Sperm metabolism

- ATP + H_2O ⇌ ADP + H_3PO_4 + 7,000 calories /mole

-Anaerobically: Fructose $\xrightleftharpoons{No\ O_2}$ 2 lactic acid + 2 ATP (net yield)

- Fructose metabolized anaerobically yields a net of 2 ATP, or 14,000 calories. This reaction provides energy to maintain the viability of spermatozoa during storage. However, an end product of this metabolism is lactic acid. If steps are not taken to slow metabolism during storage, the buildup of lactic acid will soon lower the pH of the semen, adversely affecting the viability of spermatozoa.

While under aerobic conditions, the metabolism of fructose is:

- Aerobically: Fructose $\xrightleftharpoons{O_2}$ CO_2 + H_2O + 38 ATP (net yield)

- When oxygen is present, metabolism of fructose is 19 times more efficient in terms of energy yield. The net energy from 38 ATP is 266,000 calories. When sufficient oxygen is present, the fructose molecule is metabolized completely to carbon dioxide and water. There is no buildup of lactic acid. Sorbitol and GPC are metabolized through the same biochemical pathways as fructose. Plasmalogen, a lipid rather than a carbohydrate utilizes different metabolic pathways, but the needed enzymes are in the mitochondrial sheath.

Factors Affecting Rate of Metabolism

- Measurement of metabolism rate

A. Under aerobic condition: 1) O_2 consumption 2) CO_2 liberation

3) Methylene blue reduction time.

B. Under anaerobic condition: 1) pH reduction 2) Increase in lactic acid

3) Disappearance of fructose.

- Control of metabolic rate is interest because a reduction in metabolic rate is necessary to extend the storage life of semen. A number of factors contribute to reduced metabolic rate and extend life of spermatozoa in epididymis. In the epididymis, spermatozoa may remain fertile for up to 60 days. However, spermatozoa in a fresh ejaculate of semen will be fertile for a few hours if steps are not taken to reduce their metabolic rate.

1- Temperature:

A. High temperature: Increase metabolic rate and decrease life span of sperm

B. At 50C°: Irreversible loss of sperm motility

C. At body temperature: Sperm live for a few hours only: due to increase metabolism.

D. Low temperature: Extend fertile life of sperm by decrease metabolism (when bull semen frozen at -196 C°, less than 0.02% of metabolic rate at body temperature): Problems: cold shock and freeze kill.

a. Cold shock: 1) Irreversible loss of sperm motility by sudden reduction of semen temperature from 15 C° to 0 C° (critical range), 2) Protecting from cold shock: Slow cooling after addition of lecithin and lipoproteins by diluting with egg yolk or milk diluter

b. Freeze kill: 1) Sperm killed during freezing and thawing 2) Protected satisfactorily by equilibrating bull semen in a diluter containing glycerol.

2- pH

A. Higher metabolic rate: From pH of semen near neutrality (7.0), where most enzymes in sperm are most active.

B. Deviations toward alkalinity or acidity: Can reduce metabolic rate, but the buffering capacity of diluter is rather important because pH range to be altered without permanent impairment of sperm.

3- Osmotic pressure

A. Semen diluted with isotonic diluter maintains maximum metabolic activity.

B. Hypo- or hypertonic diluter: Can reduce metabolism but detrimental to sperm.

4- Concentration of spermatozoa

- Increase concentration of sperm above that found in the normal ejaculate will decrease metabolic rate. Increase K+ (found in the sperm cell)/Na+ (found in the seminal plasma) ratio, will lead to inhibit sperm metabolism.

5- Hormones

- Testosterone and other androgen depress metabolic rate, but those concentrations found in the male system have no permanent effect. Fluid in the female tract increase the metabolic activity of sperm due an effect from estrogen and other unidentified factors.

6- Gases

- Low concentration of CO_2 stimulate metabolism of spermatozoa. If the partial pressure of CO_2 exceeds than 5-10% metabolic rate is depressed. Oxygen is necessary for aerobic metabolism, but high level of O_2 is toxic and will depressed metabolic rate. Other gases like N_2, H_2, He with no effect on metabolic rate.

7- Light

- Light intensities that are normally found in the laboratory can depressed metabolic rate, motility, and fertility in spermatozoa. The enzyme catalase will prevent the harmful effect of light, which suggests that light causes a photochemical reaction in the semen that results in the production of hydrogen peroxide (H_2O_2). Semen should be protected from light and never expose to direct sunlight.

8- Antibacterial Agents

- Gentamicin, Tylosin, and Lino-Spectin are added to semen during processing to control bacterial growth. None have demonstrated effect on metabolic rate. Also, these antibacterial agents may extend the fertility of semen by controlling bacteria, thus sparing energy substrates for spermatozoa.