Lecture 2

THE NUTRIENTS

The food needs of people from developing countries are not different from those of the developed world. There are six groups of nutrients. Nutrient is the name given to the different components of feed/food that are useful to the body. Most foods contain several kinds of nutrients but no one food has all that the body needs. Nutrients are any food constituents or groups of food constituents of the same general chemical composition that aid in the support of life. This implies that nutrients in feed/food are responsible for preserving life. Nutrients are components of food which have a function in providing energy, starting and controlling various processes, providing materials for growth, reproduction, storage, repairs and protection. They are:

(1) Water - for control of body processes. Sources of water are portable water, tropical fruits and leaf vegetables.
65-70% - of body weight of animal at birth
40-50% - of body weight at slaughter
90-95% - of blood, 80% of egg

(2) Carbohydrates – sources of calories or energy e.g. Yam, maize, sorghum, wheat, breadfruit, cassava, sugar, plants, body building.

(3) Proteins – used for protection, growth, tissue maintenance and repair. May also be used to provide energy e.g. meat, insects, soyabean meal, eggs, fish meal, groundnut cake, cowpea, milk.

(4) Fats – a source of energy and protection e.g. palm oil, coconut oil, groundnut oil, melon seeds, fish oil, butter, margarine.

(5) Minerals – regulates body processes, can be used for growth and replacement of tissue e.g. fruits and salt, leaf vegetable.

(6) Vitamins – regulate body processes, used as co-factors e.g. tropical leaf vegetables, fruits, root vegetables, carrot.

WATER

Water is an important constituent of all forms of life. Its wide distribution within feeds and feedstuffs coupled with its effect on feed quality makes the study of water a significant part of animal nutrition.

Moisture refers to the absolute amount of water present in a feed while water activity has to do with the form in which the water exists in the feed such as free or chemically bound water. Moisture is the amount of water present in a feed as component, relative to all the other solid constituents such as proteins, carbohydrates, oils and non-water liquids. Most water in foods is called **free water**. Free water is lightly entrapped and therefore easily pressed from feed matter/feed; the water can be seen and felt. Free water acts as a dispersing agent and solvent and can be removed by drying foods.

Adsorbed water or structural water is a second type of water, which associates in layers via intermolecular hydrogen bonds around hydrophilic food molecules.

Bound water sometimes called the water of hydration is a third form of water in feed or food. It exists in a tight chemically bound situation, such as within a crystalline structure via water-ions or water-dipole interactions. Bound water does not exhibit the typical properties of water such as freezing at 0^oC or solvent.

Water Activity – is a measure of the availability of water molecules to enter into microbial, enzymatic or chemical reactions. This availability determines the shelf-life of feed/food. The bound water is inversely related to water activity, as the percentage of bound water in a food increases, the water activity decreases. At any given food/feed moisture, water activity will increase with an increase in temperature.

SOURCES OF WATER

The main sources of water are potable water

(1) Metabolic water – is produced by metabolic processes in tissues mainly by the oxidation of nutrients, oxidation of 1g of CHO yields 0.6g of H_2O, 1g of fat yields 1.1g of H_2O and 1g of protein yields 0.4g of H_2O, metabolic H_2O is about 5-10% of the total water intake.

(2) Portable water – (stream, borehole, rain, river, bottled water, well, lake)

(3) Tropical feeds and fruits – oranges, water melon and

(4) Leafy vegetables – water leaf

FACTORS AFFECTING WATER INTAKE OF ANIMALS

(i) Type of diet – silage, hay high mineral salt content of feed …. H_2O intake

(ii) Purpose (and physiological status) of the animal – lactating cow, dry cow (lactating, dry …..)

(iii) Type of digestive tract – ruminant, non-ruminant

(iv) Type of urinary system – mammals, birds, sweat excretion reptiles, birds, fish, sheep and goat

(v) Environmental condition – temperature and relative humidity

Approximate water consumption of mature animals:

(i) Swine – 5.68-11.36 litres/head/day

(ii) Sheep – 3.79-11.36 litres/head/day

(iii) Cattle – 37.85-53.0 litres/head/day

(iv) Horses – 37.85-53.0 litres/head/day

(v) Poultry – 2 parts water for each
1 part dry feed

(vi) Rabbits – <3 liter/head/day

EFFECT/SIGNIFICANCE/FUNCTION/USES OF WATER

Water neither produces energy nor heat, yet it is about 75-95% of proportion of the body. Water has an inverse relationship with fat. The higher the amount of water, less fat will be found in that region of the body and vice versa. Water is found in all body cells and water is the most abundant of all the nutrients, it is the cheapest and reduces with age.

Water can be lost from the body through urine, faeces evaporation, sweat and skin (referred to as insensitive losses).

- In respiration and gaseous exchange water helps in moistening the alveoli in the lungs.
- Water has high specific heat and by this property it disperses heat fast
- It regulates body temperature through sweat and consequently cools the body. There always results loss of mineral salts through sweat, hence animal drinks more water to replace that which is lost through sweat.

- Water intake helps to prevent constipation in animals and man.
- Water is responsible for movement of minerals across cells and it helps to remove metabolic wastes from the body.
- Essential for mixing of drugs for man and farm animals
- Water supports chemical reactions like digestion, absorption, excretion and maintains shape of cells.
- Water lubricates and cushions joints and organs in the body e.g. synovial fluid, cerebrospinal fluid.

The quality and type of feed determines the water content of feeds. However, amount of water in a feed affects the following:

(a) The nutritive value of silage for example, because the dry matter content of the feed is affected by the amount of water present in the feed.

(b) High water content (>15%) lowers nutritive value at storage and moulds may occur.

(c) Spontaneous combustion may occur at 12% or lower water content and it destroys the nutritive value of feeds.

(d) High water content wastes money because farmer my end up paying for water i.e. mere bulk storage.

(e) Water make silage making easy where 90% water content is fairly tolerated, at times, however water may be added to mature forage crops to ease packing which is done to exclude air. Water affects silage preservation, excess water content of silage may cause loss of mineral through seapage into the surround oil of silage pit.

(f) Water prevents dustiness of prepared feed/feedstuff but animals get little value when fed feeds of high water content. The …… of the animals wears down (emanciates) depleting the body reserves of fat. This emanciation, will reduce the profit margin of farmers who will have to incur extra costs on feeds to restore normal growth of the animals. Excessive intake of water by animals reduces voluntary feed intake to about 30% which reduces animal's efficiency of feed utilization. Water dilutes concentration of energy in feeds hence feeds should be supplied to animals on dry matter basis.

(g) Water is a constituent of saliva (serous/mucus fluid), syovial fluid of keen caps, blood and its cell components, tears from tear glands which help to initial and clean eyes, digestive juices, amniotic fluid which supports fetuses against pressures.

(h) Water ensures sensitivity or irritability by maintaining electrolyte level (i.e. acid-base balance) of the body.

(i) Water helps in the absorption and transportation nutrients and hormones in the blood, which ensures coordination of body activities and processes.

(j) Water is the habitat of important animals plants e.g. fish, snails, cray fish and prawn and water leaf.

(k) Water of high quality is particularly important for the canning of foods and production of carbonated beverages and beer.

(l) Water acts as an important vehicle for heat transfer in foods during food processing and in food preparation.

(m) Water as an ingredient. Water is given to farm animals and can be incorporated as component of processed foods.

(n) Water act as a plasticizer – especially in low moisture and frozen foods. A plasticizer is a substance that when added to a food system, makes it softer.

WATER LOSSES: Water is lost from the body constantly

(1) In the respired air by evaporation

(2) From the skin via sweat and

(3) Periodically by excretion in urine or faeces.

Faecal water losses are considerably higher in ruminants than other animals. In diarrhea large losses of H_2O occur with the faeces.

WATER QUALITY

Water is ubiquitous, the presence of water like that of air is taken for granted. Yet water is a most remarkable liquid, having properties which make it uniquely the support of life.

Most rural people in some countries of the tropics depend on rivers, lakes, springs and shallow wells for their water supply. The purity of such water depends on the geological source and local surroundings. In some communities portable water is a luxury commodity and not within the reach of the inhabitants.

Potable water is free from harmful bacteria and chemical impurities. It is clear and bright, colourless, tasteless, odourless and contains no suspended matter or turbidity. In addition it should have an attractive appearance and be pleasant to drink.

Certain chemical substances have maximum allowable concentrations in drinking water while excess is detrimental to health.

Contamination by sewage or human excrement and by animal pollution poses the greatest danger associated with drinking water in most developing countries in the tropics. The organisms most commonly used as indicator of water pollution are E. coli and the coliform group as a whole.

Standards for drinking water have been published by the WHO for European countries and international use.

*Distinguish between SOFT and HARD water – causes, effect and prevention.

CHEMISTRY OF WATER

(1) Hydrogen Bonds – the electrostatic interaction between the hydrogen nucleus of one water molecule and the unshared electron pair of another water molecule is termed a hydrogen bond. Usually weak.

Hydrogen bonding profoundly influences the physical properties of water and accounts for its exceptionally high viscosity, surface tension, and boiling point. On average, each molecule in liquid water associates through hydrogen bonds. These bonds are both relatively weak and transient, with a half-life of about one microsecond. Rupture of a hydrogen bond in liquid water requires only about 4.5 kcal/mol, less than 5% of the energy required to rupture a covalent OH bond. Hydrogen bonding enables water to dissolve many organic biomolecules that contain functional groups which can participate in hydrogen bonding.

(2) Dissociation of water – water molecules have a limited tendency to dissociate (ionize) as follows – H_2O $H^+ + OH^-$

(3) The concept of pH – this is defined as the negative log of the hydrogen in concentration - pH ------- log $[H^+]$

Low pH values (below 7.0) corresponds to high concentrations of H^+ (acidic solutions) and high pH above 7.0 results because of low concentrations of H^+ (basic solutions). Acids are defined as proton donors and bases as proton acceptors.

(4) Solubility – hydrophobic compounds are dissolved/soluble in water e.g. minerals, salts, vitamins, sugar, carbohydrates, proteins which existed as polar (charged) substances dissolve in water.

A water molecule is an irregular, slightly skewed tetrahedron with oxygen at its center. The strongly electronegative oxygen atom pulls electrons away from the hydrogen nuclei, leaving them with a partial positive charge, while its two unshared electron pairs constitute a region of local negative charge. Water therefore greatly decreases the force of attraction between charged and polar species relative to water-free environments with lower dielectric constants. Its strong dipole and high dielectric constant enable water to dissolve large quantities of charged compounds such as salts.

(5) Hydration – this is the process by which water molecules surrounds and interact with solutes by acting as a solvent, water as a carrier.

(6) The functional properties of water in foods include acting as a diluents and carrier of hydrophilic ingredients, providing a medium for chemical and enzymatic reactions and solvent action.

(7) Condensation and hydrolysis – these are important chemical reactions involving water in the nutrition of farm animals.

(8) Presence of >15% moisture in dry feedstuffs is bad because of subsequent diminution of feeding value and the predisposition of moist feedstuffs to become mouldy or rotten (spoilage).

WATER TREATMENT

When raw water does not meet the standards required for drinking by man and farm animals and food processing, it must be purified by a combination of chemical, physical or biological procedures.

Raw water from a variety of locations can have vastly different chemical, physical, biological and bacteriological characteristics, hence there is need for treatment via processes that will improve the water quality.

However, the major contaminants of water (such as a colour, turbidity, suspended matter, mineral constituents, microorganisms) can be removed or their levels substantially reduced by standard H2O treatment processes, which includes chemical coagulation and flocculation, sedimentation, filtration, disinfection, reduction in corrosiveness, taste and odour control and softening and demineralization.