Theme 2: Forage conservation

FERMENTATION PROCESS IN SILAGE

Level 3 – Part II

Topic	Training & information Content
2.1	Fodder conservation and storage
2.2	Estimating ideal time of harvesting
2.3	Guideline for silage making
2.4	Fermentation process in silage
2.5	Treatment of straw with Urea
2.6	Making of urea/molasses/mineral lick
2.7	Management of silage pit (feed out)
2.8	Estimating fodder supplies for dry season feeding & planning of feeding management

1. You will learn about (learning objectives):

- ❑ The trainee understand the different processes which influence the silage making
  - Fermentation – types, analysis
  - Silage additives
  - Quality of silage at farm level
  - Silage feed out

IMPORTANT

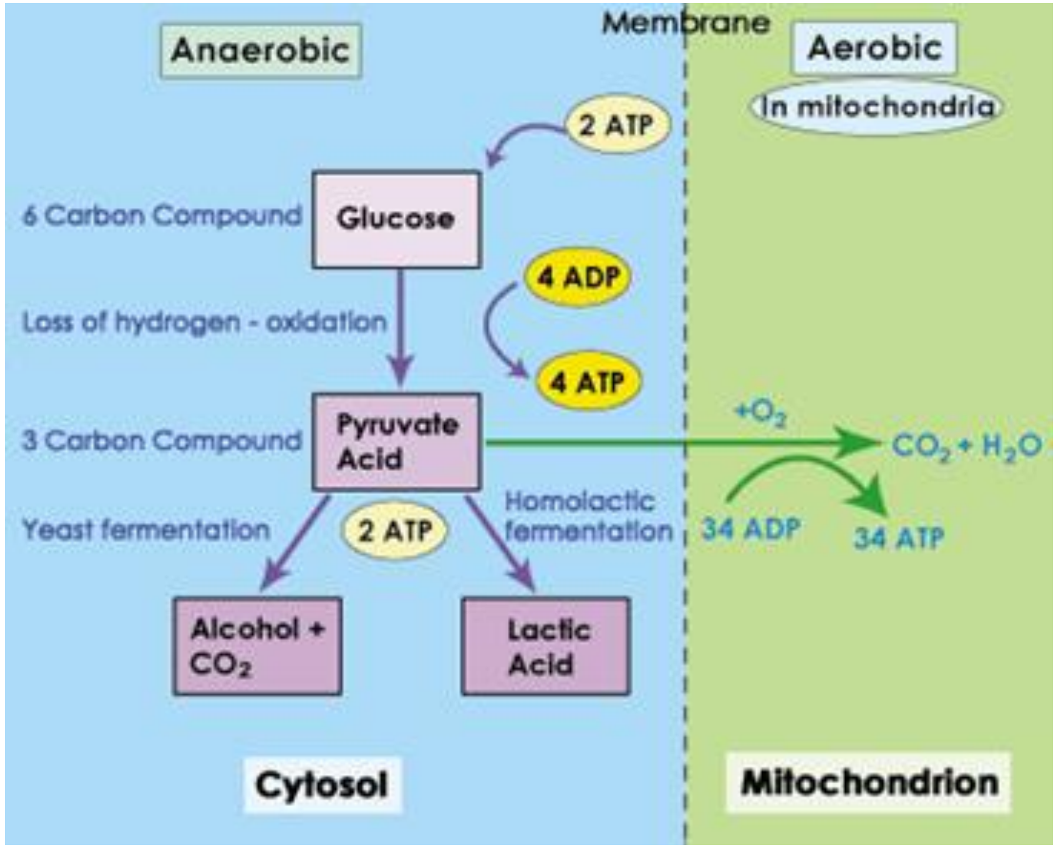
This module has two parts; this is part II – ensure you download Part I.

1. Types of fermentation in silage:

Homolactic fermentation

1. Homolactic fermentation (homofermentative pathway)

- very desirable, common in high sugar grasses
- sugars fermented to lactic acid, low pH and low nutrient loss
- mediated by *Lactobacillus plantarum, L acidilacti*
- pleasant acidic and sometimes sweet smell.



1.1 Types of fermentation Cont'd:

Heterolactic fermentation

2. Heterolactic fermentation (heterofermentative pathway)

- Less desirable, occurs when limited sugars are available.
- Mediated by *Lactobacillus brevis, L. buchneri.*
- Fermentation maybe dominated by enterobacteria.
- Sugars mainly fermented to acetic acid and alcohols.
- Less efficient than homolactic fermentation.
- pH higher then with homolactic fermentation.
- More likely to occur when unwilted or lightly wilted forage material with low DM content is ensiled.
- Typical sour, vinegar smell.

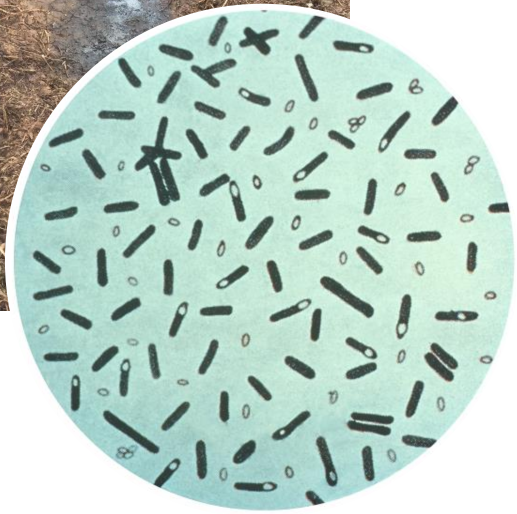
1.2 Types of fermentation Cont'd:
Secondary fermentation

3. Secondary fermentation

- Very undesirable.
- Degradation of lactate by clostridial bacteria to acetic acid & butyric acid.
- Facilitated by high moisture contents & high pH.

1.3 Secondary fermentation Cont'd:
Clostridia bacteria

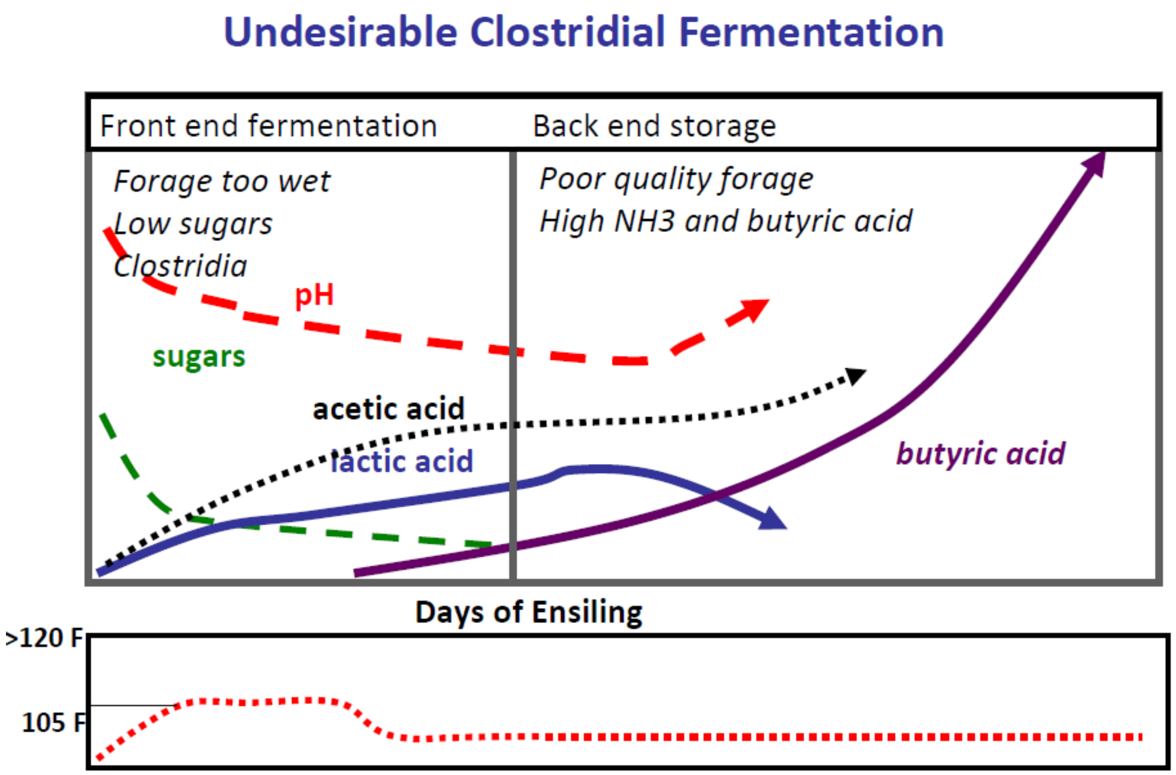
- Clostridia bacteria are also present in the forage when it is mowed and are put in the silo.
- Clostridia bacteria consume forage carbohydrates (sugars), forage proteins, and lactic acid as their energy source and excrete butyric acid.
- Butyric acid is associated with spoilt or rotten silage.
- Situations that might benefit clostridia bacteria growth are insufficient forage carbohydrate levels to complete the fermentation process and/or low lactobacillus bacteria levels. i.e;
    - rains while forage is wilting
    - extended respiration period due to poor packing
    - seepage due to excessive forage moisture



Colony of Clostridia bacteria

1.4 Clostridia affected silage

- Fermentation is dominated by clostridia bacteria
- More likely to occur when unwilted or lightly wilted forage material with low DM content is ensiled.
- Sugars and lactic acid are degraded by clostridia bacteria to butyric and acetic acid.
- Characterized by low lactic acid levels and (facilitated by) high pH
- Proteins and amino acids are extensively degraded
- Ammonia N levels are high as a percentage of total N (>15%)
- DM and energy losses can be significant (silages are less palatable or unpalatable to cattle and the utilization of N in these silages is poor)



1.5 Summary of Types of fermentation

Fermentation	Substrate (microbe)	Product	Nutrient losses
Homolactic	Glucose (L. plantarum)	2 x Lactic acid (Low pH)	Low
Heterolactic	Glucose (L. buchneri)	• 1 x Lactic acid • acetic acid • ethanol • CO_2 (Moderate pH)	Moderate
Secondary	Lactic acid (Clostridia)	• Butyric acid + • CO_2 (High pH)	High
Aerobic spoilage	Glucose, lactic acid (Yeasts & moulds)	• Ethanol • CO_2 (High pH)	Very high

2. Assessing quality of silage on the farm

Colour	Characteristics	Smell	On touching with hands	pH	Flieg score	Feeding
Pale yellow, light green to green brown, Olive	Normal colour range for grass, whole plant cereal and maize silage	Pleasant light sweet odour	Washing hands is not needed	3.6-3.8	81-100	Can be fed in large quantities
Brownish yellow	Normal colour range for wilted grass silages, Tendency for heavily wilted grass silages with restricted fermentation to be greener	Sweet & sour	Wash hands with cold water	3.9-4.2	61-80	Careful when feeding cows in milk
Dark brown	Some heating has occurred during storage or due to aerobic spoilage during feed out. Some loss in digestibility and heat damage of protein. More common in wilted silages	Strong pungent	Wash hands with hot water	4.3-4.5	41-60	Feed only to heifers
Dark brown and green	More extensive heating may also be some black patches of silage on the surface. High loss of digestibility and high proportion of protein is heat damaged and unavailable to the animal. Due to inadequate compaction delayed sealing of poor air exclusion. Usually accompanied by significant proportion of waste (mouldy) silage	Ammonia and putrid	Wash hands with hot water & soap	>4.6	<40	Feed heifers with caution
*Flieg score = 220 + (2 x DM% - 15) - 40 x pH						

3. Chemical changes and losses during fermentation

- Sugars are fermented into volatile fatty (organic) acids (VFA) like lactic, acetic, propionic & butyric) acids by anaerobic microorganisms.
- The formation of the acids reduces the pH (target = 4)
- Protein is degraded into ammonia and NPN* (target =<100g ammonia/kg total Nitrogen)

* NPN = Non Protein Nitrogen

4. Losses in maize silage

- Table below shows losses in maize silage during fermentation when harvested at different stages

Maturity stage of kernel	Dry Matter %			Ensiling losses (%)	
	cob	total plant	% cob in DM	Dry matter	Energy
Milky	30	18-21	30-35	10-15	15-20
Early dough	40	21-25	40-45	8-12	11-15
Dough	50	25-29	45-50	6-10	8-12
Late dough	55	29-35	50-55	4-8	6-10

5. Fermentation analysis

- Analysis in terms of:

  i. High pH
  ii. Lactic Acid
  iii. Acetic Acid
  iv. Propionic Acid
  v. Butyric Acid
  vi. Ethanol
  vii. Ammonia

5.1 Fermentation analysis: High pH

High pH

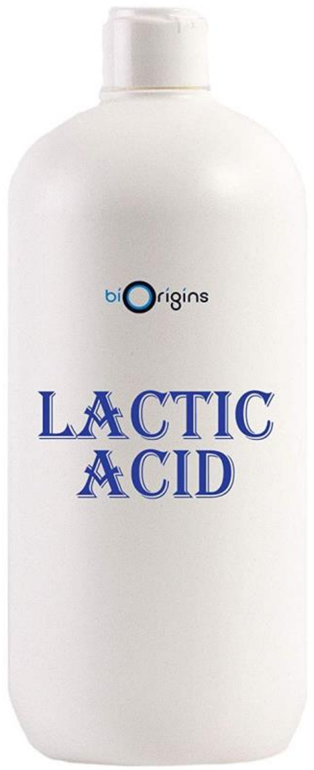
- A high pH indicates a poor or restricted fermentation that will be less stable and result in poor clamp/silo life and more spoilage at feeding.

- Legume haylage has a higher buffering capacity than grass haylage and corn silage, and quite often has a higher pH.

5.2 Fermentation analysis: Lactic acid

Low Lactic acid

- Lactic acid should make up over 65-70% of the total silage acids, with a lactic to acetic acid ratio of at least 3:1. Lactic acid is the most effective in lowering pH, and this is what we are trying to improve by using a commercial Lactic Acid Bacteria (LAB) innoculant.



5.3 Fermentation analysis: Acetic acid

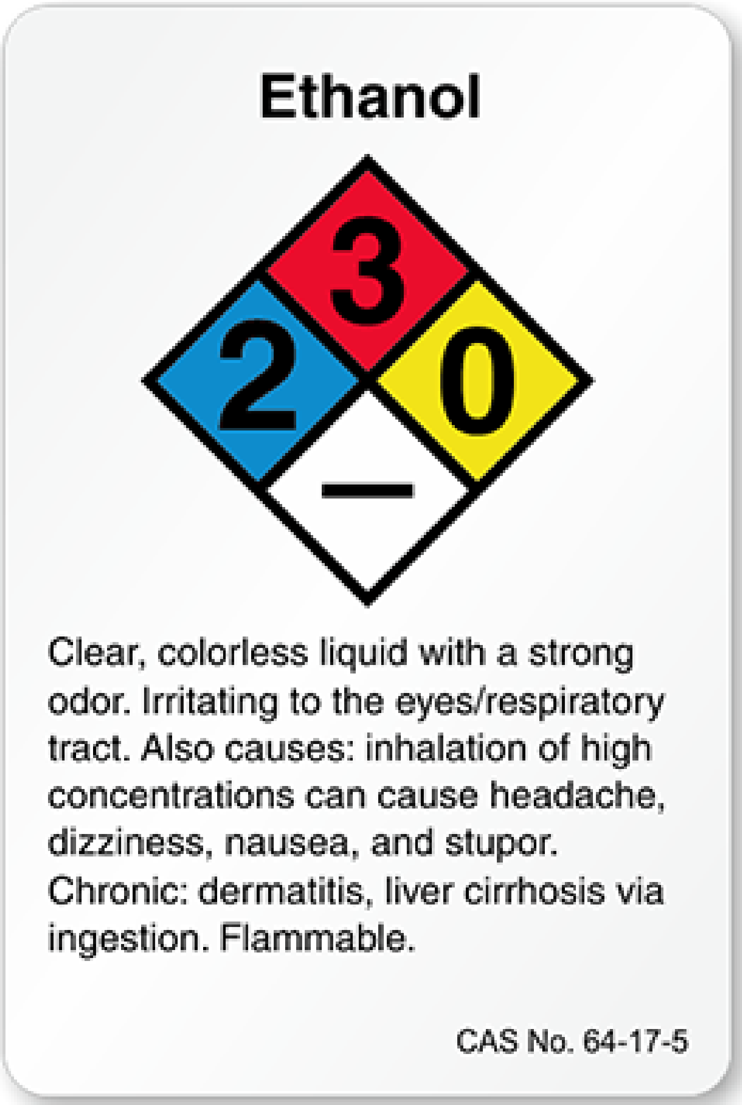
High Acetic acid

- Acetic acid levels greater than 3 - 4% can result from poor fermentations, especially if lactic acid levels are significantly low. High levels of acetic acid can be encountered in very wet silages (below 25% dry matter); in silages that were slowly compacted or badly covered; or in silages treated with ammonia, which raises pH (lowers acidity). This can lead to dry matter intake limitations.

5.4 Fermentation analysis: Ethanol

High Ethanol

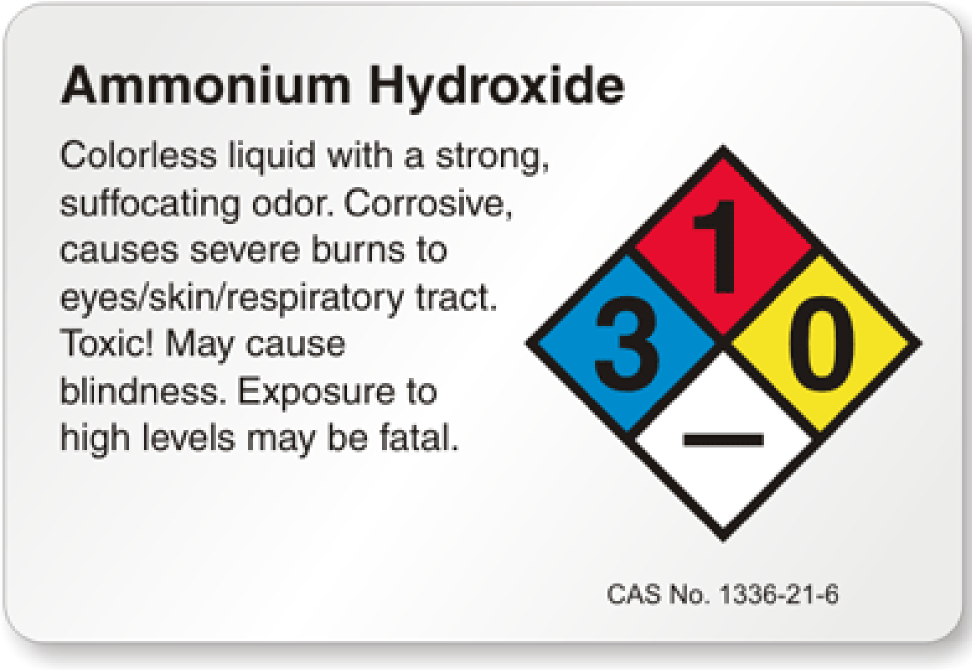
- High ethanol indicates yeast that reduces dry matter recovery and makes the silage more prone to mould and feed out spoilage. Off-flavours in milk can also sometimes result.



5.5 Fermentation analysis: Ammonia

High Ammonia - N

- This indicates excessive protein breakdown and possibly excess ruminally-degraded protein. Levels greater than 12 - 15% can be a problem for the dairy nutritionist.



5.6 Fermentation analysis: Butyric acid

Butyric acid

- This is the bad one! If it is accompanied by high percent moisture and/or high ash content, then that confirms what management issue needs to be corrected.

- In the silo, butyric acid results in high losses of dry matter and digestible energy.

- In the ruminant it results in poor intakes and metabolic problems.

5.7 Fermentation analysis: Butyric acid Cont'd…

- If possible, silage high in butyric acid should be discarded.

- High level of butyric acid, over 0.5% in dry matter shows that Clostridia fermentation has undergone.

- This situation might occur when soil is mixed with crop during harvest. Silage with high butyric acid level will have low nutritive value and high ADF and NDF.

6. Typical concentration of common fermentation end products

End product	Legume silage (30-40% of DM)	Legume silage (45-55% of DM)	Grass silage (30-35% of DM)
pH	4.3-4.7	4.7-5.0	4.3-4.7
Lactic acid (%)	7-8	2-4	6-10
Acetic acid (%)	2-3	0.5-2.0	1-3
Proprionic acid (%)	<0.5	<0.1	<0.1
Butyric acid (%)	<0.5	0	0.5-1.0
Ethanol (%)	0.2-1.0	0.5	0.5-1.0
Ammonia-N (% of CP)	10-15	<12	8-12

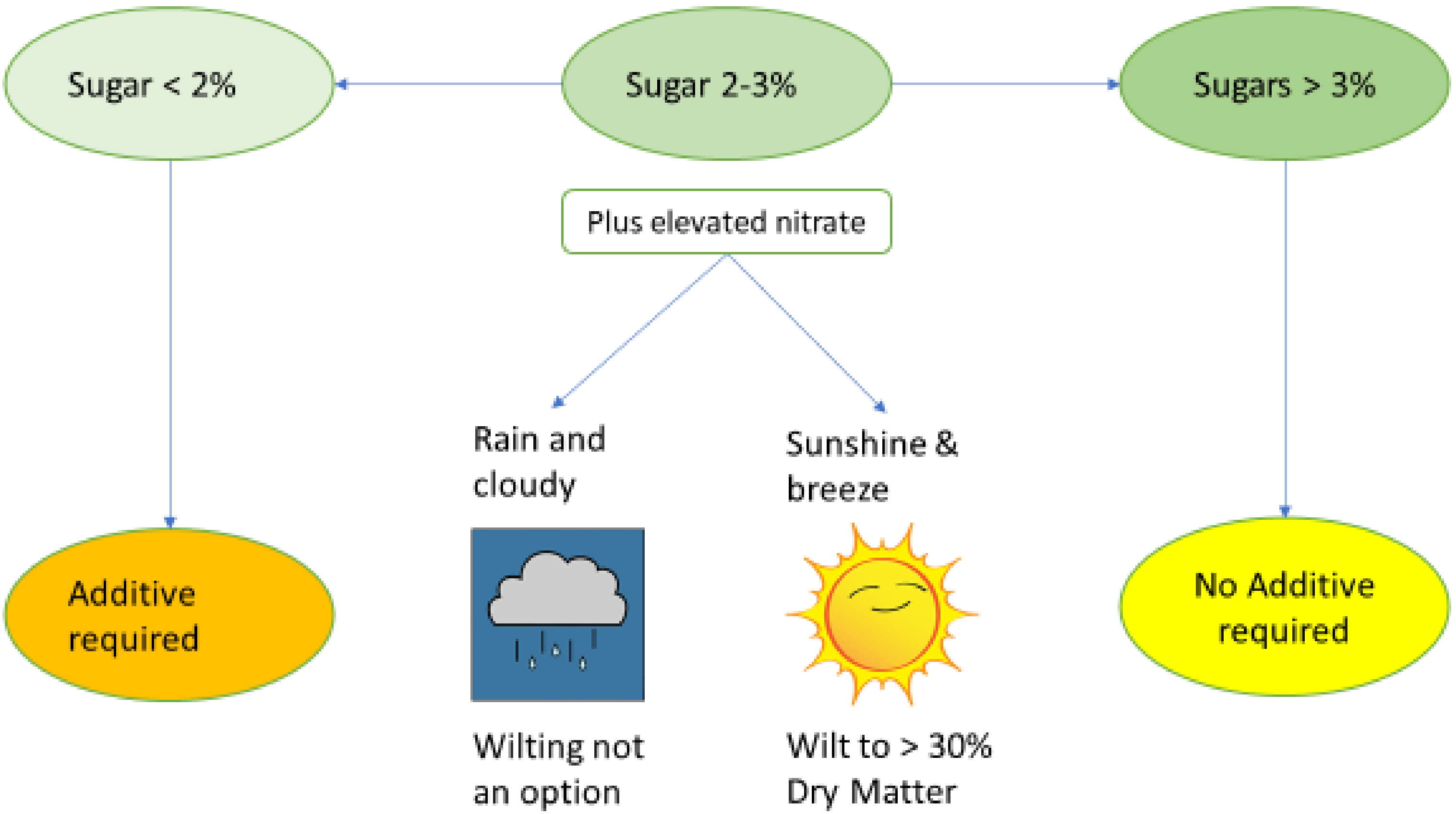
7. Silage additives

Use of additives to jump start fermentation

- Use of silage additives does not guarantee better preservation quality if silage making management is poor.
- What silage additives do is to increase lactic acid fermentation and lower pH.
- Examples of silage additives include silo guard, power start, bonsilage, ecosyl etc.

	Treated	Untreated
DM%	35%	35%
pH	3.9	4.5
Lactic Acid	85	20
Acetic Acid	10	9
Butyric Acid	0.1	8.1
Ammonia	5	14
Sugar	30	<11

7.1 When to use silage additives



7.2 Classifying Silage additives

- Silage additives can be classified into four main groups:

i. Molasses
  - Feed for bacteria
  - Good in combination with inoculants

ii. Acids
  - Suitable DM (dry matter) < 25% without sugar
  - Water (effluent) leaking out

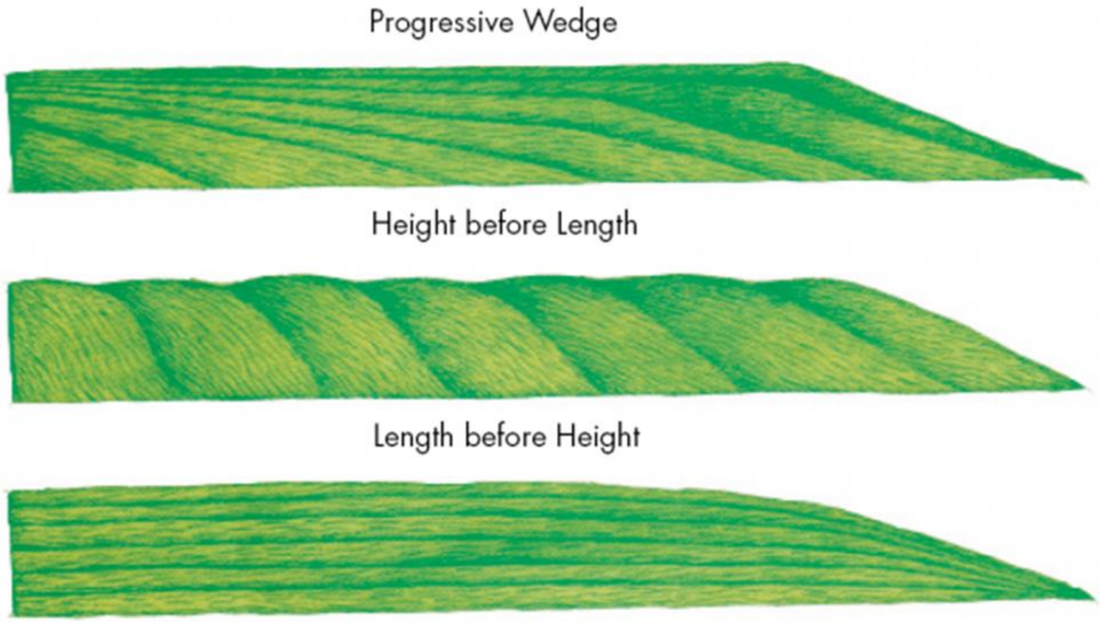
iii. Conservatives
  - Suitable for prevention of heating/fungi
  - Potassium sorbate / benzoates

iv. Inoculants/Enzymes
  - Bacteria using sugar for acid production
  - Best: Hetero-fermentative: Lactic/acetic

8. How to avoid aerobic spoilage in silage

- Includes:

  - tight sealing of silo
  - good compaction
  - filling the clamp/silo/pit fast
  - filling feed materials in thin layers
  - narrow clamp
  - wait for opening 45-60 days minimum
  - management of silo ‘face’
  - keep silage pit ‘face’ tidy
  - keep the polythene sheet away from the silage pit ‘face’ at feed out
  - ensure feeding with speed at feed out



The progressive wedge method is the best way to fill a bunker silo. There is less silage respiration with the progressive method than when bunkers are filled length before height or height before length.

8.1 How to avoid aerobic spoilage Cont'd…

Silage face management

- Silage face management is one of the most common reasons of secondary fermentation since exposure to air is huge and constant in this area.

9. Signals of poor fermentation

- Occurs when extremely wet or dry feed material is used to prepare silage; or when compaction is poor and when the silo is improperly covered with soil. Air entering the silage silo will give yeast and/or mould the opportunity to develop, which is the start of the secondary fermentation process of the silage material in the silo.
- Visible damage indications of such a silage are high pH, increasing silage mass temperature, high ethanol level, high butyric acid level, odour and colour modifications.
- Heat-damaged proteins (>35-40 ˚C) formed in the *Maillard reaction* are usually not digestible by the cow, therefore elevated temperatures can limit availability of protein nutrients from the silage.

The **Maillard reaction** is a chemical reaction between amino acids and reducing sugars that gives browned food its distinctive flavour. The reaction is a form of non-enzymatic browning which typically proceeds rapidly from around 140 to 165°C . In making silage, excess heat causes the Maillard reaction to occur, which reduces the amount of energy and protein available to the animals that feed on it.

10. Silage fermentation problems during feed out

- Increased water activity in feeds (due to rainfall during wilting or adding water to the silage or ration) will raise the potential for microbial growth and feed spoilage. Wild, spoilage yeast species are the first microbial contaminant to take hold in a spoiling TMR (Total Mixed Ration).

- Yeast are prevalent throughout East Africa, with humid and wet climates being more prone to yeast challenges.

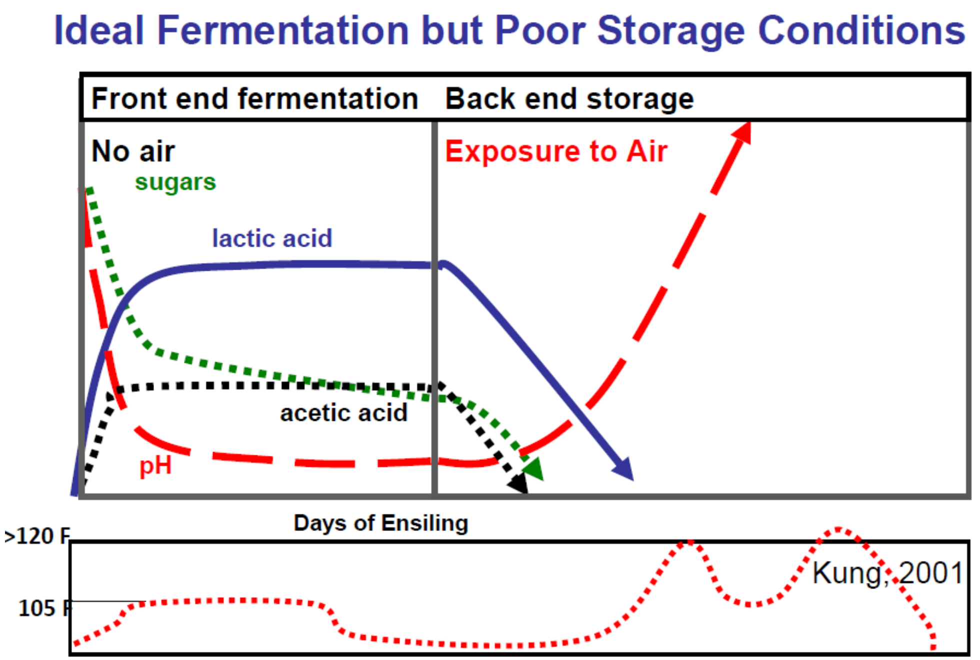
Pineapple peelings

10.1 Silage fermentation problems during feed out Cont'd…

- One of the best ways to check for yeast growth is checking temperatures at the feed bunk and doesn't involve much cost, if any.
- Checking your ration's temperature any temperatures greater than roughly 5°C above environmental temperature are indicative of microbial growth and spoilage.
- TMR or feed temperatures can be checked with a digital thermometer (several inches under the surface), an infrared thermometer (after kicking away the top several inches of TMR), or a more advanced infrared camera.

10.2 Silage fermentation problems during feed out Cont'd…

- Changes do occur in the nutritive value of forages after the fermentation process is complete. These changes may help partially explain why dairy cows produce more milk on silages fermented longer than 3 months from harvest.
- The fermentation process takes 10 days to 3 weeks for completion. Silage should not be fed until after this process is completed for the best milk production and feed intake. Thus, the recommendation is to wait at least 4 weeks before feeding new crop silage.
- To extend clamp/silo life, minimize the exposure of fermented feed to oxygen at the silo face. By properly handling silage at feed out, the feed will heat less in the clamp/silo and be more acceptable to dairy cows.



11. Take home messages

- When applying concepts from this module on the farm regarding the fermentation process for silage;

    1. Harvest forages for ensiling at the ideal dry matter and stage of maturity; ensure rapid filling and intense compaction of silages, and airtightly seal and cover silos with soil – all these directly impact the fermentation process.
    2. Well fermented silages result in reduced dry matter losses, more feed being available for feeding dairy cows, and a higher quality feed (more lactic acid) which could improve feed intake, milk production, and profitability.

- END -