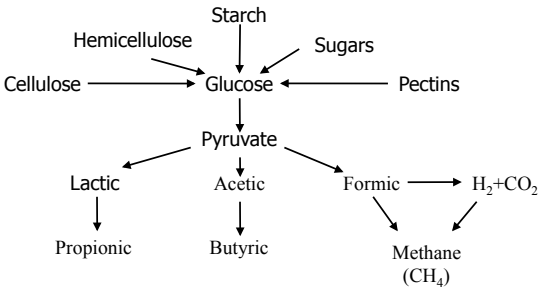
Volatile Fatty Acids (VFA)

- Produced from the fermentation of pyruvate
  - Rumen and hind gut
  - Types/ratios depends on diet
- 3 major VFAs
  - Acetate CH_3COOH
  - Propionate CH_3CH_2COOH
  - Butyrate $CH_3CH_2CH_2COOH$

Rumen Fermentation



Acetate

- Pyruvate + Pi + ADP →
  Acetate + ATP + H_2 + CO_2
- Cellulolytic bacteria
- Energy source for rumen epithelium and muscle
- Not utilized by liver

Acetate utilization

- Important as a precursor to de novo fatty acid synthesis
  - Adipose
  - Lactating mammary gland
- Oxidized via TCA
  - Activated to acetyl CoA
  - Used by skeletal muscle, kidneys, and heart for energy
  - Net gain of 10 ATP per mole of acetate

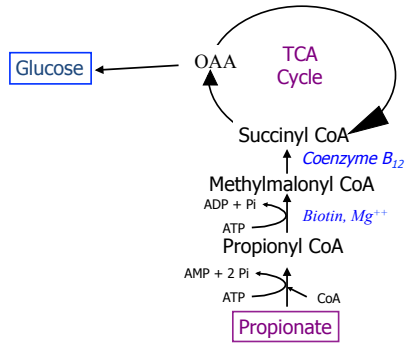
Acetate utilization

- Dependent upon
  - Energy balance
    - Generates CO_2 and H_2O (i.e., ATP) when in low energy balance
    - Used for fatty acid synthesis when animal is in high energy balance
  - Arterial concentration
    - Tissue uptake is directly related to rate of rumen fermentation [blood concentration]

Propionate

- Pyruvate + CoA + $4H^+$ →
  Propionate + H_2O
- Amylolytic bacteria
- Utilized by rumen epithelium
  - Converted to lactate and pyruvate
- Important as a precursor for gluconeogenesis

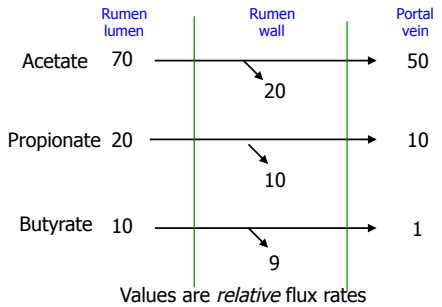
Hepatic propionate metabolism



Butyrate

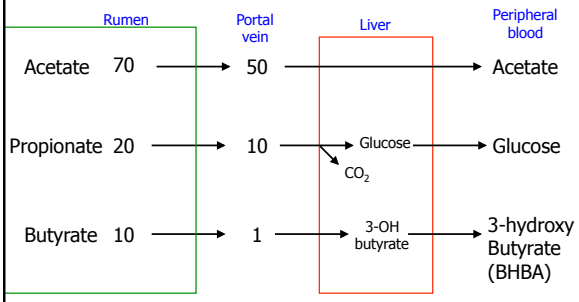
- Pyruvate + CoA →
  Acetyl-CoA + H_2 + CO_2
- 2 Acetyl-CoA + $4H^+$ →
  Butyrate + H_2O + CoA
- Metabolized by rumen epithelium to ketone bodies (acetoacetate, β-hydroxybutyrate)
  - Later metabolized in liver
- Net ATP production is 25 per mole

Ruminal VFA absorption



Values are *relative* flux rates

Hepatic metabolism of VFA



Fermentation in the Rumen

Convert all available carbohydrates and some amino acids to volatile fatty acids (VFA)

Cellulose Hemicellulose Pectin Starch Sugars

↓

Bacterial fermentation

↓

VFA, lactate and methane

Concentration of VFA in rumen = 50 to 125 µM/ml

Fermentation in the Rumen

Diet	Acetate	Propionate	Butyrate	Ratio Acetate:Propionate
Hay	65	20	12	3:1
Grain	40	37	20	1:1

Amino Acid Fermentation in the Rumen

Deamination required
- Removal of the amino (NH_2) group
- Ammonia produced

Fermentation to
- Acetate
- Propionate
- branched chain volatile fatty acids
  - Isovalerate
  - Isobutyrate

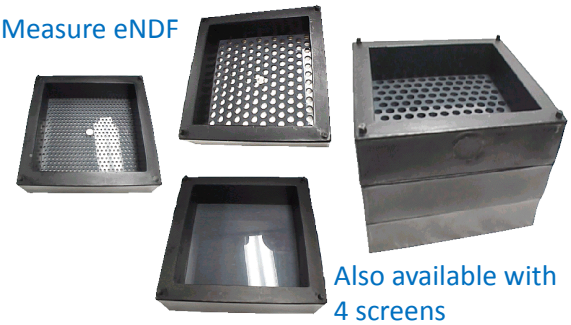
Sources of energy leaving rumen:

VFA	70%
Microbial cells	10%
Digestible unfermented feed	20%

No glucose available for the ruminant

Penn State Separator Box

Measure eNDF



Also available with 4 screens

Penn State Separator

	Top	Middle	Bottom
Corn Silage (1/4)	**< 5**	**> 50**	**< 50**
Corn Silage (1/2)	**< 5**	**> 70**	**< 30**
Haylage	**> 20**	**> 40**	**< 40**
TMR	**> 10**	**> 30**	**< 50**

http://www.das.psu.edu/dairynutrition/documents/das0242.pdf

Applying the Results Penn State Box

Effective NDF = 100 - (% in bottom box)

Example:

Alfalfa Haylage with 52% in the bottom box

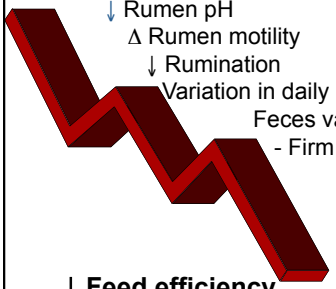
Effective NDF = 100 - 52

= 48%

FIELD TOOLS

- Milk yield changes
- Milk component changes
- Signs of acidosis
  - Laminitis, sore feet
- Manure scores
- Free choice buffer use
- Grain in manure

Subclinical Ruminal Acidosis



↓ Rumen pH
Δ Rumen motility
↓ Rumination
Variation in daily intake
Feces variable
- Firm ↔ diarrhea
- Undigested fiber & grain
- Gas bubbles
- Mucin/fibrin casts
↑ Fecal particle size

↓ Feed efficiency
↓ Production

Ruminal Acidosis

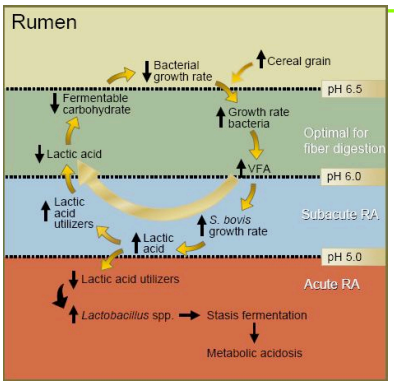
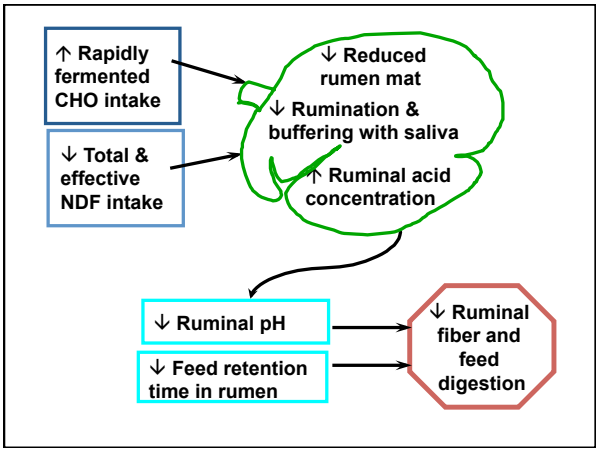
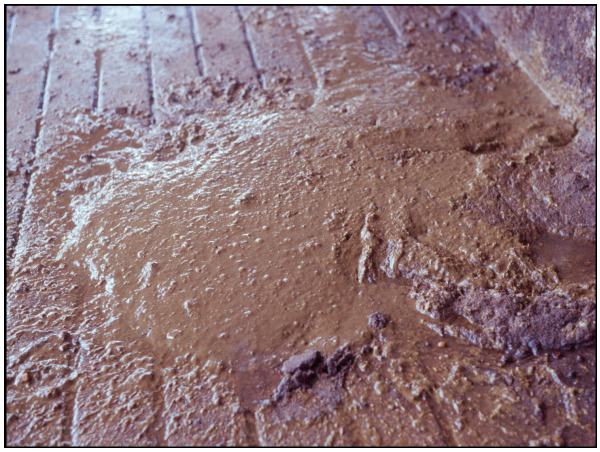
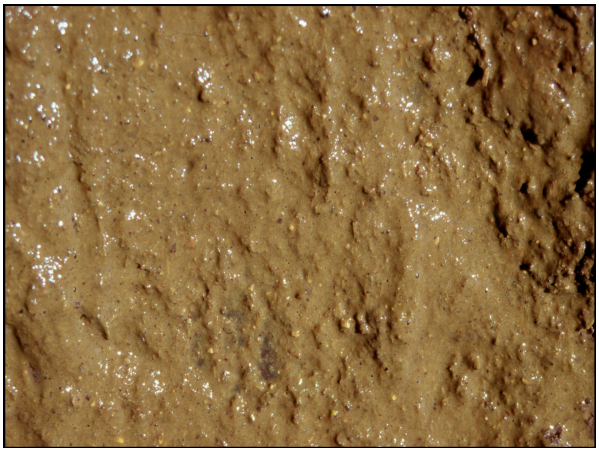
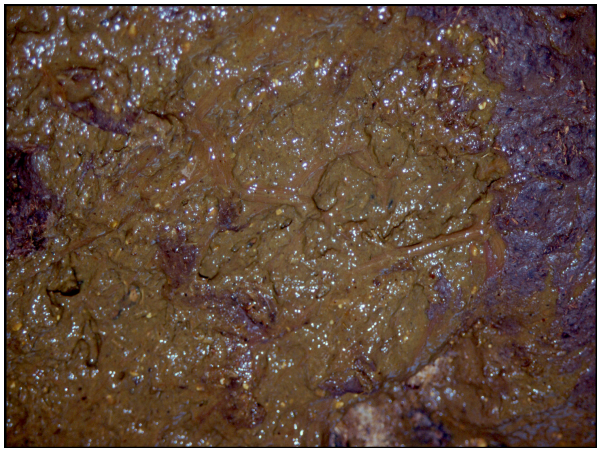


Figure from Karen Beauchemin

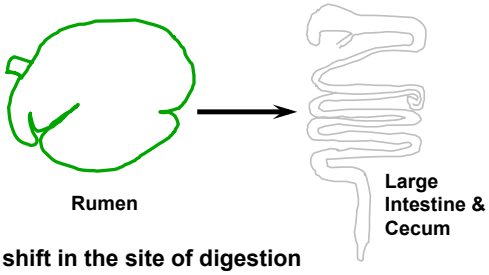




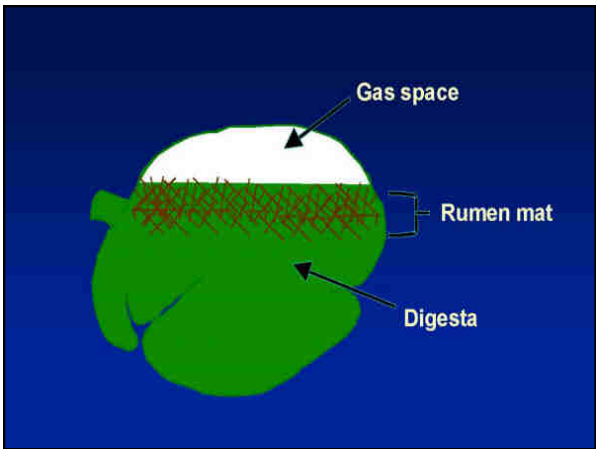


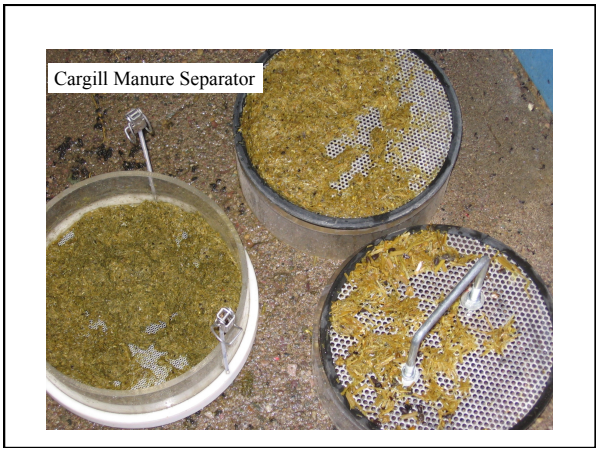


Where Does The Feed Ferment?



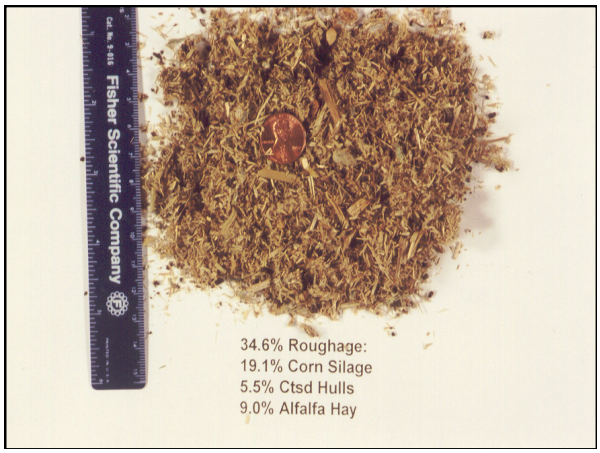
A shift in the site of digestion changes nutrient supply & causes some of the symptoms of ruminal acidosis.


Gas space
Rumen mat
Digesta

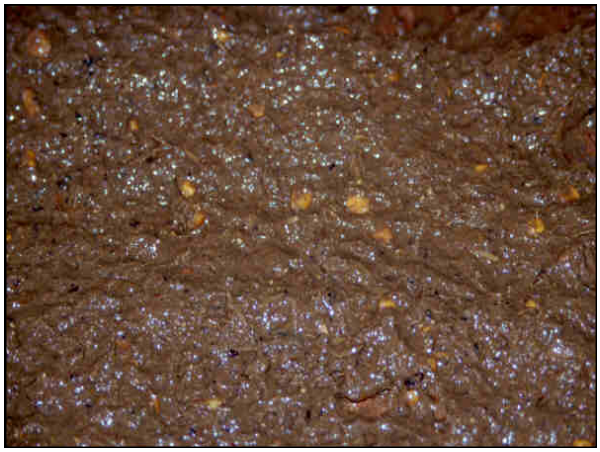

Cargill Manure Separator

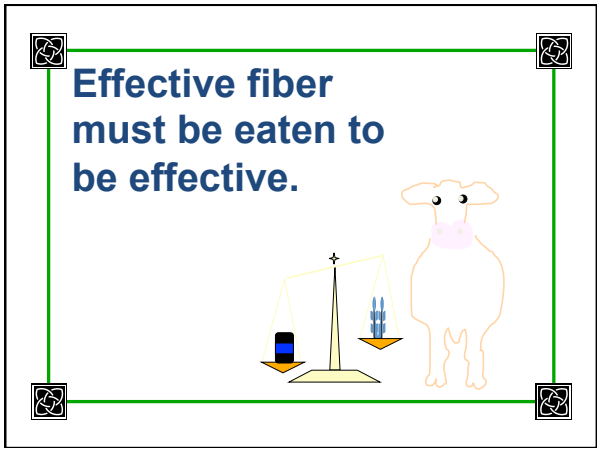
Fisher Scientific Company
40% Roughage:
40% Sorghum

Fisher Scientific Company
Large Particle Passage


Fisher Scientific Company
34.6% Roughage:
19.1% Corn Silage
5.5% Ctsd Hulls
9.0% Alfalfa Hay

Fisher Scientific Company
Whole Corn &
Large Particles




Effective fiber
must be eaten to
be effective.