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COOPERATIVE EXTENSION
University of California, Davis

Feeding Silage For Production and Animal Health

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Forage Preservation

- **Hay: preservation by desiccation**
  - Air dry to <15% DM (usually ~12%)
    - basically in equilibrium with environmental humidity
  - Successful hay making is rapid desiccation
    - prevents mold growth
- **Ensilage: preservation by acidification**
  - Composting in an anaerobic system followed by bacterial death

Ensiling Types

- **Enhanced fermentation**: acids produced in the silo
  - Principle
    - use bacteria and substrate in the crop to create the acid
  - Practice
    - restrict oxygen and use crops with high sugars
    - drive pH down to <5 and a stable environment is created
- **Restricted fermentation**: acids added
  - Principle
    - add the acid directly
  - Practice
    - use commercial acids to pickle the crop
    - drive pH down to <5 and a stable environment is created
- **Stabilization**: acids not involved
  - Principle
    - kill all of the bacteria
  - Practice
    - use bacteriostats to stabilize the crop in a bacteria free environment

Why ensile?

- Convenience
  - ensiling can be faster than hay making
- Cost
  - ensiling can be less expensive
    - less passes over the field
- Weather
  - ensiling happens in shorter harvest windows

Why ensile?

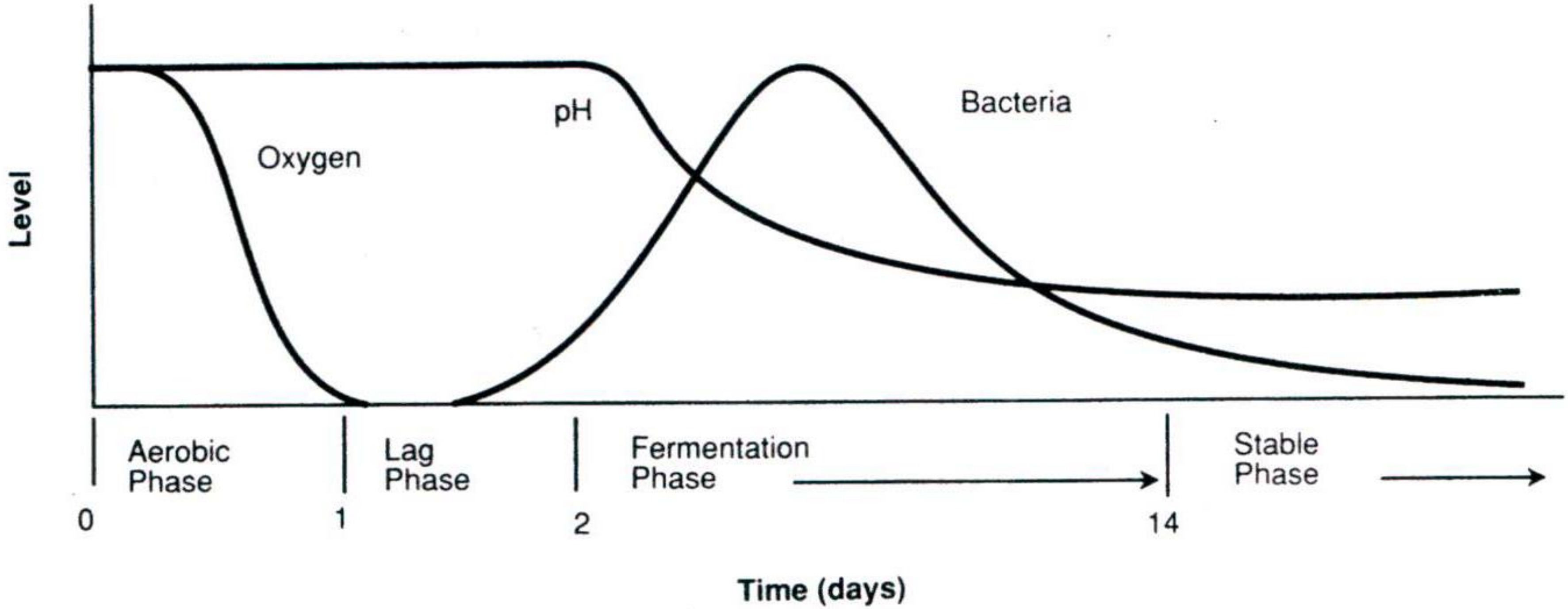
- Lower DM loss
  - leaf shatter can be a major DM loss in hay making
- Lower DM loss after preservation
  - hay losses can be high without cover from weather
- Crop characteristics
  - some crops just don’t hay at all (thick stems, grain filled heads)

The 3 Principles of Ensiling

- Get air out to stop yeast and mold growth
  - chop and compact
- Keep air and water out
  - seal the silo
- Get pH down to 4 quickly
  - stimulate lactic acid bacterial growth with added sugars or with added lactic acid producing bacteria

Objective: minimize nutrient loss/degradation due to ensiling (bacterial growth)

The Ensiling Process



When primary anaerobic fermentation goes wrong

- Reasons
  - Silo not airtight
    - poor packing and oxygen infiltration
  - Low epiphytic lactic acid bacteria on the crop
  - Low sugar levels in the crop

- Results
  - Slow drop in pH
  - Higher fermentation losses of nutrients
  - Production of heat
    - Maillard reactions reduce protein digestion
  - Mold growth
    - can reduce animal performance
    - mycotoxins


<- Mold in alfalfa silage

Silo types In California

- Bunkers
- Bags
- Rollover Piles
- Stack Piles


Bunkers

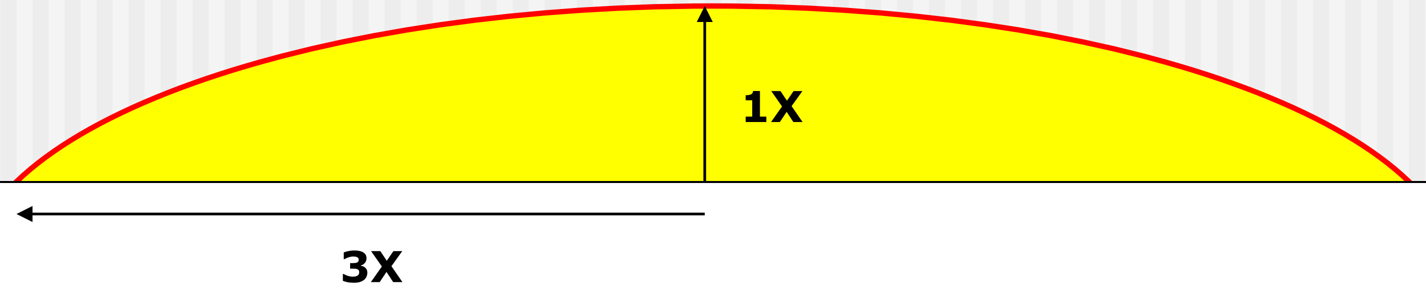
Bunkers

Bags

Bags can be wasteful

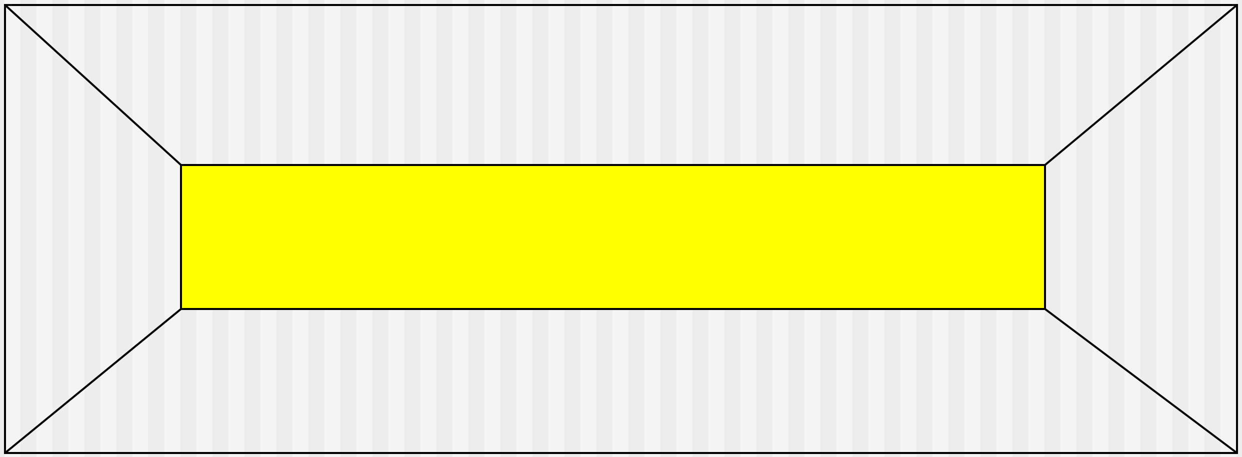
Bags can have other problems

Rollover Piles



Rollover Piles

Stack Pile Aerial View




Stack Piles

The 3 Principles of Ensiling

- **Get air out to stop yeast and mold**
  - **chop and compact**
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- Get pH down to 4 quickly
  - stimulate lactic acid bacteria

High Capacity Field Chopping

Sufficient Silo Pile Packing

The 3 Principles of Ensiling

- Get air out to stop yeast and mold
  - chop and compact
- **Keep air and water out**
  - **seal the silo**
- Get pH down to 4 quickly
  - stimulate lactic acid bacteria

Covering the Pile

- Thicker plastic is better: > 150 micron
- White better than black
- 2 layers better than 1
  - use oxygen barrier plastics
- Overlap seams 1 yard
- Keep the plastic down
  - old tires are commonly used


Result of
Poor Covers

The 3 Principles of Ensiling

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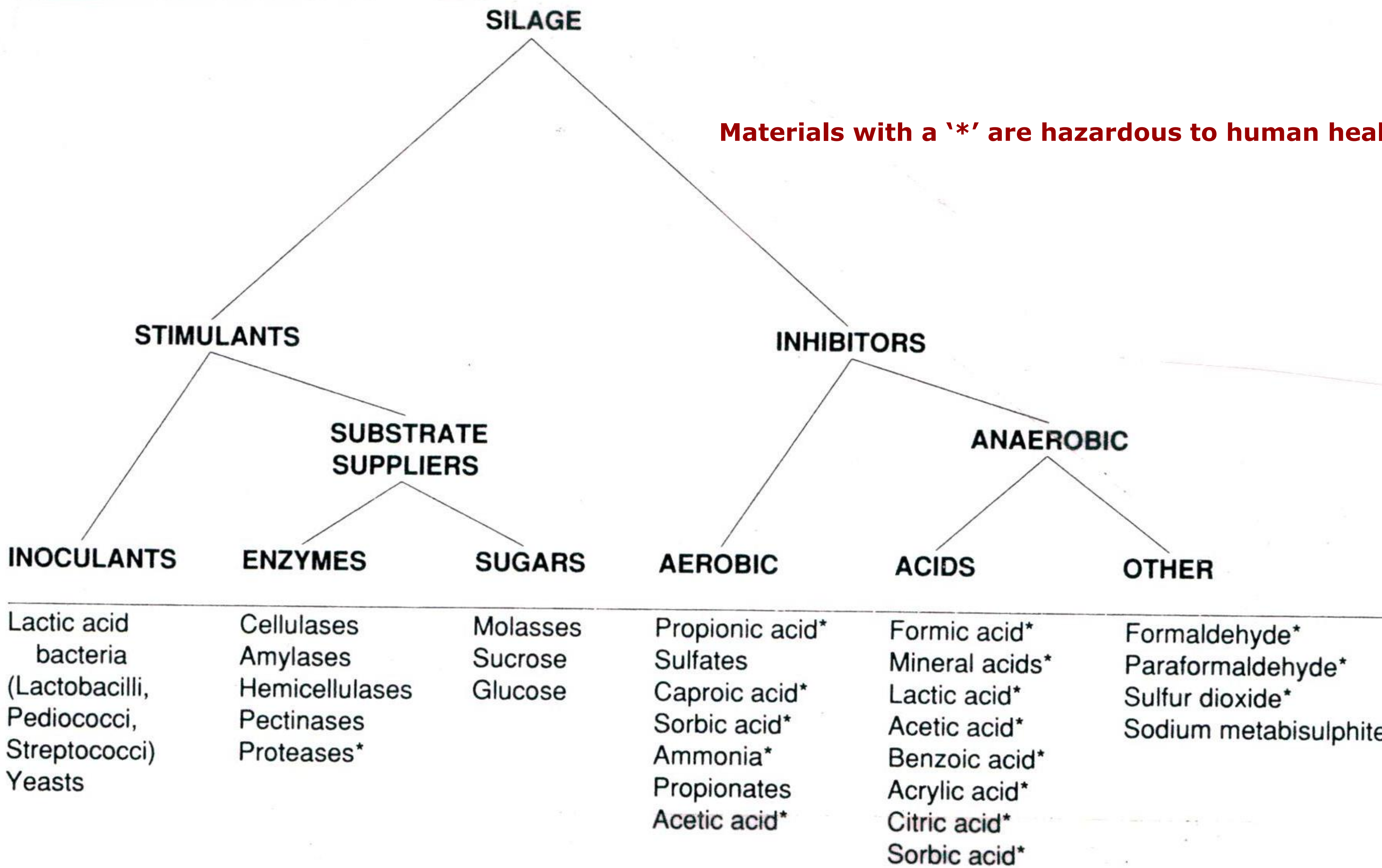
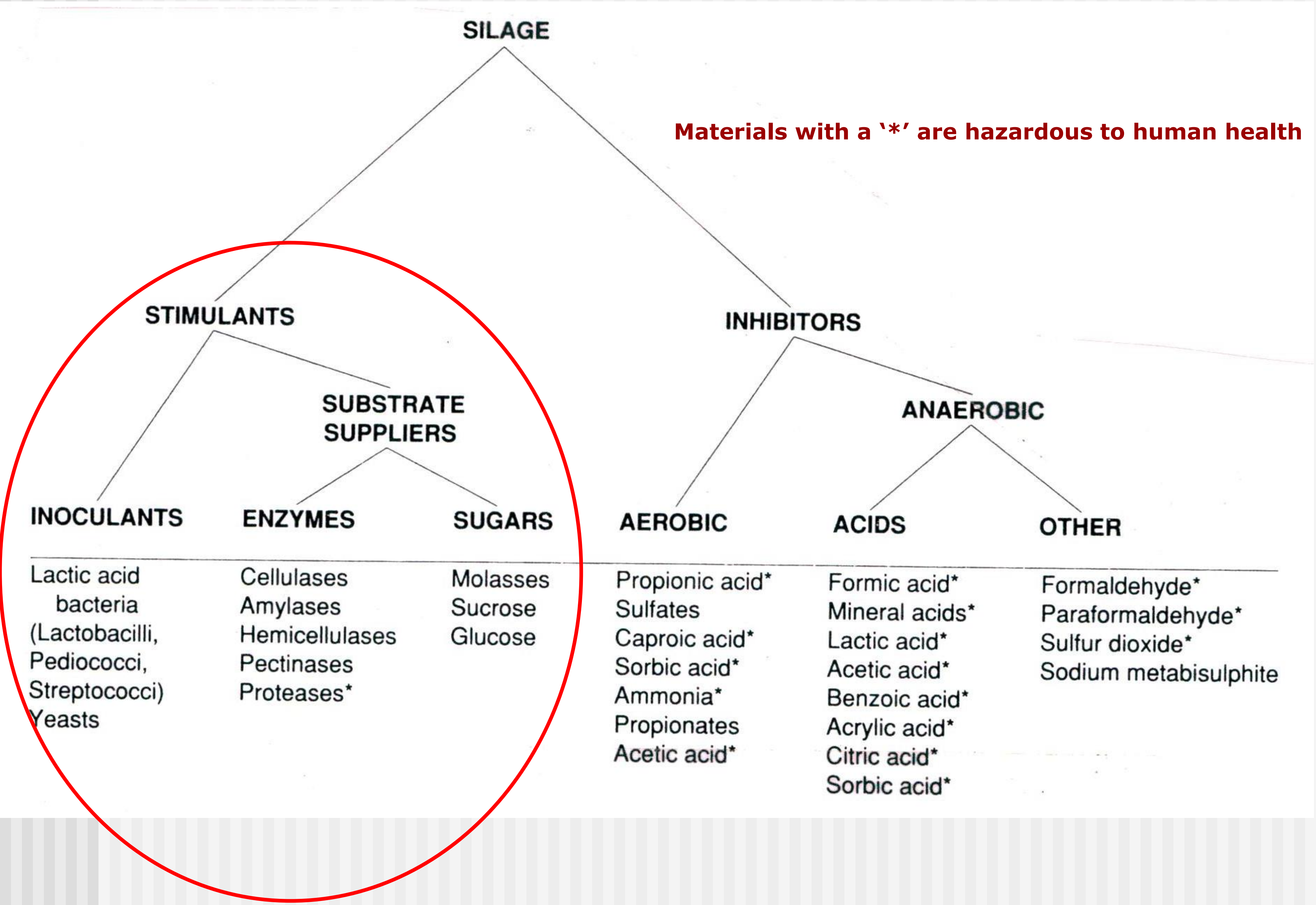
Materials with a '*' are hazardous to human health




SILAGE
Materials with a '*' are hazardous to human health
STIMULANTS
INHIBITORS
SUBSTRATE SUPPLIERS
ANAEROBIC
INOCULANTS
ENZYMES
SUGARS
AEROBIC
ACIDS
OTHER
Lactic acid bacteria (Lactobacilli, Pediococci, Streptococci)
Yeasts
Cellulases
Amylases
Hemicellulases
Pectinases
Proteases*
Molasses
Sucrose
Glucose
Propionic acid*
Sulfates
Caproic acid*
Sorbic acid*
Ammonia*
Propionates
Acetic acid*
Formic acid*
Mineral acids*
Lactic acid*
Acetic acid*
Benzoic acid*
Acrylic acid*
Citric acid*
Sorbic acid*
Formaldehyde*
Paraformaldehyde*
Sulfur dioxide*
Sodium metabisulphite

Commonly Ensiled Crops in California

- **Alfalfa**
  - Usually in the spring and fall
    - low sugars lead to unpredictable silage quality (esp. fall)
    - rain leads to low epiphytic bacterial numbers (esp. spring)
- **Winter Cereals**
  - Wheat, triticale, barley
    - grow slowly all winter to mature with long daylength
    - not irrigated but a big user of manure solids
  - Lose nutritional value rapidly at heading
    - adequate sugars to support rapid fermentation
    - tradeoff of head (starch) vs. higher fiber quality

Time of cutting in the day <u>is</u> a factor in silage quality

Commonly Ensiled Crops in California

- **Corn**
  - **Summer crop grows under very hot conditions**
    - **irrigated and a big user of ‘pond’ water**
  - **Loses nutritional value slowly with ear formation**
    - **lots of sugars to support rapid fermentation**
    - **tradeoff of head (starch) vs. higher fiber quality**
- **Sorghum**
  - **Similar to corn**

Time of cutting in the day is <u>no</u> factor in silage quality

Nutritional value of Ensiled Crops in Dairy Rations

- Relatively low cost nutrient source
  - creates the base of the ration due to its structural fiber
  - net energy values are relatively low
- Low transport requirement
  - most fields are near the feeding site
  - inexpensive storage form as silage
- Flexible feed source
  - can be rapidly increased or decreased in the diet
- Source of several nutrients required by dairy cattle
  - pe fiber, protein, minerals
- Different silages can be combined in diets

How do our main silages stack up relative to protein?

	DM	OM	Fat	CP	SolP	UndP	NDF	dNDF	ADF	NEl
	%	--------- % DM ---------			----- % CP -----		% DM	% NDF	% DM	Mcal/kg DM
Soy (meal, solvent)	91.3	92.4	1.2	52.3	18.1	2.0	9.8	79.7	6.7	1.96
Canola Pellets (38% CP, solvent)	89.6	91.8	3.1	41.2	31.5	31.5	27.1	55.3	19.0	1.70
Distillers Grains (dehy/corn/w sol)	90.3	95.1	11.5	30.1	15.7	26.4	34.7	76.2	20.1	1.93
Alfalfa hay	90.2	89.1	2.1	22.1	36.1	6.2	37.1	41.4	29.5	1.36
Barley (grain)	90.4	97.2	2.1	12.3	17.4	6.9	21.0	53.0	8.4	1.90
Wheat (whole crop, silage)	31.6	87.0	2.7	10.6	72.9	10.6	51.8	51.6	37.4	1.29
Citrus Pulp	22.9	92.0	2.2	9.2	56.9	7.5	21.0	83.3	25.1	2.00
Corn (grain, flaked)	87.4	99.0	3.6	9.0	21.7	9.4	11.0	71.2	4.0	2.19
Corn (whole crop, silage)	29.5	93.6	3.4	7.9	59.7	9.5	48.0	47.6	30.8	1.44
Almond Hulls	87.7	93.5	6.4	5.6	37.3	33.3	35.2	34.4	28.7	1.40

How do our main silages stack up relative to fiber?

	DM	OM	Fat	CP	SolP	UndP	NDF	dNDF	ADF	NEl
	%	--------- % DM ---------			----- % CP -----		% DM	% NDF	% DM	Mcal/kg DM
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Fiber Quality

- Fiber level
  - higher levels reduce net energy value
- Lignification
  - higher levels reduce fiber fermentation <u>within a crop</u>
    - but fiber fermentability is poorly understood
- Physical effectiveness (pe)
  - a ruminant nutrition fudge factor
  - driven by fiber length and ability to stimulate chewing
  - forages (and silages) are high in peNDF

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What about costs?

% of diet DM

Corn silage	22.2
Wheat silage	4.3
Alfalfa, hay	8.7
Oat, hay	2.4
Corn grain	16.0
Canola meal	9.3
DDGS, hi pro	9.3
Almond hulls	8.2
Cottonseed, pima	3.5
Cottonseed, fuzzy	3.5
Tomato, pomace	3.5
Carrots, whole tubers	2.6
Molasses, liquid	1.0
Whey, liquid	2.6
Fat, rumen inert	1.3
TM premix	1.7

Local forages
silage 26.5%
hay 11.1%

Local feeds
total 64%

Future California Silage Challenges: Atmospheric Impacts

Aerosol releases of interest

- **Dust**
  - Cropping and animal movement and vehicle movement
- **Methane**
  - Kyoto (global) issue
  - from animals and animal wastes
- **Ammonia**
  - ‘local’ issue
  - primarily from animal wastes
- **Volatile Organic Compounds (VOC)**
  - a big contemporary California issue
  - from animals, animal wastes and silages

Future California Dairy Silage Challenges: Atmospheric Impacts

Aerosol releases from silages

- Organic acids
  - acetic acid, butyric acid from fiber fermentation
  - lactic acid from sugar fermentation
- Alcohols
  - primarily ethanol from sugar fermentation
- A host of <u>minor</u> bacterial fermentation end-products
  - NOx ?

Future California Dairy Silage Challenges: Atmospheric Impacts

Suggested mitigations

- Finer chopped forage
- Tighter packing
- Use of lactic acid bacterial inoculants

- Flat silo faces
- No loose silage at the end of the day

In the pipeline?

- Feed silages more frequently
- Inhibit bacteria which create the undesirable VOC


CORN
SILAGE


CEREAL SILAGE


THE CLAW

Future California Dairy Silage Challenges: Atmospheric Impacts

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In the pipeline?

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- **Inhibit bacteria which create the undesirable VOC**

Key Points

- **Silages are a big part of the California dairy feed mix**
  - **summer: corn and sorghum**
  - **winter: cereals**
  - **spring and fall: alfalfa**

- **Emissions from silages are an air quality issue**
  - **mitigations may be costly and relatively ineffective**
    - **current key emission of interest is EtOH**
    - **next up: NOx**
  - **you can help by following good silage management practices**
    - **rapid filling, packing and double covering**
    - **minimize exposed faces and keep them flat**

THE UNIVERSITY OF CALIFORNIA

LET THERE BE LIGHT

1868