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DEPARTMENT OF ANIMAL NUTRITION

MEASURES OF FOOD ENERGY AND THEIR APPLICATION

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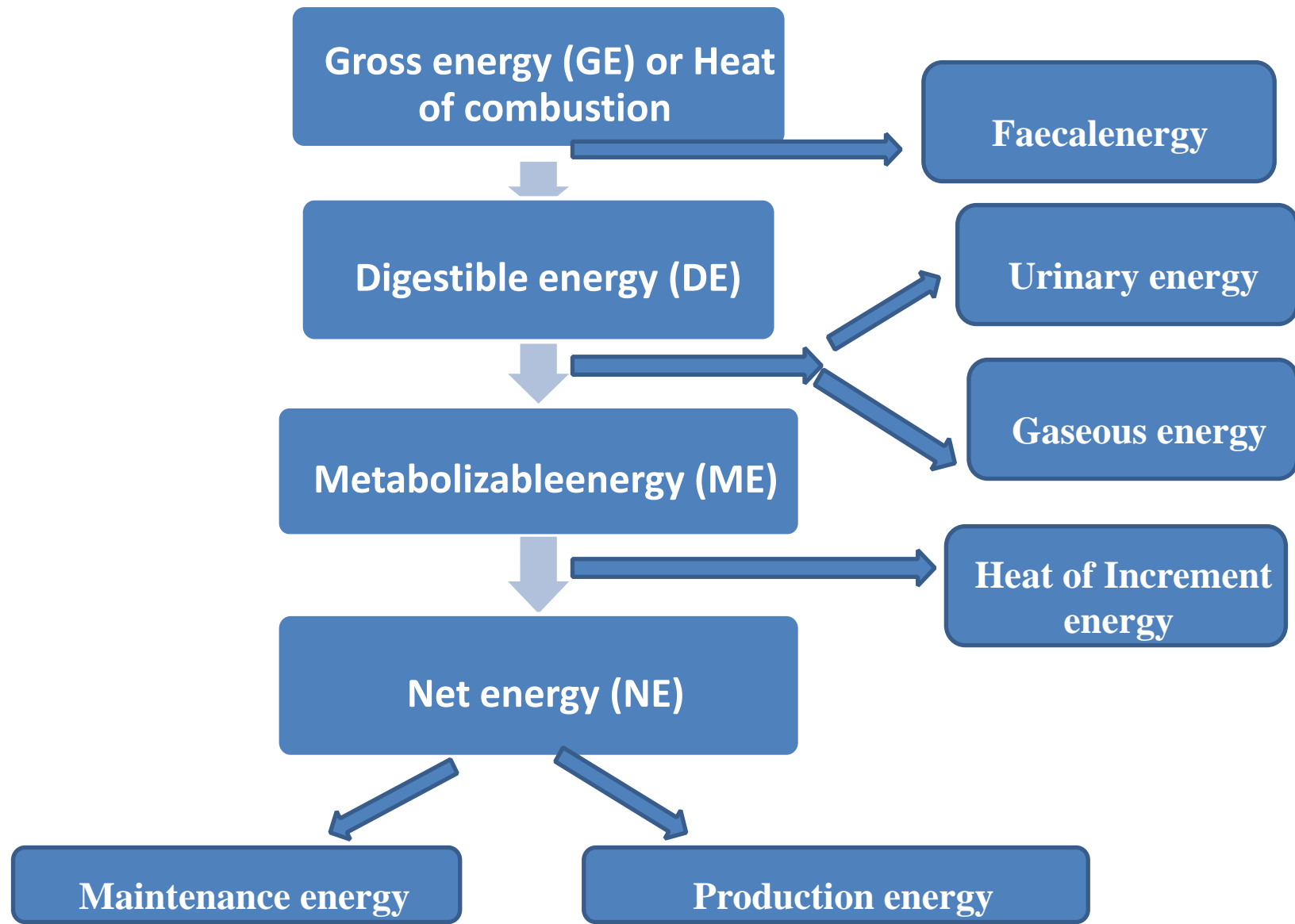


Figure : Partitioning of Feed Energy

Partitioning of Feed Energy

Gross energy (GE) or Heat of combustion

- Fecal Energy (FE)
 - a. Undigested feed residues and enzymes
 - b. Gastrointestinal microbes and their products
 - c. Cellular debris from the gastrointestinal tract

Digestible energy (DE)

- Urinary energy (UE)
- Gaseous energy (Products of fermentation *viz.*

methane) Metabolizable energy (ME)

- Heat of increment energy (HI)
 - a. Heat of nutrient metabolism (HNM)
 - b. Heat of fermentation (HF)

Net energy (NE)

- Maintenance energy (NE_m)
 - a. Basal metabolism
 - b. Activity at maintenance
 - c. Sustaining body temperature
- Production energy (NE_p)
 - a. Growth
 - b. Work

Stored in products (milk, wool etc.)

Glossary of terms

- **Gross energy (GE):** Gross energy is the amount of heat that is released from a given amount of food following complete combustion in a bomb calorimeter.
- **Digestible energy (DE):** Digestible energy is the energy remaining after subtracting the gross energy of feces from the gross energy of food.
- **Metabolizable energy (ME):** Metabolizable energy is the energy remaining after subtracting the gross energy of urine and the gross energy of gaseous products of fermentation from digestible energy.
- **Net energy (NE):** Net energy is the energy remaining after subtracting heat increment (heat production associated with the consumption of food from metabolisable energy).
- **Heat increment (HI):** Heat increment is the energy expenditure associated with ingestion, digestion, assimilation, and metabolism of food. Heat increment is also called thermic effect of feeding, diet-induced thermogenesis, or meal-induced thermogenesis.

GROSS ENERGY (GE)

- **Gross energy (GE):** Gross energy is the amount of heat that is released from a given amount of food following complete combustion in a bomb calorimeter.
- Energy is stored in the chemical components of feed as chemical energy.
- Primary sources of dietary energy - Carbohydrates, lipids, protein, and amino acids.
- When a substance is completely burned to its ultimate oxidation products, *viz.* carbon dioxide, water, and other gases, the heat given off is considered as its gross energy, or 'heat of combustion'.

DIFFERENCE IN GE OF NUTRIENTS

- Different nutrients - difference in gross energy value.
- GE of the fats has approximately twice the energy value of the carbohydrates.
- Proteins occupy an intermediate position in energy value.

Benefits of Gross energy

- GE is simple and is precisely defined attributes of a feed.
- GE is the starting point for estimating various feed energy values.

Limitations of Gross energy

- GE depends on nutrient composition but doesn't tell anything about the contribution of the energy.
- GE value varies little between feeds (e.g Lucerne hay and saw dust have GE value of 20 and 18 MJ/kg dry matters, respectively).

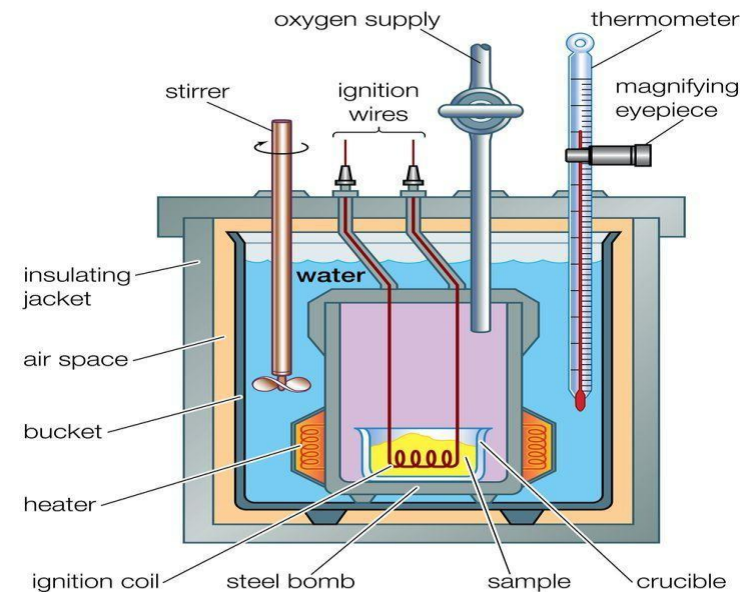
GE gives little information about the energy available to the animal since foods are not entirely digested and energy is lost in feces, urine, and as heat produced during the digestion and assimilation of dietary nutrients

MEASUREMENT OF GROSS ENERGY

- Gross energy is measured in a bomb calorimeter.
- Bomb calorimeter contains a strong metal chamber (bomb) resting in an insulated tank of water (a thermodynamically closed system).
- The food sample is dried, weighed, pelleted and placed in the bomb, which is then completely burned by igniting electrically it in a high pressure (25 -30 atmospheres of oxygen) with oxygen. •
The initial temperature of the water in the bucket is recorded before the sample is electrically ignited. The heat produced during oxidation is dissipated through the wall of the bomb, causing the temperature of the water in the bucket to rise.

Bomb calorimeter ...

- When equilibrium is reached, the final temperature is recorded.
- The quantity of heat produced (H) is then calculated from the rise in temperature (ΔT) and the weights (M) and specific heats (S) of the water and the bomb ($H = MS\Delta T$) and compared with that produced by burning a substance of known energy content.
- Bomb calorimeter is calibrated by **benzoic acid**.



DIGESTIBLE ENERGY (DE)

- Digestible energy is the energy remaining after subtracting the gross energy of feces from the gross energy of food.
- Not all of the gross energy in foods is available for use by the animal.
- Some is lost from the animal in faeces, urine or gaseous excretory products, and some is lost as heat.
- The first loss of the GE occurs in digestion through faeces.
- **Digestible energy = Gross energy - Fecal energy**
- This value is 'apparent digestible energy' because the fecal energy includes that of undigested feed as well as metabolic products of the body (digestive fluid and abraded intestinal mucosa).
- **Apparent digestible energy = Gross energy - Fecal energy**

- True digestible energy= Gross energy-Fecal energy (of feed origin only)
- Faecal energy loss is variable loss of energy from animal foods.
- Cattle and sheep- 40 to 50%, Horses- 35 to 40 %, Pigs & Poultry- 20%.
- Digestible energy represents energy absorbed by the animal.
- DE is a far better measure of the energy available to support animal production than GE. • DE and TDN (total digestible nutrients) have similar variables which affect digestion and the same additional losses.
- DE varies with gross energy and digestibility of feed.