Lecture # 5

Volatile Fatty Acids

A. Sources and significance of Volatile fatty acids(VFA)

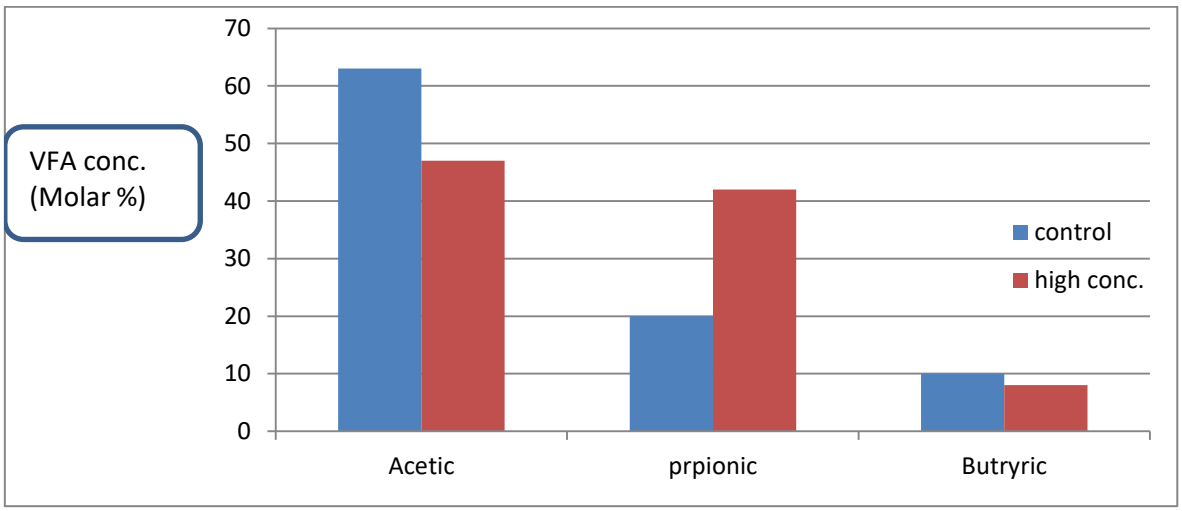
- VFA are short-chain (C2 – C6) fatty acids. are fatty acids with two to six carbon atoms
- In higher animals, VFA are produced mostly by microbial fermentation of carbohydrate and other organic matter in the fore stomachs and /or hind gut. Volatile fatty acids are the main energy source for ruminants, providing approximately 70% of the total energy requirements. They are used primarily by the microorganisms for reproduction and growth, with the excess production being used by the ruminant itself.
- Most abundant VFA are:
  Acetic CH_3-COOH
  Propionic CH_3- CH_2-COOH
  N-Butyric CH_3-CH_2-CH_2COOH
  e.g. these three acids account for~ 95% of total VFA in the rumen
- Some acetic acid is also produced in liver and other tissues by hydrolysis of acetyl CoA (endogenous acetate).

B. Ruminal production and absorption of VFA:

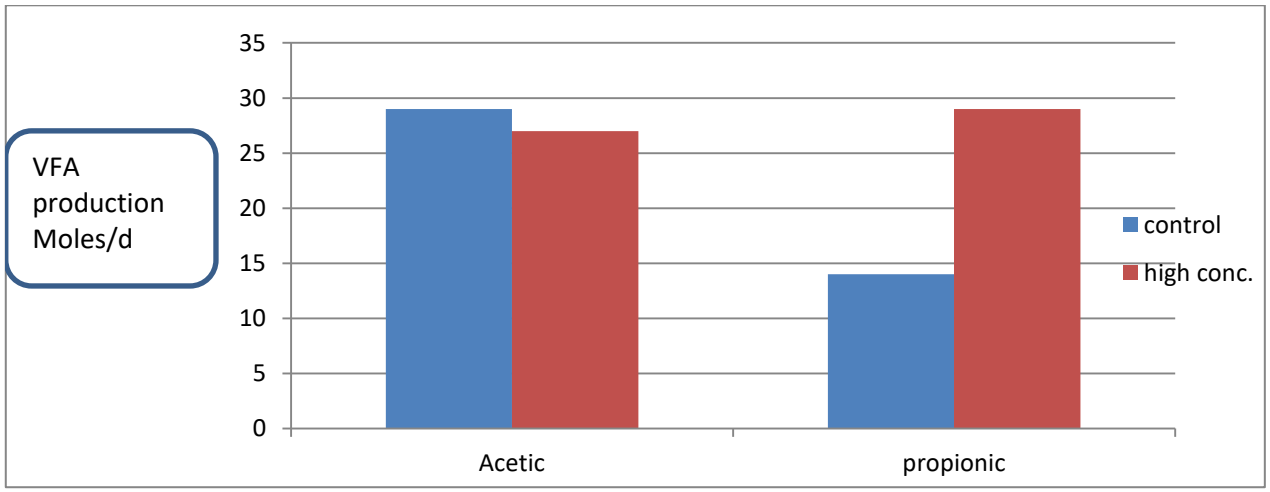
1. production

(a) In general, the total rate of production and concentration of rumen VFA are directly related to the intake of fermentation organic matter, especially carbohydrate.

(b) Relative rates of production and concentration of individual VFA are affected by diet quality, especially the forage: concentrates ratio. In particular, increasing the fraction of starchy concentrate causes a disproportionate increase in the rate of production of propionic acid by amylolytic bacteria e.g. dairy cows fed control versus high concentration, low fiber diets.



Note: The decrease in Molar % of acetic acid is not due to a decrease in its production. It is simply an inevitable consequence of the increase in production of propionic acid.



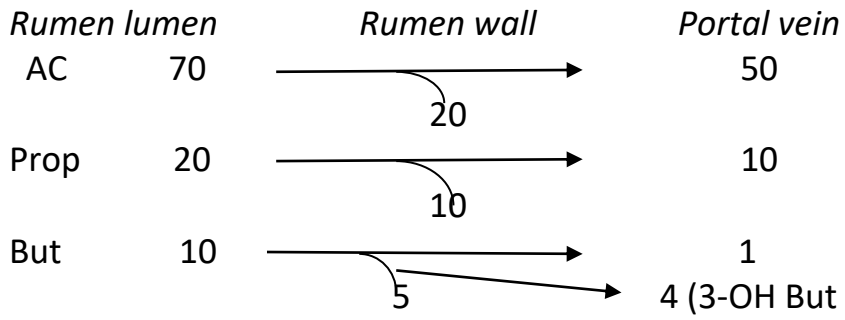
2. Absorption

(a) VFA are absorbed by epithelial lining of rumen papillae via passive diffusion.

(b) Rate of absorption is affected by:

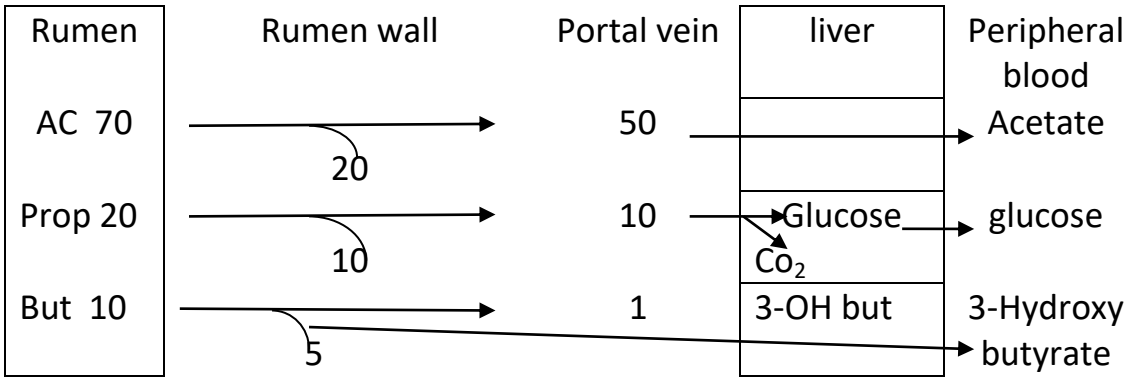
- VFA concentration in rumen fluid (most important)
- Rumen fluid pH
- VFA chain length

(c) VFA uptake by the rumen papillae is greater than delivery into the bloodstream because some VFA are metabolized by tissues of the rumen wall (especially epithelium), to an extent that varies among the major VFA.



C. Postabsorpative Metabolism

1. Liver



Features of hepatic VFA metabolism:

- Little capacity for acetate utilization, therefore most absorbed acetate appears in peripheral blood.
- >90% of propionate in portal venous blood is extracted by the liver and used mainly for glucose synthesis.
- >90% of butyrate in portal venous blood is also extracted by the liver and converted to 3-hydroxybutyrate
- Net results are that peripheral blood contains relatively high concentration of acetate, glucose and 3- hydroxybutyrate, and negligible concentrations of propionate and butyrate.

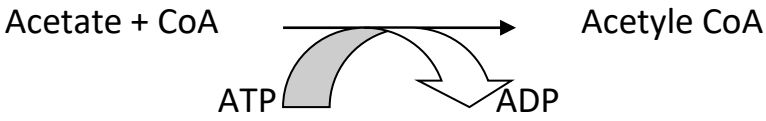
2. Post-hepatic tissues

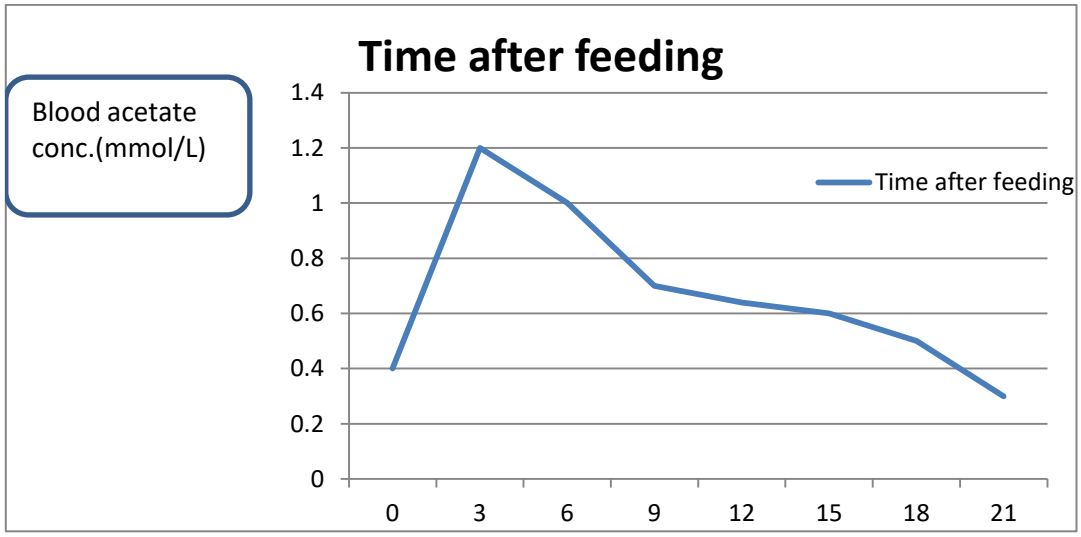
Features of tissue metabolism of blood acetate:

(a) Arterial blood acetate concentration is an important determination of acetate uptake by tissues with enzymatic capacity for acetate metabolism because uptake is by passive diffusion.

(b) Arterial concentration is directly related to rate and pattern of feed intake, which determines rates of rumen fermentation, and production and absorption of acetate.

(c) After tissue uptake, acetate must be converted to acetyle CoA before it can be further metabolized in mitochondria or cytoplasm.

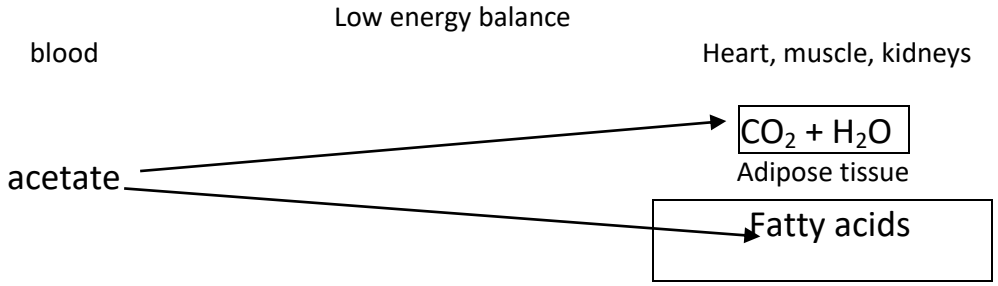




(d) In ruminant tissue, the metabolic fate of acetyl CoA derived from acetate varies with tissue and energy status:

- In energy – demanding tissues such as heart, skeletal muscle, and kidneys, acetate is transported in to the mitochondria, converted to acetyl CoA, and oxidized via the TCA cycle.
- In adipose and lactating mammary tissues, acetate can be converted to acetyl CoA in the cytoplasm and then used for long –chain fatty acid synthesis if acetate supply exceeds requirements for oxidative metabolism.

- Thus, in animals on a low energy intake priority is given to oxidation of acetate in heart, muscle, and kidneys, whereas animals on a high energy intake can use surplus acetate for fatty acid synthesis



Effect of energy balance on tissue acetate utilization in ruminant animals