LACTATION PHYSIOLOGY

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Syllabus

In this chapter, student will learn about anatomy of mammary gland, physiology of milk secretion and feeding lactating cow.

Synthesized feed into milk

Milk Composition - FH

Component	Percentage
Water	87.5
Total solids	12.0
Fat	3.5
Solids not fat	8.5
Protein	3.0
Lactose	4.8
Ash	0.7

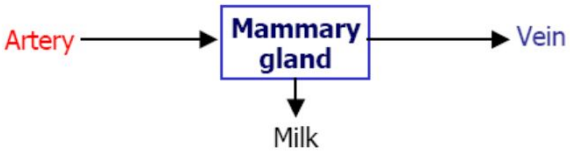
Component	Percentage
Ash	0.7
Ca	0.13
P	0.10
K	0.14
Cl	0.11
Mg	0.01
Na	0.05

Milk Compsition of Other Spesies

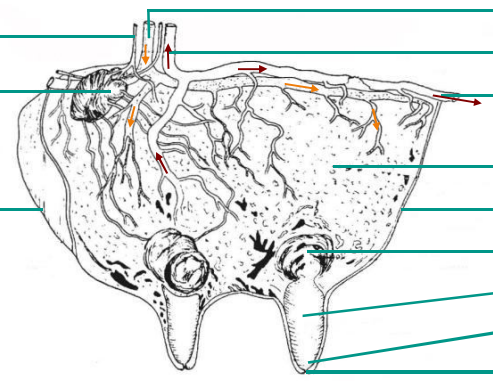
Species	Total solids	Fat	Protein	Lactose
Cow				
Holstein	12.5	3.5	3.0	4.8
Jersey	15.0	5.5	3.9	4.8
Human	12.5	4.4	1.0	7.0
Horse	11.0	1.6	2.7	6.1
Pig	19.6	8.3	5.4	5.0
Sheep	19.9	8.2	5.8	4.8
Whale	57.2	42.3	12.2	1.3

Measurement of Nutrient Intake

- Arteriovenous difference
  - Nutrient uptake = (arterial concentration – venous concentration) • blood flow
  - Nutrient yield = milk yield • nutrient concentration

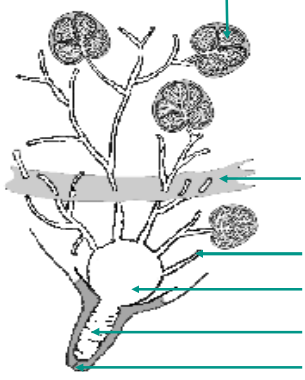


Udder Anatomi & Blood Flow

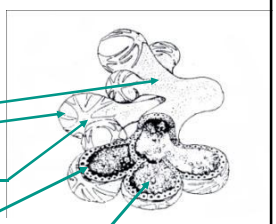


Frandsen, 1981. Anatomy and Physiology of Farm Animals

Duct System and Secretory System



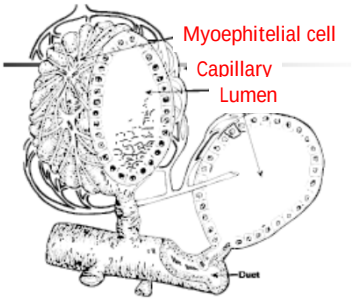
Lobe
- Connective tissue
- Lobules
  - Blood capillaries
  - Intralobular ducts
  - Alveoli
    - Myoepithelial cell
    - Secretory cells
    - Milk



Supportive (connective tissue)
Major duct
Gland cistern (400 ml)
Teat cistern (30 - 40 ml)
Streak canal

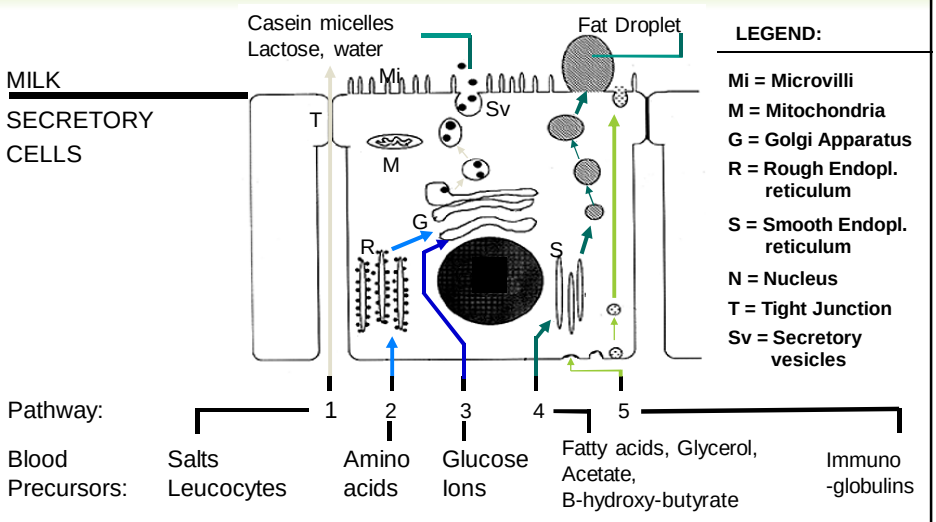
Frandsen, 1981. Anatomy and Physiology of Farm Animals

Alveoli – Fuctional Milk Synthesizing Unit

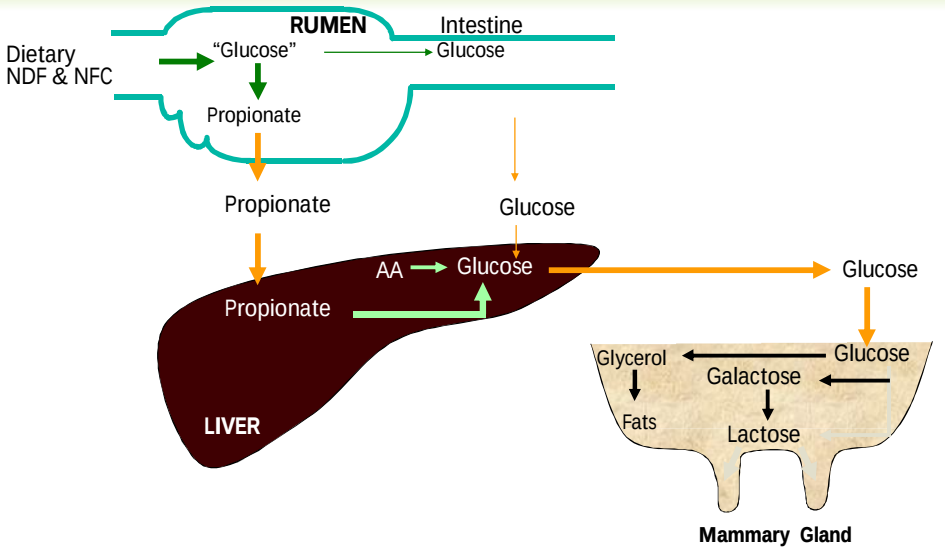


Alveoli – functional milk synthesizing units

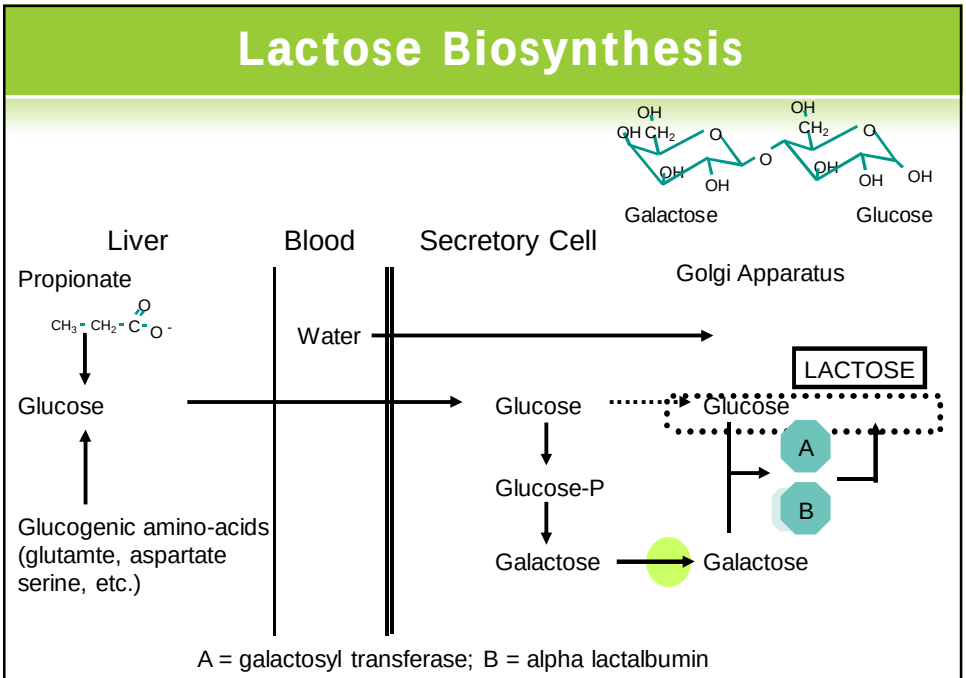
The Origin of The Component of Milk



Origin of Lactose



Lactose Biosynthesis

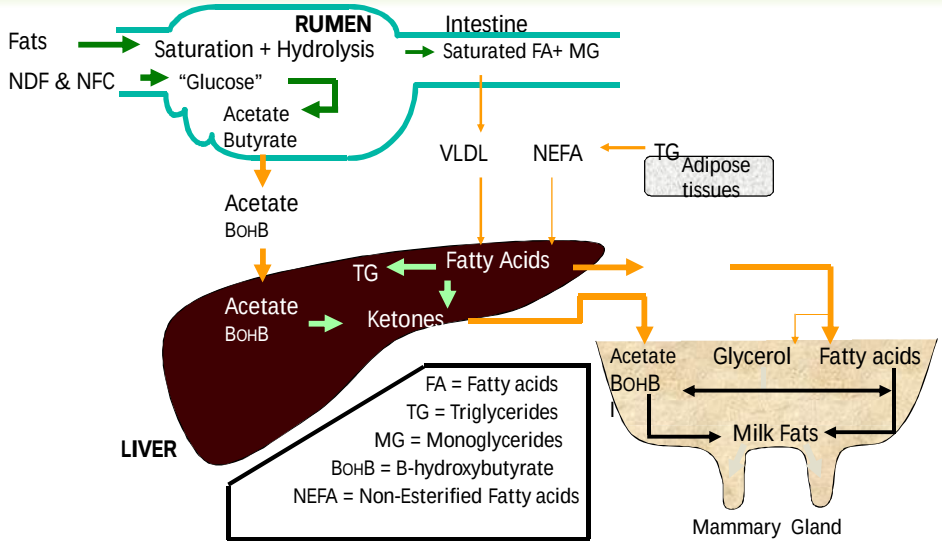


A = galactosyl transferase; B = alpha lactalbumin

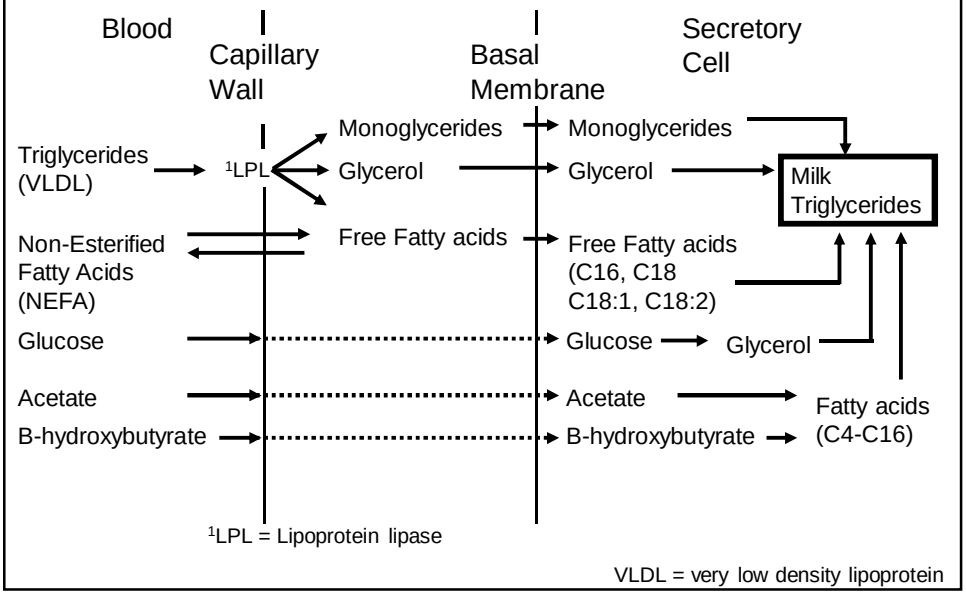
Milk Synthesis - Lactose

- Lactose synthesis accounts for >80% of mammary glucose uptake
- Enzyme is lactose synthase, composed of 2 proteins
  - Galactosyl transferase
  - **α-lactalbumin** (KEY)

Origin of Milk Fat

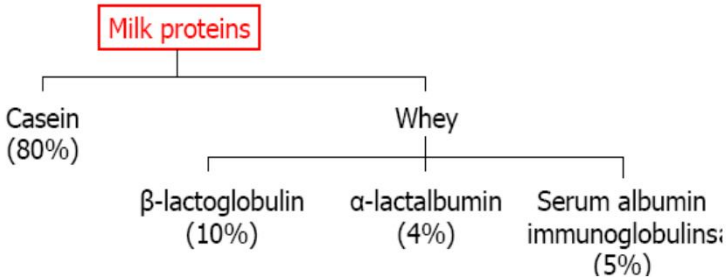


Biosynthesis of Fat



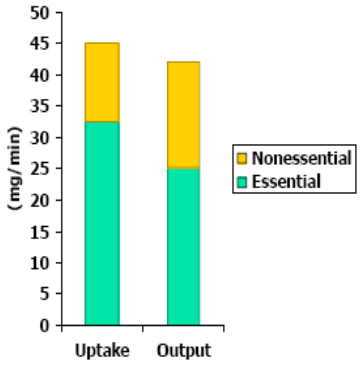
Milk Syntesis - Protein

- Like all proteins, from amino acids
- Specific proteins are synthesized in the mammary gland

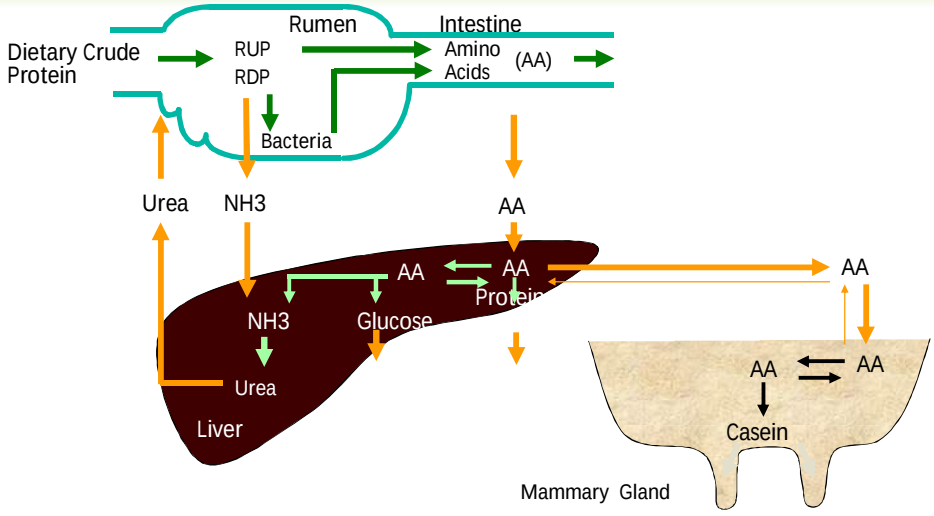


Milk Syntesis - Protein

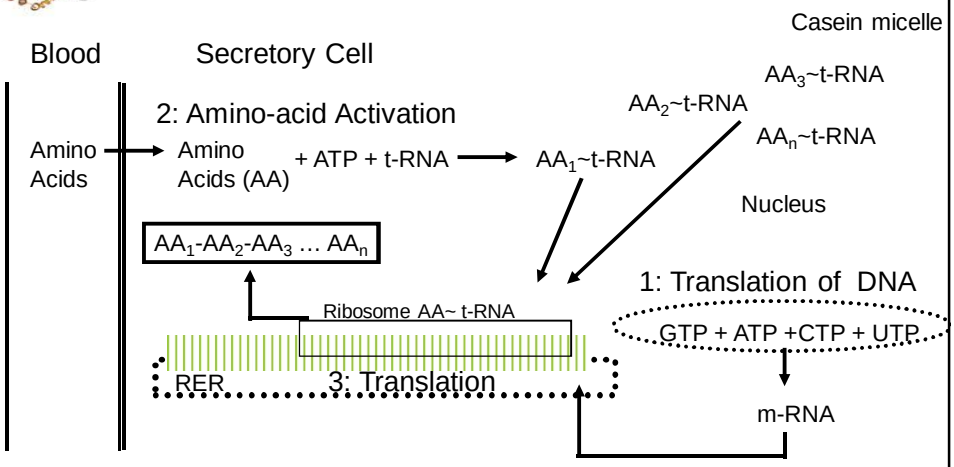
- Mammary use of amino acids
- Essential amino acids are 72% of amino acid taken up by mammary gland but only 60% of those secreted in milk protein



Origin of Casein

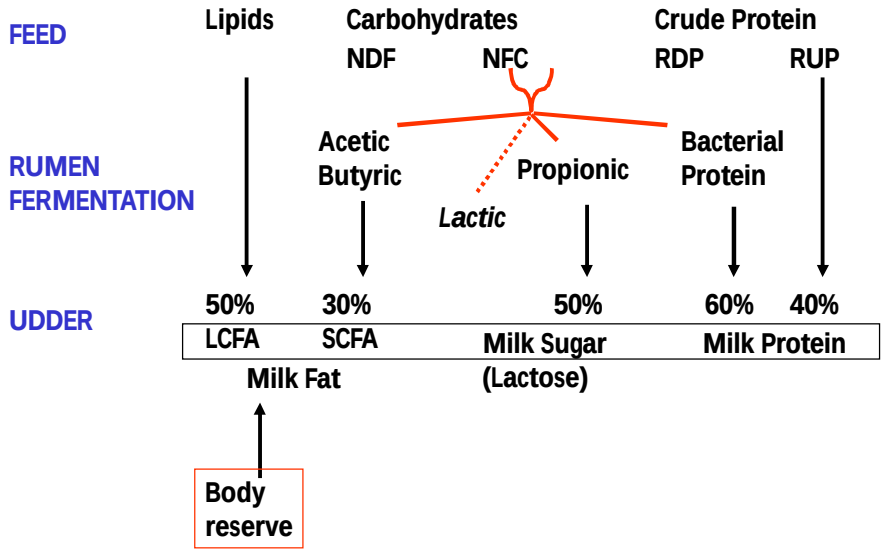


Biosynthesis of Protein

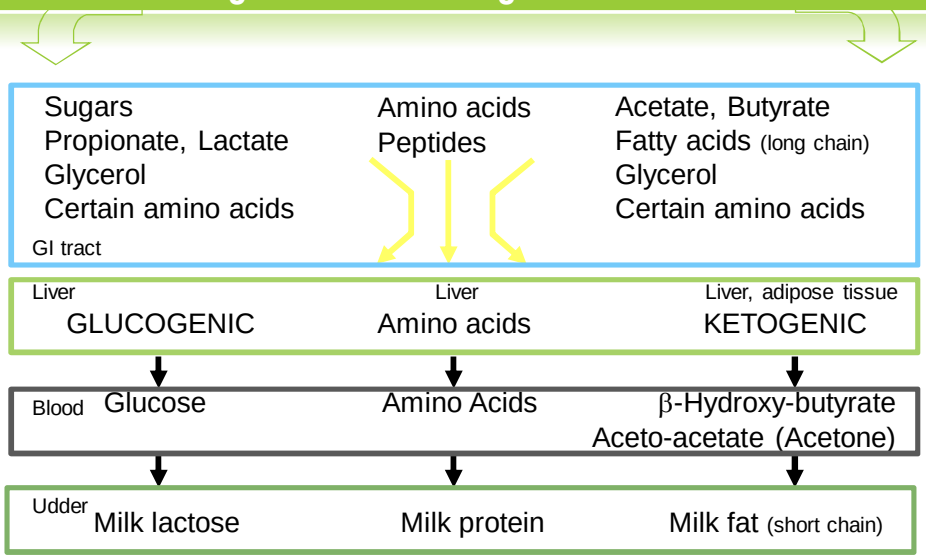


RER =Rough Endoplamic Reticulum.

Summary
Origin of Milk Components



Milk Volume vs Milk Component: Glucogenic vs Ketogenic Nutrients

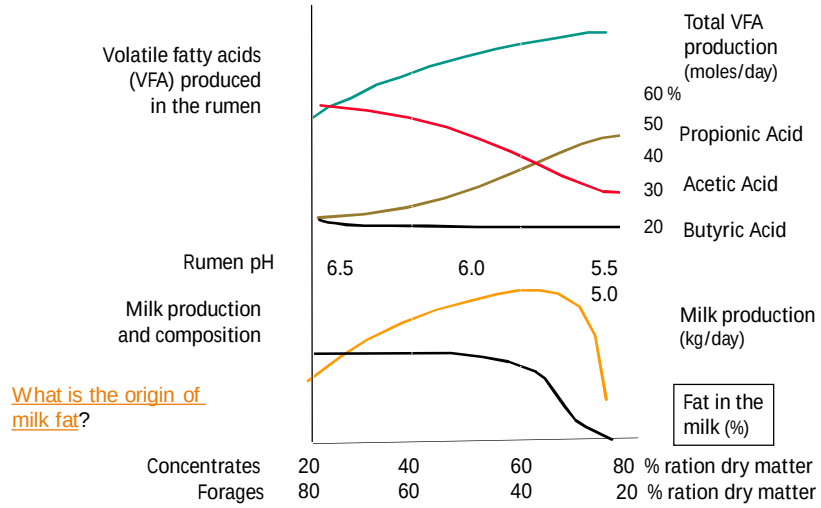


Amino acids in the Liver and the Udder

Amino Acid	E NE	G K	Grp	Amino Acid	E NE	G K	Grp
Arginine	E	G	G_2	Alanine	NE	G	G_3
Histidine	E	G	G_1	Asparagine	NE	G	G_3
Isoleucine	E	G K	G_2	Aspartate	NE	G	G_3
Leucine	E	K	G_2	Cysteine	NE	G	G_3
Lysine	E	G K	G_2	Glutamine	NE	G	G_3
Methionine	E	G	G_1	Glutamate	NE	G	G_3
Phenylalanine	E	G K	G_1	Glycine	NE	G	G_3
Threonine	E	G	G_2	Hydroxyroline	NE	G	G_3
Tryptophan	E	G K	G_1	Proline	NE	G	G_3
Valine	E	G	G_2	Serine	NE	G	G_3
				Tyrosine	NE	G	G_1

E = Essential, NE=Non Essential, G= Glucogenic, K = Ketogenic
Group = G_1: mammary uptake = milk secretion; G_2 : mammary uptake > milk secretion
G_3 : Non-Essential AA, with variable uptake / milk secretion

Milk Fat Depression and Forage to Concentrate Ratio

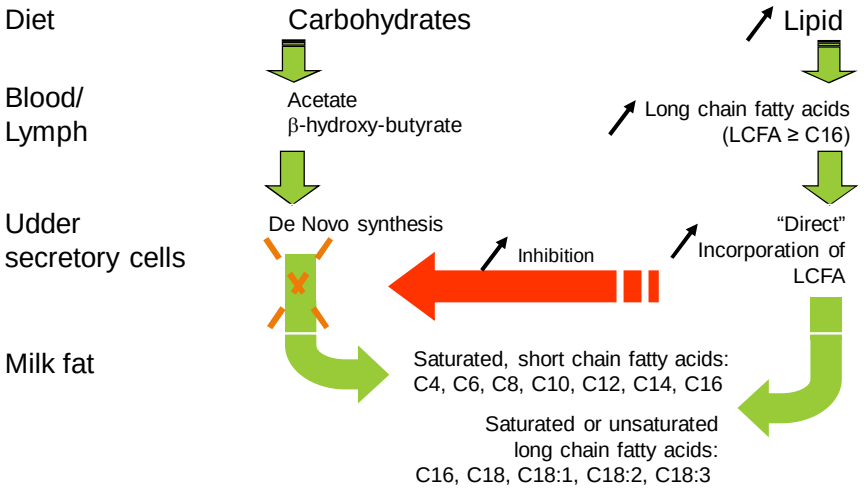


What is the origin of milk fat?

Theories Regarding Milk Fat Depression

- Acetate deficiency
  - Low acetate: propionate ratio is not due to lower acetate, but rather an higher amount of propionate.
- Vitamin B_{12} deficiency
  - Ruminal synthesis of vit. B_{12} is low under high grain diet. Vit B_{12} is required for **propionate metabolism** in the liver and elongation of fatty acid chains with acetic acid or β-hydroxy-butyrate (BHBA) in milk fat synthesis.
- Insulin and suppression of fat mobilization
  - Hormonal messages, with high amount of propionate and possibly glucose absorption in the lower intestine elicitng an insulin response which tend to inhibit fat mobilization and the availability of ketones for fatty acids synthesis in the udder.
- Inhibition of the *de novo* synthesis of short and medium chain of fatty acids in the mammary gland by trans fatty acids (TFA).
  - TFA are produced during ruminal hydrogenation of polyunsaturated fat supplements (vegetable oils)

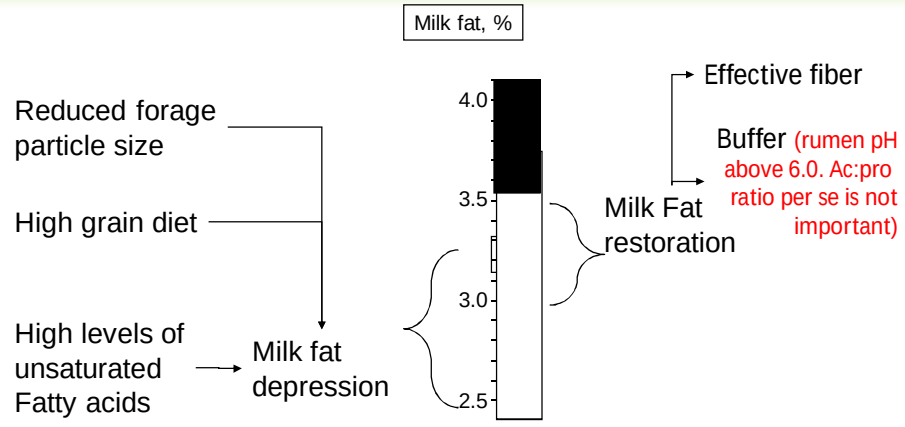
Origin of Long Chain Fatty Acids (LCFA) and Short Chain Fatty Acids in Milk Fat



Role of Trans Fatty Acids (TFA) in Milk Fat Depression

- Milk fat depression results from change in rumen hydrogenation (saturation) of fats rather than change in rumen VFA patterns.
  - TFA are produced from incomplete saturation of polyunsaturated fatty acids (PUFA).
  - TFA in milk fat is high on high grain-fat depressing-diets.
  - Vegetable or marine PUFA depress milk fat% even in diets with normal amounts of forage.
  - Addition of buffer decreases production of TFA in rumen, decreases TFA in milk fat and alleviate milk fat depression
  - Lower rumen pH (insufficient effective fiber) favors the production of TFA with fat-depressing effects. Fat depression does not occur if rumen pH remains > 6.0

Dietary Induced Milk Fat Depression



Erdman, Tri-State Dairy Conference 1996.

Summary and Implications

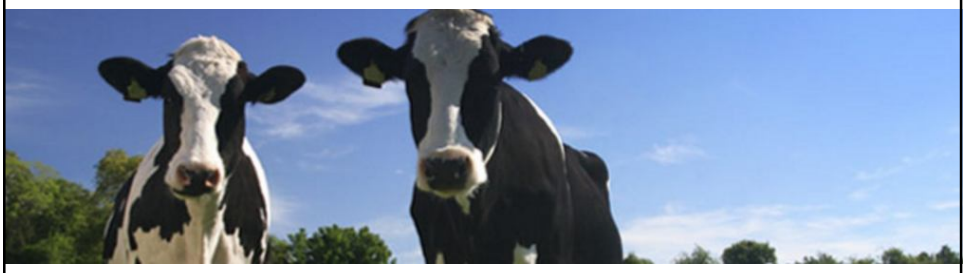
Milk biosynthesis - things to remember:

- Lactose synthesis:
  - depends on liver gluconeogenesis (glucogenic precursors),
  - determines milk volume.
- Protein (casein) synthesis:
  - is regulated by DNA,
  - relies on transamination of amino acids.
- Fat synthesis:
  - is the most variable of the main three components,
  - depends upon ketogenic precursors.

Ultimately milk composition depends upon:

- breed / nutrition / management / environment / health.

Thank You



Better feed for better milk production and quality