Ensiling experiment in bagged silage with 3 silage additives

Ensileringsförsök i slang med 3 olika ensileringsmedel

by

Cecilia Lundmark

Institutionen för husdjurens utfodring och vård **Examensarbete 217**

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Department of Animal Nutrition and Management

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1. Abstract

The aim with this project was to test the effect of three different silage additives with respect to the chemical quality of the resulting silage. The three additives tested were Kofasil Ultra, Kofasil Life and AIV 2S. The additive-treated silages were compared with each other and also with untreated silage (no additive).

The experiment was performed on July 22, 2004 at Kungsängen Research Centre in Uppsala. The silage bag that was made had a total length of 48 m and a theoretical diameter of 2.44 m (8 feet). The different additive-treated silages were separated by rolled barley. Unloading was performed in the period between Jan. 3rd and Jan 7th, 2005. Samples were cored out with a drilling-machine and analysed with respect to DM, ash, WSC, ME, ammonia nitrogen (Am-N), pH, fatty acids (FA), ethanol and clostridial spores (*Clostridium* spp.).

Acceptable silage quality was produced in the untreated control silages (no additives), but all additive-treated silages were of better quality than the control silages. The best silages qualities were achieved with the additives Kofasil Ultra and AIV 2S.

2. Sammanfattning

Målet med projektet var att testa tre olika ensileringsmedel med avseende på ensilagets kemiska kvalitet. De tre ensileringsmedel som testades var Kofasil Ultra, Kofasil Life och AIV 2S. Ensilage behandlat med de olika ensileringsmedlen jämfördes mot varandra samt mot obehandlat ensilage.

Experimentet startade den 22 juli 2004 vid Kungsängens Försöksstation i Uppsala. Ensilage tuben som lades hade en total längd på 48 m och en teoretisk diameter på 2,44 m. Ensilage som behandlats med olika ensileringsmedel skildes åt i tuben med hjälp av kornkross. Tuben tömdes mellan den 3: e och 7: e januari, 2005. Prov på ensilaget togs med en borr och proven analyserades med avseende på TS, aska, WSC, ME, ammonium-kväve (Am-N), pH, fettsyror (FA), etanol och klostridiesporer.

Kvaliteten på det obehandlade ensilaget var acceptabel, men allt ensilage som behandlats med något av ensileringsmedlen var av bättre kvalitet än det obehandlade ensilaget. Den bästa ensilage kvaliteten återfanns då ensilaget behandlats med Kofasil Ultra och AIV 2S.

3. Introduction

Bagged silage system is an oxygen-free storage of chopped silage in long polythene tubes lying on the ground. There are different bagging machine systems in use on the market and they differ in some aspects. During silo filling the chopped forage is either transferred to the loading table of the bagging machine (e.g. Ag-Bag system, Figure 1) or loaded in an open container attached to the bagging machine (e.g. Winlin system). For further information about the different bagging machine systems see Godin (2005). A packing rotor equipped with teeth (Figure 2) is then moving the forage in a tunnel behind the bagging machine. The plastic tube is pulled off the tunnel and the tube is formed while the packing machine and the tractor are passively pushed forward by the growing tube (Figure 1) (Sundberg and Pauly. 2005). The tubes can be up to 152.5 m (500 feet) long and the largest ones reach a diameter of 3.66 m (12 feet) (Ag-Bag International Ltd. 2000). On Scandinavian farms the most frequent diameter used is 2.44 m (8 feet) and the tubes are usually not longer than 70 m (Pauly, pers. comm.).

Figure 1: The chopped forage is transferred to the loading table of the press and the tube is formed while packing machine and tractor (Ag Bag G 7000 Europé) are mowing foreward.
Photo: BAG Budissa Agroservice GmbH

Figure 2: The packing rotor is equipped with teeth and moving the forage in a tunnel behind the bagging machine (Winlin 5400). This photo is taken from inside the bag.
Photo: Martin Sundberg, JTI, Uppsala

Silage bagging was developed in Germany in 1970 but refined in North America about 20 years later (Sundberg and Pauly. 2005). The use of bagged silage system has been going on

for more than 20 years in the USA (Ag-Bag International Ltd. 2000). In Sweden this silage technology is quite new and the first machine was brought into the country in 1998. The interest has increased a lot since then and this technology is now quickly moving forward (Sundberg and Pauly. 2005).

Silage bagging system has been economical compared with bunker silo system in another Swedish study. This study showed that silage bagging system is less expensive to invest in compared to bunker silo system. On the other hand the cost per year, if loading 1000 metric ton DM, showed out to be more economical profitable when using bunker silo system. This is if the investment cost of the bunker silo is written off within 20 years (Krijger. 2002).

To succeed with silage storage is actually more about good ensiling practice than to pick a particular ensiling method or the right silage additive.
Good ensiling practice means that the silage should be ensiled at a moisture level that is appropriate for the picked ensiling method, the crop should be chopped to an appropriate particle size, the silage should be packed to a high density and the sealing of the bag must be good enough to avoid the ingress of oxygen that would impede the growth of the anaerobic lactic acid bacteria (Kautz and Kung. 2000).

The aim with this project was to test the effect of three different silage additives with respect to the chemical quality of the resulting silage. The additive-treated silages were compared with each other and also with untreated silage (no additive). The 3 additives are presented in Section 4.4.

4. Method

The experiment was performed on July 22, 2004 (2nd cut) at Kungsängen Research Centre in Uppsala (59.8°N, 17.6°E). The approx. composition and stage of development of forage plants is shown in Table 1 below.

Table 1: Approximate composition and stage of development of forage plants.

Forage species	**Stage of development**
35% Timothy, *Phleum pratense*	Early to full boot
35% Meadow fescue, *Festuca pratensis*	Full boot
20% Red clover, *Trifolium pratense*	Single buds on inflorescence visible
10% Others (dandelion, weeds)	

The crop was cut with a conventional mower-conditioner and wilted in the field to a dry matter (DM) content of approx. 33%. The forage was then collected from the field with a self-loading forage wagon (Pöttinger Jumbo 7200 L), which was equipped with a set of knives in the pick up unit, the knife distance was 34 mm. The forage was unloaded in front of the AgBag press (Ag Bag G 7000 Europé) and the loading table of the press fed the forage into the bag. At unloading 6 samples per section of appox. 600 g were taken. 3 samples were then merged into one composite sample, resulting in 2 samples per section. These samples were analysed with respect to contents of DM, ash, crude protein (cp), fibre (NDF), sugars (WSC), metabolisable energy (ME), buffering capacity and nitrate. The particle size was ascertained from two dried samples using JTI's particle size machine (Sundberg, pers. comm), in which forage particles were sorted in 10 different length fractions. The result is given as the median particle size according to weight (see Section 3.1.).

During filling of the tube, two steel cables run on both sides of the tube from the packing machine to a sturdy frame at the end of the tube. The two cables are connected to the packing machine by a pair of drums. By applying more braking force on the drums the forward movement of the packing machine is restricted and the packing density of the tube is increased. In this experiment the level of brake pressure did not change during the filling. The bag was made on asphalted ground and the different bag sections were marked with spray colour to indicate boundaries between sections (Figure 3). The contractor Per-Uno Andersson from Ringsjö Maskin (Hörby, Sweden) operated the AgBag machine. He has a long experience of operating this type of press.

The silage bag had a total length of 48 m and a theoretical diameter of 2.44 m (8 feet). The film used was an AgBag polythene film with a thickness of 250 µm (Andersson, pers. comm). The bag was divided into 12 sections with an untreated end plug at the end of the bag. Each bag section was approx. 5 m long. The different sections were separated by an approx. 0.30 m wide layer of rolled barley (2 m^3). The 4 silage treatments were allocated at random to the 12 sections and each additive treatment was therefore repeated in three sections (Figure 3). Application rates (litres/metric ton FM) of additives used are shown in Table 2 in Section 4.4.

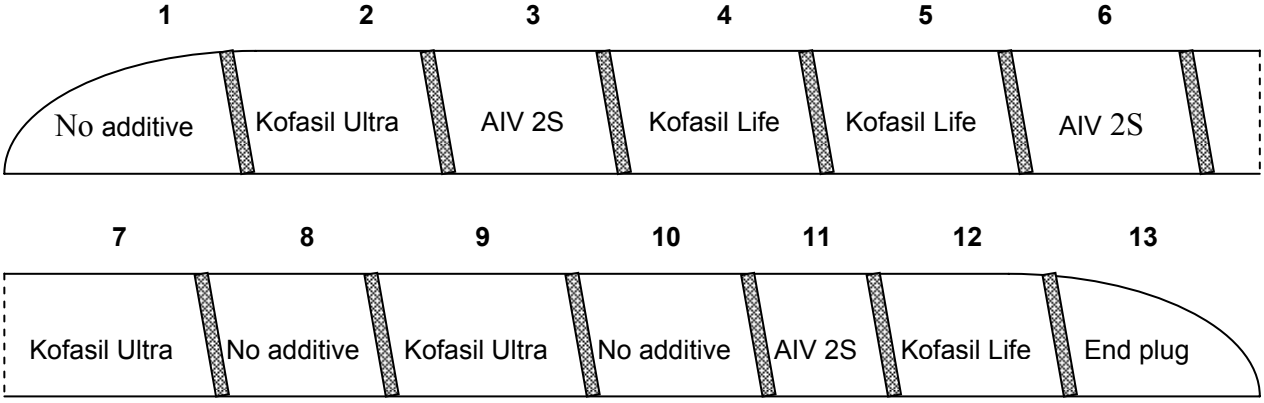

Figure 3: The 12 bag sections treated with different additives and separated with rolled barley.

Unloading was performed in the period between Jan. 3rd and Jan 7th, 2005. The average temperature outside during this period was -5 °C. Samples were cored out with a drilling-machine (Makita 6013B-R, Makita Electric Works Ltd., Japan) and a stainless steel corer (diameter 40 mm, length 90 cm).
In each section two approximately vertical surfaces were made and samples for determination of density and silage quality were taken. At the first surface chemical samples were cored and at the second surface both chemical samples and samples cored for determination of density were taken. During unloading, mouldy spots in the silage and injuries of the plastic film were recorded. The amount of effluent couldn't be measured but didn't appear to be very extensive.

4.1 Sampling scheme for determination of silage quality

In each section 7 samples each were cored at two approximately vertical silage surfaces according to the pattern shown in Figure 4 below. The corer was cleaned and flamed with ethanol (99%) after sampling of each silage surface. The 7 samples were merged and analysed with respect to DM, ash, WSC, ME, ammonia nitrogen (Am-N), pH, fatty acids (FA), ethanol, and clostridial spores (*Clostridium* spp.). Hence 2 samples were produced from each bag section.

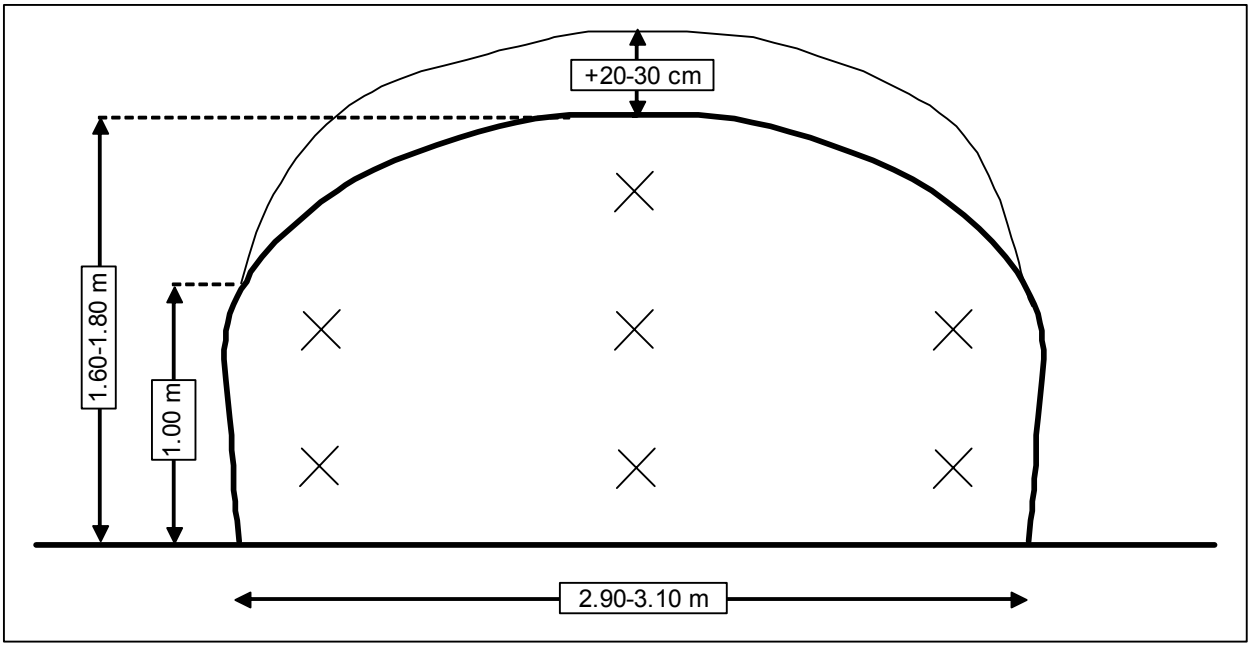

Figure 4: Sampling scheme for determination of silage quality: 7 cores were taken at each of 2 vertical silage surfaces within each bag section. The 7 cores were merged into one sample.

4.2 Sampling scheme for determination of silage density

In each section 13 samples each were cored according to the pattern shown in Figure 5a and 5b below. These samples were collected from only one vertical silage surface per bag section. To be able to get a good density sample 2 cores were extracted from each hole. The first core was discarded and the depth of the hole was measured (approx. 20 cm). The second core (approx. another 20 cm) was taken from the same hole. The depth of the hole was measured again and the sample transferred into a plastic bag. The 13 samples were weighted and analysed with respect to DM. Silage density (kg DM/m^3) was determined the following way:

1. DM weight (g) of second core: core weight (g) × DM content (%) / 100
2. Volume of the second core (cm^3): (depth2 – depth1) × corer area
3. Silage density (kg DM/m^3): DM weight (g) × 1000 / Volume (cm^3)

Figure 5a: The vertical silage surface where strings are used to locate the sampling spots. Note the gap at the top of the bag (hump).

Photo: Cecilia Lundmark

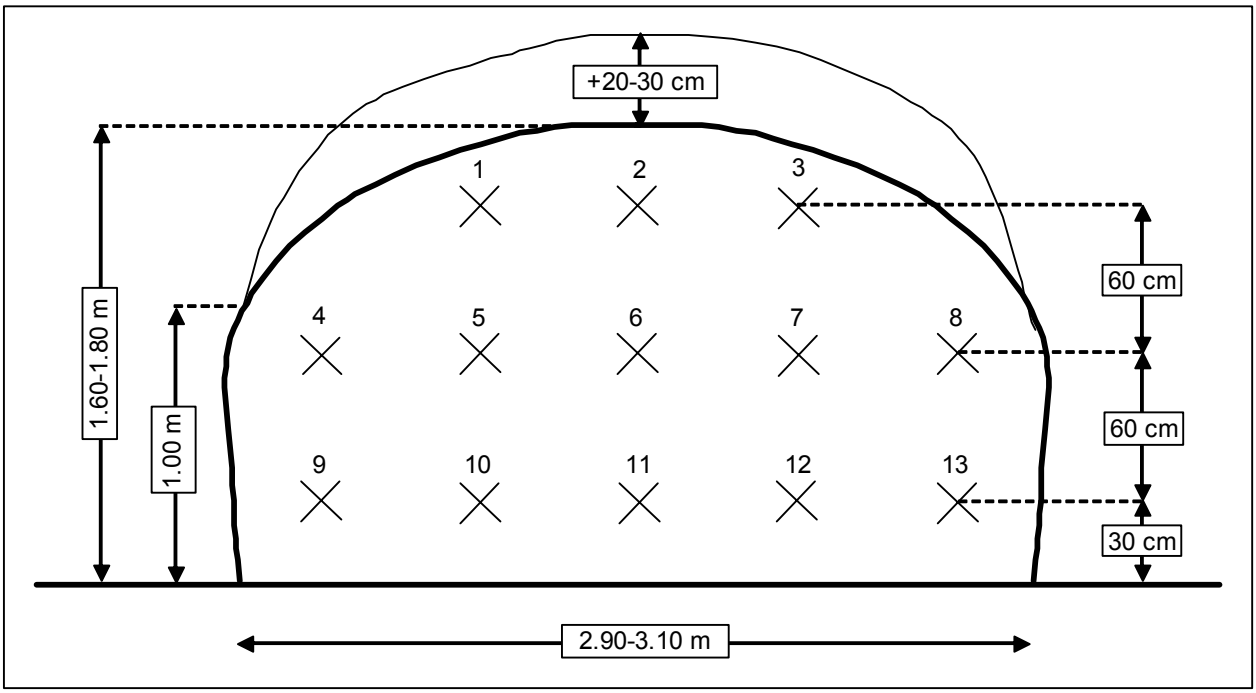

Figure 5b: Sampling scheme for determination of silage density: 13 samples were taken from one vertical silage surface within each bag section. Horizontal distance between sampling spots approx. 50 cm.

4.3 Analytical methods

4.3.1. Fresh crop

DM content was determined by drying approx. 200 g of wet forage in a ventilated oven at 65°C for 16 – 18 h. The samples were then left to rest for a couple of hours for the moisture content to stabilise. The samples were weighed (DM-1) and then ground in a hammer mill through a 1 mm sieve. The milled samples were dried at 103 °C over night and were weighed again (DM-2). The DM content was then calculated the following way:

$$DM = DM\text{-}1 \times DM\text{-}2 / 100$$

The milled samples were used for all other chemical analyses. Ash contents were determined by incinerating samples at 550 °C for 3 h. The WSC content was determined according to Larsson & Bengtsson (1983) where glucose, fructose, sucrose and fructans are determined. Fructose is enzymatic transformed into glucose and the concentration of glucose is determined with a spectrophotometer. Energy content (ME) was calculated using a correlation between *in vitro* rumen degradable organic matter (VOS) and metabolisable energy (Lindgren.1979). Cp was determined according to Nordic Committee on Food Analyses (1976) where a 2020 Digestor and a 2400 Kjeltec Analyser Unit (FOSS Analytical A/S Hilleröd, Denmark) were used. Protein was then calculated as nitrogen × 6.25. NDF was determined according to Chai & Udén (1998) where 100 % ND-solution but no amylase and no sulfite were used. Buffering capacity was determined by measuring the amount of lactic acid necessary to lower pH to 4.0 according to McDonald & Henderson (1962). Determination of nitrate was done using a Bran & Lubbe autoanalyzer (TRAACS Model 800). The extract was prepared by boiling the wilted silage (2 g / 100 ml water) for approx. 10 min and then diluted until 250 ml and filtrate through a Schleicher & Schuell 602 h paper. The amount of nitrate and nitrite in the extract was determined by reduce nitrate to nitrite at pH 8 according to Method nr: ST9002-NO_3D (Grasshoff. 1964)(Wagner. 1974).

4.3.2. Silage, microbiological and chemical samples

Clostridial spore counts: 40 g forage was weighed into a stomacher bag and 360 ml Ringer solution (Merck 1.15525) was added (first dilution). The sample was pummelled in a Seward stomacher for 2 minutes on normal intensity. Three tenfold dilutions (10^{-2}, 10^{-3} and 10^{-4}) were prepared and 0.1 ml of each dilution was then spread on agar plates (RCM agar, Merck 1.05410, supplemented with 0.2 g D-cycloserine/litre agar). Colonies (cfu) were enumerated after seven days anaerobic storage at 37°C according to Niemelä (1983).
For determination of DM see *Fresh crop* (2.3.1.). In the silage 1.4 %-units were added to DM to compensate for losses of volatile DM. The milled samples were used for all other chemical analyses.
Am-N was analysed in the silage juice according to Broderick & Kang (1980). The pH value was measured with a calibrated pH meter (Methrom 654, Switzerland) in the silage juice. Fatty acids and ethanol was determined using HPCL according to Andersson & Hedlund (1983). Ash, WSC and energy *see Fresh crop* (4.3.1.).

4.3.3. Silage, density samples

DM content was determined by drying the samples at 65°C for 24 h. Samples were weighed warm directly from the oven. 1.4 %-units was added to compensate for losses of volatile DM.

4.4 Additives

Additives act in different ways and might be divided into different groups. One way to group the additives is to distinguish between chemical, biological and nutritious additives (Swedish Dairy Association. 2004).

Table 2: Additives and application rates used in the experiment.

Additive	**Application rate** (litres/metric ton FM)
Kofasil® Ultra	3.0
Kofasil® Life	2.0
AIV® 2S	4.0

4.4.1. Kofasil®Ultra (Addcon Agrar GmbH, Germany) is an alkaline, chemical additive that contains sodium nitrite, hexamethylenetetramine[1], sodium bensoate and sodium propionate (Hansson & Möhring, 2002). Nitrite and bensoate inhibit the growth of clostridia (Lingvall.1994). The recommended application rate is 2.5 – 3.5 litres/ metric ton FM (Hansson & Möhring, 2002).

4.4.2. Kofasil®Life (Addcon Agrar GmbH, Germany) is a biological additive that after application to the forage is able to quickly lowers the pH in the silage (Addcon Agrar GmbH. 2000). The bacteria applied are composed of 2 strains of *Propionibacterium* spp. and 2 strains of *Lactobacillus plantarum*. The freeze-dried additive is retailed in 2 litres plastic cans. After addition of water the additive has to be stored at a warm place (20-25°C) for 48 hrs to increase LAB (lactic acid bacteria) counts to approx. 7×10^9/ml. After that the additive will keep its viability for 4 weeks if stored in a refrigerator (4-6ºC). Before application on the crop the contents of the 2 litres can are diluted in 58 litres of tap water, which is sufficient to treat 30 metric tons of forage. With an application rate of 2.0 litres/ metric ton FM approx. 500 000 LAB are applied per gram of forage (Pauly, pers. comm.).

4.4.3. AIV®2S (Kemira Grow How Oy, Finland) is an acid-based additive that contains formic and propionic acid, ammonium formiate, and K-sorbate (Kemira Grow How Oy). Formic acid gives an instant lowering in the pH value (Swedish Dairy Association. 2004) but an additional fermentation by bacterial lactic acid is usually necessary for good silage quality (Pauly, pers. comm.). The recommended application rate according to the producer Kemira Grow How Oy is 3.0 -5.0 litres/metric ton FM.

[1] Even called methenamine, hexamine or urotropine. Antibacterial properties; will split into formaldehyde and ammonia in silage: $C_6H_{12}N_4 + 6\ H_2O \leftrightarrow 6\ CH_2O + 4\ NH_3$.

4.5. Statistical methods

The density data were statistical analysed by using one factorial analyses of variance (ANOVA). 12 bag sections × 13 sampling spots/section = 156 samples.

Model: density = overall mean + sampling spot + error

d.f.: 155 12 143

Chemical silage parameters were statistical analysed by using two factorial analyses of variance (ANOVA). 4 additives × 3 bag sections/additive × 2 samples/section = 24 samples.

Model: y = overall mean + additive + bag section + add×sec + error

d.f.: 23 3 2 6 12

5. Results

5.1 Fresh crop

The median particle size according to the samples dry weight was determined to be 58 mm (Figure 6).

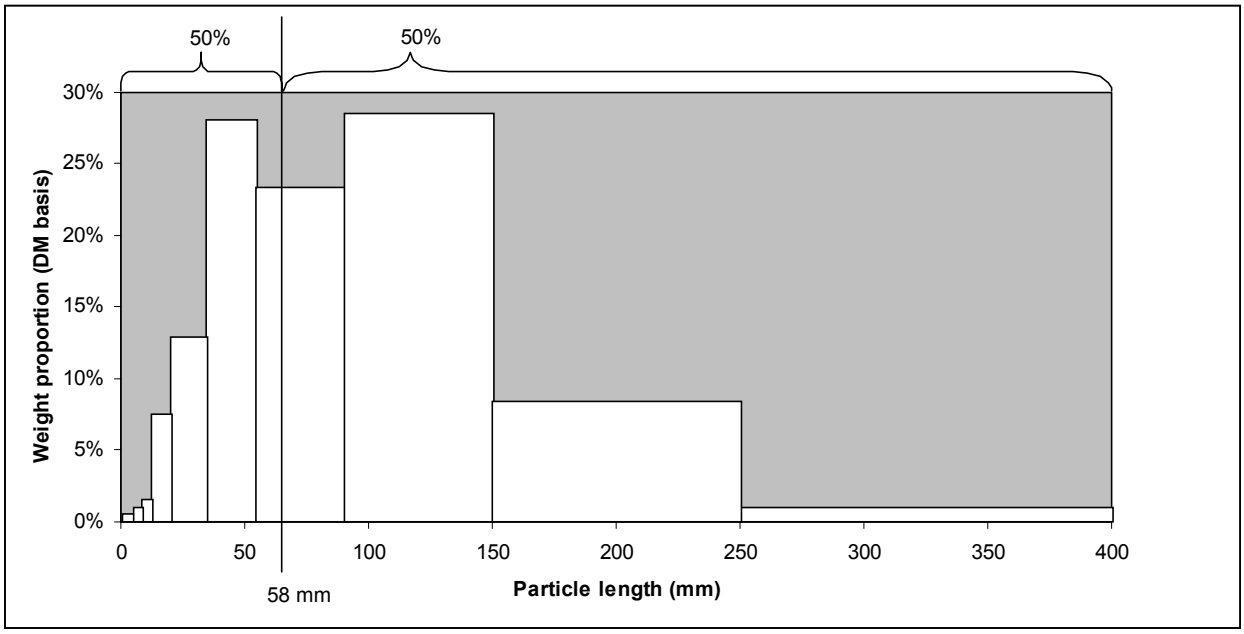

Figure 6: The dried samples were sorted by length in 10 fractions and then divided in two equal parts by weight. The result is given as the median particle length.

The results from analyses of the fresh crop are given in Table 3 and Appendix 1.

Table 3: Contents of DM and sugars (WSC) in the fresh crop (n=6).

Additive	DM	WSC
	%	% /DM
Control		
Mean	33.4	7.0
CV	20	9
AIV 2S		
Mean	33.5	6.8
CV	22	5
Kofasil Life		
Mean	34.8	7.2
CV	16	6
Kofasil Ultra		
Mean	31.1	6.7
CV	16	3
Total		
Mean	*33.2*	*6.9*
CV	*18*	*6*

5.2 Microbial and chemical analyses in the silage

Acceptable silage quality was shown in the silage with no additive added: no butyric acid and only small amounts of ammonia were found. All additive-treated silages were of better quality with lower pH values than the control silages. Silage treated with AIV 2S had a larger amount of WSC left after fermentation compared to the other treatments. Additives had no significant effect on the amount of clostridia spores (Pr = 0.86).

There were significant differences between sections within an additive with respect to DM, WSC, ammonia-N and lactic acid (significant interaction: additive x section). With respect to pH significant differences were found between silage treated with different additives as well as between different sections. The results are shown in Table 4 and Appendix 2.

Table 4: Treatment means of microbial and chemical analyses in the silages (n=6). NS = not significant.

Additive	DM	WSC	Ammonia-N	pH	Lactic acid	Butyric acid	Clostridia spores
	%	% / DM	%NH_3-N / N		% / DM	% / DM	cfu / g silage
Control							
Mean	33.2	0.5	9.5	4.26	6.8	0.05	229
CV	19	122	9	2	20	#	169
AIV 2S							
Mean	32.4	2.0	7.9	4.08	6.1	<0.04	18
CV	19	58	7	4	38	#	55
Kofasil Life							
Mean	33.1	0.5	8.7	4.09	7.8	<0.04	60
CV	10	29	27	3	9	#	86
Kofasil Ultra							
Mean	30.5	0.2	7.2	4.20	7.7	0.05	45
CV	12	80	15	2	10	72	125
Significance level:							
Additive	**	***	**	**	**	NS	NS
Section	***	***	*	**	***	NS	NS
Add*Sec	**	**	**	NS	**	NS	NS

5.3 Density in the silage

Additives had no significant effect on silage density (Pr = 0.31), which was expected. But the different sections had no significant effect on silage density either (Pr = 0.17). However, there were significant differences in silage density among sampling spots (Pr = 0.03). Sampling spots number 6, 10, 11 and 12 are significant different from sampling spots number 1, 2, 3, 4, 9 and 13. Sampling spots number 5, 7 and 8 are not significant different from any other sampling spots (see Figure 6).

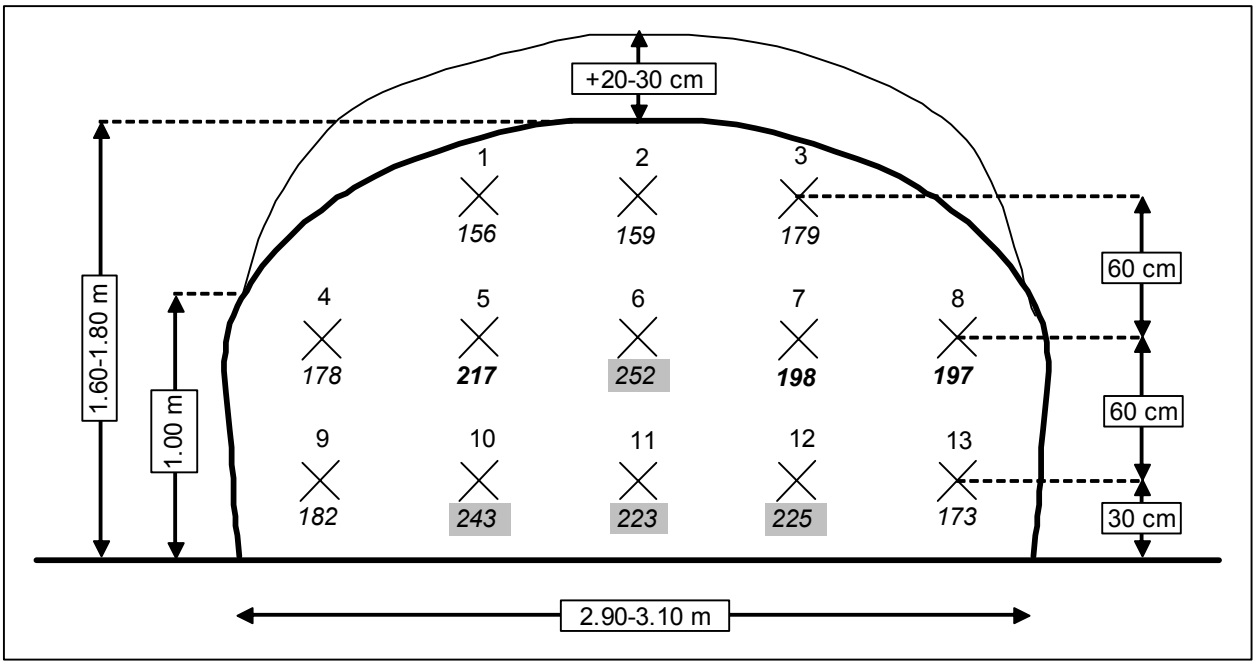

Figure 6: Mean silage density (kgDM/m^3) at the different sampling spots. Values are means over all 12 bag sections.

5.4 Observations made during unloading of the bag

At unloading it was noticed that all 3 sections treated with Kofasil Life had some kind of fermentation trouble. In section 12 a large area of mouldy silage was located (approx. 2 m^3). In section 5 small yeast colonies were found right under the plastic film and the silage in section 4 had an odd acidic smell. The chemical analyses confirmed that the Kofasil Life-treated silage was not very well fermented and contained higher amounts of ammonia than silages treated with other additives.
In section 7, treated with Kofasil Ultra, a large spot with mouldy silage (approx. 1 m^3) was found. The mould growth appeared at a place where an injury on the plastic film that had been patched during filling of the bag. The silage in this section was also very dark and wet (probably aerobic deterioration). In section number 2, also treated with Kofasil Ultra, some soil was found. Despite of that, counts of *Clostridium* spores were very low (45 cfu/g silage). Section 1 and 8 were left untreated. In section 8 the silage seemed to be loose and in section 1 some soil was found.
The bag didn't look as it should. The upper part was not even but rather bumpy. It was also noticed that the silage in the upper part of the bag often was split in the length direction. That created a deep gap in the silage (see Figure 5a).

6. Discussion

When taking a look at the chemical analyses of the fresh crop one can notice that the fresh crop contained sufficient amount of WSC. The WSC content in the fresh crop should be at least 2.0 to 2.5 % of the fresh crop to avoid a shortage of WSC during fermentation (Pettersson 1988).

The overall silage quality in this project showed out to be acceptable. The amount of butyric acid was acceptable in all treatments; the amount shouldn't be more than 0.3 % of the wet sample to get silage of acceptable quality (Spörndly, 2003). All treatments also contained low numbers of clostridia spores. The recommendations are that silage shouldn't contain more than 10^3 clostridia spores / g silage (Spörndly, 2003). Untreated silages had an amount of ammonia-N (NH_3-N) of 9.5 % of total N, and silage treated with Kofasil Life had an amount of 8.7 % NH_3-N of total N. Recommendations according to Spörndly (2003) is that silage of good quality shouldn't have an amount over 8 % NH_3 of total N. The untreated silage also had a higher pH value than silage from any other treatment. However, a pH value of 4.3 is still acceptable. Silage treated with AIV 2S contained less lactic acid while silage treated with Kofasil Life contained more lactic acid than silages with other treatments. In studies done at SLU, Department of Animal Nutrition & Management, it has been shown that additives containing lactic acid bacteria usually produce higher contents of lactic acid and additives with formic acid lead to lower amounts of lactic acid in the silage (Pauly. 1994). The chemical analyses on the silage also showed that AIV 2S had a much higher content of WSC left after the fermentation. Strong acids such as formic acid are known to restrict the fermentation and therefore "save sugar" in the silage (Lingvall 1994).

When making silage it is important to get a porosity that is as low as possible [2]. That is because oxygen penetrates the silage more easily if the porosity is high. If the silage has a low DM content the porosity will be lower than if the silage has a higher DM (because silage juice will fill out many pores). In addition, a higher density produces lower porosity. When looking at the differences in density between sampling spots it is noticed that the outer and upper sides had lower density than the sampling spots in central and lower positions. This was also noticed in a study by Holmes & Muck (2001) who showed that the highest density was found in positions equivalent to no. 6 and 11 and the lowest density in positions 2 and 4 (see Figure 6).

[2] Porosity = total silage volume – water volume – DM volume. The specific weight of forage DM is approx. 1.45 kg/litre; hence the DM volume can be calculated as DM weight / 1.45.

The bag didn't look as it supposed to do at unloading. The upper part was not even but rather bumpy (Figure 7).

Figure 7: The upper part of the bag was rather bumpy.

Photo: Cecilia Lundmark

That was probably because the particle length of the forage was too long and the forage was too dry for that particular particle length (Björkegren, pers. comm.). According to Björkegren, the manufacturer of the Winlin bagging machine, the DM content should be kept between 35 – 40 % and the forage should be precision-chopped to get the best silage quality. The fresh crop in this study was cut in a loading wagon and had an average DM content of 33 %. Björkegren recommends that if the particle length of the forage is this long then the DM should be less than 30 % and the packing density should be reduced. Density in the bag can be reduced by decreasing the brake pressure applied by the cable drums (see Section 4). This is though very risky because the low density makes it easier for oxygen to penetrate the silage. To compensate that a higher unloading rate will be required according to Björkegren.
At unloading it was also noticed that the silage in the upper parts of the bag was split in the length direction (Figure 5a). According to Björkegren the reason for that is probably the low DM content.

According to this study the best silage quality is achieved by adding one of the additives Kofasil Ultra or AIV 2S. These additives didn't show any fermentation troubles if looking at the results of the chemical analyses or if looking at the observations done at the unloading of the bag. The mould found in section 7 treated with Kofasil Ultra wouldn't have been there if it hasn't been for the injury at the plastic film. Kofasil Life on the other hand showed lower fermentation quality according to the chemical analyses and the observations done at unloading.
The most interesting result is that the control silages (no additives added) proved to be of such an acceptable quality, in spite of the long particle length and the low DM content. It is

however not clear if similar results are possible to reach under more realistic conditions, i.e. when the unloading would reach over a period of approx. 3 months and with an average outside temperature of approx. +15°C. I think that it would have been of great interest to make a similar experiment where the recommendations about to use precision-chopped silage with a DM between 35 – 40 % are followed more strictly and where the unloading is done at higher temperatures and over a longer period of time.
For farmers it would be very interesting to know if it is possible to get silage of very good quality without any additives given that recommendations are followed, that the farmer has good knowledge about the ensiling technique and knows how to manage the press. Silage additives can then be used as quality improvers when harvest conditions are difficult.

7. Conclusions

- Acceptable silage quality was produced in the untreated control silages (no additives).
- All additive-treated silages were of better quality than the control silages.
- The best silages qualities were achieved with the additives Kofasil Ultra and AIV 2S.

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