		% in dry matter								
Sorghum	3,8	6,00	1,87	1,35	—	—	+	1,72	0,96	0,12
s.d.	—	2,39	0,81	0,62				0,11	0,14	0,02
Corn plant	4,0	5,60	1,82	1,12	—	+	—	1,50	0,85	0,12
s.d.	—	1,54	0,80	0,76				0,19	0,18	0,04
Sugar corn .... stover	4,0	5,45	1,97	1,18	—	+	—	1,86	0,99	0,17
s.d.	—	1,33	1,12	0,54				0,14	0,07	0,07

the low palatability is urea that had been added to the silages before feeding. To reduce the taste of urea, urea should be added to the silage before the ensiling (HUBER et al. 1968).

Table 4. Consumption and feeding value of sorghum, corn and sugar corn stover silages.

	Silage		
	sorghum	corn	sugar corn stover
DM/100 kg liveweight	1.44	1.59	1.88
f.u./kg silage[1])	0.12	0.14	0.12
Kg silage DM/f.u.	1.57	1.37	1.44
% DCP in DM (urea included)	7.45	6.20	8.59

[1]) f.u. = 0.7 kg starch.

The high acidity could also have reduced the consumption of the silages (WILKINSON et al. 1976). According to ZIMMER (1976) the content of alcohols is usually small in corn silages, but after an intensive fermentation alcohols could exist in the silages and also they could have reduced the palatability of the silages. The alcohol content of the silages was not determined.

During the first two weeks of the digestibility trial there were some difficulties in the feeding of the animals. After the silage were unfrozen, the daily doses were weighed and given to the each animal. The silages fermented and spoiled in the feeding vessels in 3—4 hours. However, this had not very marked effect on the consumption of the silages, because the animals consumed in 1—2 hours almost entirely the amount of silage they ate that time.

The feeding value of the silages

The effect of urea on the feeding value of the silages was taken into consideration according to LAMPILA (1968). The starch content of the ears has a great effect on the energy value of corn silages. Because there were no ears in the sorghum and corn stover silages the energy values were worse compared to an ordinary grass silage (Table 4). Because of the ears the corn silage has higher energy values than the other silages.

In spite of the urea included the DCP % in silage DM was very low in all silages.

REFERENCES

ANDRIEU, J. 1976. Factors influencing the composition and nutritive value of the ensiled whole-crop maize. Anim. Feed. Sci. Technol. 1: 381—392.

BARKER, S. B. & SUMMERSON, W. H. 1941. The colorimatric determination of lactic acid in biological material. J. Biol. Chem. 138: 535—554.

BIGGS, E. & STEWART, A. 1970. Let's look at corn. Ontario Dep. of Agric. Publ. 13. 32 p.

ETTALA, E. 1973. Nurmisäilörehun säilöntätappiot tornisiilossa. Työtehoseuran rakennustiedote 74. 4 s.

GIARDINI, A., GASPARI, F., VECCHIETTINI, M. & SCHENDNI, P. 1976. Effect of maize silage harvest stage on yield, plant composition and fermentation losses. Anim. Feed. Sci. Technol. 1: 313—326.

GROSS, F. & BECK, T. 1970. Untersuchungen über die Hemmung von aeroben Abbauprozessen durch Propionsäure bei der Auslagung von Gärfutter. Wirtschaftseigene Futter 16: 1—14.

— & RIEBE, M. 1974. Gärfutter. 282 p. Stuttgart.

HUBER, J. T., POLAN, C. E. & HILLMAN, D. 1968. Urea in hign corn silage ration for dairy cattle. J. Anim. Sci. 27: 220—226.

HUIDA, L. 1973. Quantitative determination of volatile fatty acids from rumen sample and silage by gas-liquid chromatography. J. Scient. Agric. Soc. Finl. 45: 483—488.

LAMPILA, M. 1968. Urea supplements in the rations of dairy cows. Ann. Agric. Fenn. 7: 46—58.

LANCASTER, R. J. 1966. Relative efficiency of silage making in polythene covered bunkers and vacuum-compressed stacks. Proc. 10th Intern. Grassl. Congr. p. 560—564. Helsinki 1966.

MCCULLOUGH, H. 1967. The determination of ammonia in whole blood by a direct colorimetric method. Clin. Chim. Acta 17: 297—304.

MORVARID, A., KOCH, G. & KIRCHGESSNER, M. 1973. Chemische und mikrobielle Veränderungen instabiler Maissilagen. Wirtschaftseigene Futter 19: 5—14.

SALO, M-L. 1965. Determination of carbohydrate fractions in animal feeds and faeces. Acta Agr. Fenn. 105: 1—120.

SYRJÄLÄ, L. 1972. Effect of different sucrose, starch and cellulose supplements on the utilization of grass silages by ruminants. Ann. Agric. Fenn. 11: 199—276.

ULVESLI, O. & BREIREM, K. 1960. Førsok over ensileringsmetoder. Meld. Norg. Landbr. høgsk. 39, 1—75.

WILKINSON, J. M., HUBER, J. T. & HENDERSON, H. E. 1976. Acidity and proteolysis as factors affecting the nutritive value of corn silage. J. Anim. Sci. 42: 208—218.

ZIMMER, E. 1976. Efficiency of harvesting and conservation. Anim. Feed. Sci. Technol. 1: 289—299.

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SELOSTUS

Alustava tutkimus koko hirssi ja maissikasvin sekä sokerimaissin lehti- ja varsiosan säilönnästä

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Maissia ja hirssiä viljellään pääasiassa jyväsadon tuottamiseen. Viljelyn raja-alueilla kuten Suomessa maissi ja hirssi eivät ehdi tuleentua, vaan koko kasvi on tehtävä säilörehuksi. Säilörehututkimukset aloitettiin Suomessa Maissitoimikunnan aloitteesta vuonna 1976 ja ne suoritettiin pääasiassa Helsingin yliopiston kotieläintieteen ja kasvinviljelytieteen laitoksilla.

Hirssi säilöttiin lasikuitusiiloon ja rehumaissi ja sokerimaissin varsi ja lehdet muoviaumaan ilman säilöntäainetta. Koska hirssi ja maissi sisältävät runsaasti helppoliukoisia hiilihydraatteja ja säilöntä tapahtuu lisäksi syksyllä, säilöntä ilman säilöntäaineita on mahdollista.

Kun säilörehua nostettiin siilosta ja aumoista sulavuuskokeeseen, rehu joutui kosketuksiin ilman kanssa, ja säilörehuissa alkoi tapahtua jälkikäymistä. Jälkikäymistä ilmeisesti kiihdyttivät rehun suuri vesi-, sokeri- ja multapitoisuus. Aumarehujen runsas vesipitoisuus johtui siitä, että puristeneste ei poistunut muoviaumoista. Voimakkaan käymisen seurauksena orgaanisia happoja muodostui runsaasti ja rehujen pH vaihteli 3.8—4.0. Säilörehuissa ei havaittu voihappoa, ja rehut olivat hyvälaatuisia.

Säilörehujen alhaista raakavalkuaispitoisuutta pyrittiin kohottamaan urealla. Ruokinnan yhteydessä rehuun lisättynä urea huononsi säilörehujen maittavuutta. Pässit söivät säilörehuja 1.4—1.9 kg ka/100 elopainokiloa.

Säilörehut olivat rehuarvoltaan keskilaatuista nurmisäilörehua huonompia. Erikoisesti srv-% säilörehun kuiva-aineessa oli alhainen vaihdellen 7.5—8.6 prosenttiin.