Quality silage – minimal losses

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Objectives of ensiling grass and other forages:

- Balanced feeding year around in spite of fluctuating annual feed supply
- High quality of feed
  - Chemical and microbiological parameters
  - Health of animals, farmers and consumers
- Minimal ensiling losses
  - Mechanical losses
  - Spoilage in silo
  - At feeding
- Utilization in feeding
  - High voluntary intake
  - Concentrations of nutrients
  - Digestibility
  - Economy

Photos: Markella Rinne
Finland has strong traditions in silage making based on acid additives

- A.I. Virtanen patented the use of acids in silage preservation in 1920’s
- Virtanen was awarded the Nobel Prize in Chemistry in 1945
- The use of formic acid as a silage additive started in a large scale in 1960’s
Forage in the field

- Shedding, leaching
- Respiration

Forage in silo

- Poor fermentation
- Effluent production
- Aerobic deterioration

Forage in feeding

- Low intake
- Aerobic deterioration

Forage in the rumen

- Rumen fermentation and digestibility

Production

- Milk quality, animal health

Payment

Milk quality, animal health, payment

Rumen fermentation and digestibility

Low intake

Aerobic deterioration

Effluent production

Poor fermentation

Respiration

Shedding, leaching

Forage in the field
<table>
<thead>
<tr>
<th>Process</th>
<th>Classification</th>
<th>Losses, %</th>
<th>Causative factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual respiration</td>
<td>Unavoidable</td>
<td>1 - 2</td>
<td>Plant enzymes</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Unavoidable</td>
<td>2 - 4</td>
<td>Microorganisms</td>
</tr>
<tr>
<td>Effluent OR Field losses by wilting</td>
<td>Mutually</td>
<td>5 → 7</td>
<td>DM content</td>
</tr>
<tr>
<td></td>
<td>unavoidably</td>
<td>or 2 → 5</td>
<td>Weather, technique, management, crop</td>
</tr>
<tr>
<td>Secondary fermentation</td>
<td>Avoidable</td>
<td>0 → 5</td>
<td>Crop suitability, environment in silo, DM content</td>
</tr>
<tr>
<td>Aerobic deterioration during storage</td>
<td>Avoidable</td>
<td>0 → 10</td>
<td>Filling time, density, silo, sealing, crop suitability</td>
</tr>
<tr>
<td>Aerobic deterioration during storage</td>
<td>Avoidable</td>
<td>0 → 15</td>
<td>As above, DM content, unloading technique, season</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7 → 40</td>
<td></td>
</tr>
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</table>

Most losses are never “seen” and can thus easily be neglected.

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<td>2 → 5</td>
<td>Weather, technique, management, crop</td>
</tr>
<tr>
<td>Filling time, density, silo,</td>
<td>Unavoidable</td>
<td>0 → 5</td>
<td></td>
</tr>
<tr>
<td>Nutrient content</td>
<td>Unavoidable</td>
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Aerobic deterioration has become a big issue – silage heats at feedout

• In efficiently wilted silages, air penetration into the silage mass is easier than in wet herbage mass

• Restrictively fermented silages contain water soluble carbohydrates which are good substrates for yeasts
  • Substances such as benzoic, sorbic or propionic acid may be included in the additives to improve aerobic stability

• Pure lactic acid containing silages are more susceptible as acetic acid restricts heating
  • Heterofermentative LAB such as L. Buchneri may be used
Spoilage may occur, when:
- Not acidic enough
- Suitable humidity, temperature
- Oxygen available
- Nutrients easily available

Yeast
Bacilli and other aerobic bacteria
Moulds

Temperature rises

Carbohydrates and organic acids are oxidized

Nutrient losses
Mycotoxins
Listeria etc.

Feed intake decreases

The problems are exaggerated in TMR
How to evaluate silage quality?

- pH – depends on DM concentration
- Proportion of ammonium N from total N
  - If the additive contains ammonium, the results may be corrected for the added amount
- Butyric acid – risk particularly to cheese quality
- Amount of lactic acid, VFA, VFA to lactic acid ratio
- Total amount of fermentation acids
- Residual water soluble carbohydrates (WSC), ”sugars”
- Smell, colour, visual signs of mould, yeasts and spoiled feed
- Aerobic stability – raise in temperature after opening the silo
- Silage DM intake index
- Transfer of energy and nutrients from the field into animal products
- Amount and quality of animal products
Acceptable silage pH depends on silage DM concentration – lack of water partly restricts the detrimental microbial activity.

Residual WSC content at least 0.7 % FM when DM<27.5%, and 3 % DM when DM>27.5 %.
Proportion of poor quality silages classified by silage DM concentration in Finnish farm samples analysed by Valio Ltd. during autumn 2013
Meta-analysis of formic acid as silage additive

• Masters thesis by L. Blomqvist (2010) at University of Helsinki, Finland supervised by Seija Jaakkola

• Includes scientific reports where same forage material was ensiled using formic acid and without an additive (control)
  • Comparison of different additives (also biological additives included)
  • Effect of application rate of formic acid

• Material:
  • 62 research reports (29 from Finland)
  • 111 experiments, total number of observations 451
  • 385 grasses, 34 lucerne and 32 wholecrop-pea bi-crops

• The grass material was classified according to water soluble carbohydrate (WSC) concentration in the grass:
  • <15 g/kg fresh matter (FM) – difficult to ensile (DM 207 g/kg)
  • 15-30 g/kg FM – intermediate to ensile (DM 212 g/kg)
  • >30 g/kg FM – easy to ensile (DM 297 g/kg)
Formic acid was particularly effective in preservering the low WSC herbage

- Blomqvist 2010
Increasing the application rate of formic acid linearly improved silage quality the effect being strongest for low WSC herbage

- Blomqvist 2010
Increasing the application rate of formic acid restricts lactic and acetic acid production and saves sugars

- Blomqvist 2010

...which is reflected in high acetic acid concentration.

Loss of lactic acid in untreated silages indicates secondary fermentation...
Good quality silage could be produced from lucerne only by using formic acid as an additive.

The XVI International Silage Conference was held in Finland at 2-4 July 2012: www.mtt.fi/isc

Proceedings and presentations still available
Formic acid reduced fermentation losses the difference being greatest for immature lucerne

- Tuori et al., 2012.
Formic acid works also in UK 🙂

Which additive to choose?

• Acid based additives are a good choice for challenging herbage materials – type of risk management, ”insurance”
  • DM concentration <250 g/kg
  • Legumes (little sugars, high buffer capacity)
• LAB inoculants improve silage quality compared to no additive, and can be recommended to successfully prewilted grass material
• Wilted silages are prone to aerobic deterioration
  • Modern additives contain substances that restrict it (benzoate, sorbate, propionic acid, acetic acid, heterofermentative LAB)
• Consider total losses in the chain and how much of the feed can be converted to salable animal products!
• Is the additive of choice successfully and evenly distributed into the harvested herbage?
The “easiest” way to improve milk production is to increase feed intake!

Variation in milk production of dairy cows is mainly affected by variation of voluntary feed intake.
Silage dry matter intake index
SDMI index

• Based on a large meta-analysis of systematically conducted dairy cow feeding trials

• Effects of silage quality on relative silage intake potential
  • Digestibility (D-value)
  • **Extent of silage fermentation**
  • Silage DM and fibre concentration
  • Plant species, season

• Publication:
• When the concentration of fermentation acids increases by 10 g/kg DM, silage intake decreases by 128 g DM/day.
• Compensation is no longer done, when the concentration reaches 40 g/kg DM.
Restriction of silage fermentation was reflected as animal responses (Jaakkola et al. 2006)
Crimped grain

- More flexibility in harvest time and conditions
- No drying costs
- Fits well with TMR feeding
Different additives for crimped grain

- A pilot scale experiment
  - No additive
  - KemiSile Crimp 3 l/t
  - KemiSile Crimp 4 l/t
  - Biotal
- Seppälä et al. Unpublished.

- KemiSile:
  - Formic acid 425, ammonium formate 303, propionic acid 100, benzoic acid 22 and water 150 g/kg

- Biotal Biocrimp
  - Pediococcus pentosaceus, Lactobacillus buchneri
- **Annabell** (Bor) barley
- Ensiled at Jokioinen, Finland on 17 August 2010
- Ripened at yellow stage, partly dough stage

### Grain composition prior to crimping

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, g/kg</td>
<td>605</td>
</tr>
<tr>
<td>In DM, g/kg</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>32</td>
</tr>
<tr>
<td>Crude protein</td>
<td>118</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>50</td>
</tr>
<tr>
<td>Starch</td>
<td>567</td>
</tr>
</tbody>
</table>
Water soluble carbohydrates

Treatments differ statistically significantly

pH

Treatments differ statistically significantly
Sum of all fermentation acids

Treatments differ statistically significantly

Acetic acid

Biotal differ sstatistically significantly

Sum of all VFA

Treatments differ statistically significantly except KemiSile rates.
### Aerobic stability, hours (2°C difference to ambient temperature)

<table>
<thead>
<tr>
<th>Additive</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additive</td>
<td>162</td>
</tr>
<tr>
<td>Biotal</td>
<td>&gt;300</td>
</tr>
<tr>
<td>KemiSile3</td>
<td>&gt;300</td>
</tr>
<tr>
<td>KemiSile4</td>
<td>273</td>
</tr>
</tbody>
</table>

![Graph showing aerobic stability over time for different additives.](image)
Different additives for crimped grain

• A farm scale experiment
  • Propcorn NC
    • 72.6% propionic acid, 21.4% ammonium propionate and 6% water
  • AIV Ässä
    • 59% formic acid, 20% propionic acid, 4% ammonium formate, 2.5% benzoic acid/sorbate and 14% water
  • At rates 0, 3, 6 ja 9 l/t

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley composition prior to crimping</td>
<td></td>
</tr>
<tr>
<td>DM, g/kg</td>
<td>792</td>
</tr>
<tr>
<td>In DM, g/kg</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>26</td>
</tr>
<tr>
<td>Crude protein</td>
<td>113</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>47</td>
</tr>
<tr>
<td>Starch</td>
<td>582</td>
</tr>
</tbody>
</table>
Aerobic stability of crimped barley was improved by the use of additives. Additive already at crimping works also as stabilizer in the TMR giving double benefit.
Successful silage making

- High yield (kg/ha)
  - Take care of agronomic factors – important economically
  - Ensure possibilities to produce good quality raw material for silage
  - Minimize losses in the silage chain

- High nutritional value
  - Digestibility / energy value
  - Fermentation quality
  - Intake potential

- High hygienic quality

Affects the price of silage

Results in high milk output

Ensures the health and safety of animals, barn staff and consumers
Finnish cows dreaming of grass – living on silage

Questions & comments!