เอกสารประกอบการสอน

วิชา 502411
โภชนศาสตร์คลินิกสัตว์ใหญ่
(Large Animal Clinical Nutrition)

รศ.น.สพ.ดร. ธีระ รักความสุข
ภาควิชาเวชศาสตร์คลินิกสัตว์ใหญ่และสัตว์ป่า
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Large Animal Clinical Nutrition

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Course description

Basic principles of clinical nutrition in large animals. Nutrient requirements and nutritional management in relation to health, reproduction, and production of cattle, goats, sheep and horses.

Study evaluation

- Self-study 20%
- Examination
  - Midterm 30%
  - Final 30%
  - Class attendance 20%

Topics

- Basic concepts and ration formulation
- Protein nutrition and nonprotein nitrogen
- Major minerals and trace minerals
- Vitamins and water requirements
- Control of feed intake
- Effects of diseases on nutritional needs
- Feeding beef cows for optimal production
- Pasture management and forage related health problems in beef cattle
- Colostrum and feeding management of dairy calves and nutrition of dairy replacement heifers
- Feeding dairy cows for optimal production
- Nutritional support for sick cattle and calves
- Feeding goats for optimal health and production
- Feeding sheep for optimal health and production
- Feeding horses for optimal growth and production
- Feeding sick horses

Bioenergetics : basic concepts and ration formulation

- Nutrition involves the acquisition and utilization of the chemical substances that are necessary to establish, maintain, and propagate life.
- These chemicals are called “nutrient” and include water, carbohydrates, fats, proteins, minerals, and vitamins.

Bioenergetics

- It is a branch of energetics concerned with energy transformation in living organisms.
- Energy exists in two states:
  - Kinetic energy is the energy of motion. This energy is actively engaged in doing work.
  - Potential energy is stored. The chemical energy in nutrient molecules is an example of potential energy.

Systems of energy measurement

- Energy is the most critical consideration in animal nutrition.
- It is measured as heat expressed as kilocalories (kcal), megacalories (Mcal), or megajoules (MJ).
- The energy in foods is stored as potential energy, which is released by chemical reactions.

- The kinetic energy released may be used to make muscle contract, to induce glands to secrete, or to supply energy for storage.

A number of terms are used to describe energy at various stages of transition from food to animal energy

- Gross energy (GE) is obtained from the whole feed.
- Fecal energy (FE) is for the fecal matter produced by the digestion of feed. The fecal material contains undigested feed, enteric microbes and their products, and excretions from the gastrointestinal tract.
- Combustible gas energy (CGE) is for the nonabsorbable gases (mostly methane) that are produced during digestion. This is most important in ruminants.
- Digestible energy (DE) equals GE minus FE.
- Urinary energy (UE) is the energy content of the urine produced by the metabolism of the DE of a specific feed sample.
- Metabolizable energy (ME) is DE minus (UE plus CGE).
- Net energy (NE)is ME minus the heat increment (Hi). The heat increment is sometimes called the *specific dynamic activity* (SDA). The heat increment results from energy lost in the production of digestive secretions and in the absorption, circulation, and metabolic conversion of nutrients into end product.

Net energy is divided into two categories.

- Net energy for maintenance (NEm)includes the energy required for basal metabolism (Hb) and the energy required for normal activity (Ha).
- Net energy for production (NEp) includes energy deposited in growth and fat storage (NEg), energy deposited in the products of gestation (NEr), and energy deposited in milk (NEl), and energy used to perform work (NEw).
- Energy interconversions
- 1 Mcal = 1,000 kcal = 4.184 MJ
- 1 kcal = 3.968 British thermal units
- Ruminants, horses
    - 1kg TDN = 4.409 Mcal of DE
    - 1lb TDN = 2.000 Mcal of DE
    - 1kg starch equivalent = 5.082 Mcal of DE
    - 1lb starch equivalent = 2.305 Mcal of DE

- Beef cattle, sheep, goats
    - ME = 0.82 X DE (Underestimates the ME content of high grain rations)
- Goats
    - ME = 0.464 X DE

Chemical composition of feeds

The energy-containing components of food are mainly proteins, lipids, and carbohydrates

- Proteins are composed of amino acids, which consist of a short hydrocarbon chain with an amino (NH_2) and a carboxy acid (COOH) group.
- Lipid is the generic term given to fats, which are solid at room temperature, and oils, which are liquid. Oils have shorter carbon chain lengths and tend to be less saturated but their caloric value is similar to fats.

  - The main role of fats in animal nutrition is as a concentrated energy source. Fats are useful in situations where it is difficult to meet energy requirements within the constraints of dry matter intake.
- Carbohydrate (sugar, starches, fiber), carbohydrates are divided into two categories: storage and structural CHO
  - Storage CHO are compact polysaccharides used as an energy store by plants and animals.
  - α-linkage that join the sugars can be degraded by mammalian digestive enzymes.
  - Amylose and amylopectin are the two forms found in plants.
  - Glycogen is the animal equivalent of plant starch..
  - Structural CHO form dietary fiber, mainly found in the cell wall of plants and tend to be insoluble and provide strength.
  - In structural CHO, the sugar subunits are joined in chains by β-linkages. These cannot be degraded by mammalian digestive enzymes.
  - Cellulose, a glucose polysaccharide.
  - Hemicellulose, a pentose sugar polymers.
  - Lignin is a polymer of aromatic alcohols.
- The usefulness of various types of fiber as energy sources depends on the degree of lignification; lignin energy is unavailable, even to herbivours.
- Fiber content of feeds is classified according to solubility:
  - Crude fiber (CF)
  - Neutral detergent fiber (NDF)
  - Acid detergent fiber (ADF)

Energy content of feeds

- An old system of estimating the energy content of feeds is the total digestible nutrient (TDN) system. This is the summation of the digestible crude protein, digestible fiber, digestible nitrogen-free extract, and digestible ether extract and is expressed as a percentage of the total amount of feed.

Concentrates and roughages

- Concentrates contain less than 20% crude fiber.
- Roughages contain more than 20% crude fiber.

Signs of energy deficiency and toxicity

- Energy deficiency causes loss of weight. Animals die when they have lost about 25-30% of normal body weight. Death is thought to be due to protein depletion and loss of respiratory and cardiac muscle function.
- Energy restriction delays puberty, and in adults it reduces estrus behavior, ovulation rates and libido. Conception and birth rates fall.
- Energy excess results in obesity. This may exacerbate chronic lameness and reduces fitness for work. There is reduced reproductive efficiency in both males and females, and dystocia is more likely. Obesity predisposes to ketosis and fatty liver in heavily pregnant sheep and recently calved cattle.

Maintenance energy

- Basal energy requirement is measured with the animal at rest. It represents the amount of energy used to maintain normal cellular function. Energy requirements for maintenance are about 25-100% higher depending on energy expenditure for movement in the natural environment. Maintenance requirements are even higher if the environment is adverse, for example, because of heat or cold stress.

Factors affecting Maintenance energy

- Cold and heat stress
- Season
- Growth pattern
- Foraging

Feed-conversion ratio

- The feed conversion ratio is the ratio of feed ingested (in kg or Mcal) to liveweight gain. Low ratios of feed fed per unit of gain indicate efficient production. Feed conversion efficiency and feed conversion rates decline with age.

Dry matter intake

- Dry matter intake is controlled by the animal's requirement for energy intake and the physical capacity of the gut.
- When a high-quality diet is fed and requirements are low, food intake is regulated in accordance with requirements.
- Gastrointestinal fill is the major limiting factor when requirements are high and ration nutrient density is low.

Ration formulation

- Nutritional advice frequently involves recommendations on the comparative value of different types of feed and the evaluation and formulation of rations for animals.

Nutritional goals and sources of information

- The first step in diet formulation is to obtain a reliable sources of nutrient requirements for the target animal. For example, the National Research Council (NRC) of the USA, is generally regarded as the authoritative source. Other sources may include extension publications and the results of university research. In some situations, this information may provide useful modifications to published requirements based on "local conditions".
- In addition to reliable animal nutrient requirement information, it is essential that accurate feed nutrient values be available for the diet formulation process.
- Not only is content required for an increasing number of nutrient fractions, but also descriptive utilization data such as the rate of digestion.

Feed formulas and conversions

- There are several basic types of data manipulation used in formulating a giving ration:
- Amounts of DM to amounts as fed.

  10 lb of DM required and feed is 30% DM: 10 lb of DM/0.30 ld DM per lb as fed = 33.3 lb as fed.
- Amounts as fed to amounts of DM

  50 lb of corn silage as fed and DM content is 35%: 50 X 0.35 = 17.5 lb DM

Feedstuff	% of ration DM	DM of feed	As fed	Total as fed	% As fed
Corn silage	60	0.35	171.4	225.4	76.1
High moisture shelled corn	30	0.70	42.9	225.4	19.0
Supplement	10	0.90	11.1	225.4	4.9
Totals	100		225.4		100.00

Feedstuff	% As fed	DM of feed	DM	Total number of parts	% Ration DM
Corn silage	76.1	0.35	26.64	44.35	60.1
High moisture shelled corn	19.0	0.70	13.30	44.35	30.0
Supplement	4.9	0.90	4.41	44.35	9.9
Totals	100		44.35		100.00

Simple ration balancing

- Pearson's square : This is a useful technique for balancing one nutrient using two feeds. One feed must have a nutrient concentration above and one feed below the desired nutrient level.

Example 1

Balance a ration for 11.5% crude protein using alfalfa hay (17.1% CP) an ground ear corn (9.3% CP).

			DM parts	DM (%)
Alfalfa hay	17.1	2.2	2.2/7.8	28.2
	11.5			
Ground ear corn	9.3	5.6	5.6/7.8	71.8
		7.8		100%

Check: 28.2(.171)+71.8(.093) = 11.5%

Modified Pearson's Square

- The Pearson's square method can be expanded to include three or more feeds if the decision is made to "lock in" two or more of the feeds in a fixed proportion.

Example 2

Alfalfa hay 20% CP

Corn grain 10% CP

Wheat 12% CP

A decision is made to fix the two grains at 60% corn grain and 40% wheat on a DM basis. How should the alfalfa hay and grain mixture be combined to produce a total ration containing 15% CP

Grain protein mix : 0.60(10) + 0.40(12) = 10.8% CP

Balance for 15% CP in total ration :

				DM parts	DM (%)
60:40 Grain Mix	10.8		5	5/9.2	54.3
		15			
Alfalfa Hay	20		4.2	4.2/9.2	45.7
			9.2		100%

			Percent of DM
Final ration :	Alfalfa hay		45.7 %
	Corn grain 54.3 X 0.60		32.6
	Wheat 54.3 X 0.40		21.7
		total	100%

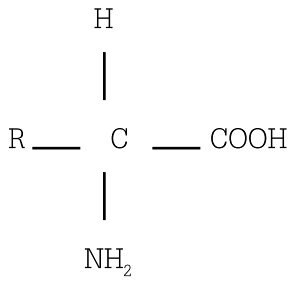
Check :	0.457(20) +	0.326(10) +	0.217(12) = 15% CP
	Hay	Corn	Wheat

Exercise

- Balance a ration for 14.5% CP using corn silage (8.5% CP) and soy bean meal (21% CP).
- Balance a ration for 16% CP using a grain mix [30% cotton seed (18% CP) and 70% corn grain (10%)] and alfalfa hay (20% CP)

Protein Nutrition and Nonprotein Nitrogen

Chemical structure of amino acid



Protein is required to:

- Enhance feed intake and energy use
- Supply N to the rumen microbes
  - Ammonia
  - Amino acids
  - Peptides

Protein is required to:

- Supply amino acids for synthesis of
  - Milk protein
  - Tissue protein
  - Enzymes, hormones etc.
- What are proteins and amino acids?

Protein terminology

- Intake protein : what the cow eats
- Soluble and insoluble – refer to breakdown in water or rumen fluid
  - Broken down very rapidly in the rumen to ammonia
  - What many of the rumen microbs live on
- Degradable and undegradable – refers to whether it ever breaks down in the rumen or not
  - Broken down in rumen
  - Undegradable protein is also referred to as bypass protein.

Protein terminology

- Digestible protein – refers to the portion of the protein that is absorbed somewhere in the GI tract
- Microbial protein – refers to the portion of the protein produced by the microbes in the rumen
- True protein – made up of amino acids not NPN
- Nonprotein nitrogen – any substance that contains N that is available to the rumen microbes but not made up of amino acids
- Protein terminology
- Intake protein
  - Undegradable – by passes rumen – 30%
  - Degradable – broken down – 70%
- Amino acids (40% of the total)
  - Some bypass
  - Deaminated to NH_3 + VFA
- NH_3 (60% of the total)
  - Used by bacteria to manufacture microbial protein
  - NH_3 + CHO = protein

  - Absorbed by rumen, converted to urea
  - Saliva
  - Excretion

Two forms available to cattle

- True protein
- Non-protein nitrogen
- The rumen microbes use these two sources for the production of microbial protein supplies 50% of cow's protein requirement.
- The protein that the microbes produce is much higher quality protein than the feed components from which they are produced.

Nonprotein Nitrogen

- Several forms
  - Ammonia
  - Urea
  - 281% protein
  - Other nitrogen compounds – nitrates etc.
- Only used in rumen
- Supplies rumen microbes with NH_3
- Ammonia is either used by the rumen microbes or absorbed by rumen wall

Microbial protein synthesis

- Protein converted to ammonia, also urea converted to ammonia
- Ammonia + a carbon skeleton converted to AA and microbial proteins by microbes
- Microbial protein and bypass protein digested in the true stomach and small intestines.

Effect of protein on dry matter intake and digestibility

- With high producing or rapidly gaining cattle, the benefits of supplemental protein have been accounted for through increased voluntary dry matter intake and increased dry matter digestibility.

Total Crude Protein

CP = Nitrogen (N) x 6.25, 100 lb CP = 16 lbN, 100/16 = 6.25

Example : Alfalfa hay = 3% N x 6.25 = 18.75% CP

Available Protein

- Protein available for digestion
- Should be 90% or more of CP
- Less than 90% CP available indicates:
  - Heat damage
  - Excessive maturity at harvest

Unavailable Protein

- Protein unavailable for digestion
- Should be less than 10% of CP
- If greater than 10% of CP indicates:
  - Heat damage
  - Malliard Reaction
  - Carmelized protein
  - Bound protein
  - ADF-N

Urea Calculations

1. 46% N in urea X 6.25 = 287% CP
2. Obtain % CP from NPN on feed tag
3. % CP from NPN / 287 = % Urea

Example:

11.5% CP from NPN in 36% CP dairy feed

11.5 / 287 = 4% urea

4 lbs dairy feed X 0.04 = 0.16 lb urea

Several factors influence the conversion of dietary nitrogen to microbial protein

- Rate of passage
  - The faster it goes through the cow the less opportunity to breakdown
- Solubility
  - Soluble proteins or feedstuffs are more easy to breakdown
  - Urea just add water and its gone
- N concentration in the diet/rumen
  - Higher protein in the feed more ammonia in rumen
  - You don't make microbes work as hard for their meal
- Energy available in the rumen
  - Take energy to make protein
  - NH_3 needs a carbon skeleton to build AA
- Bacteria stimulating factors
  - Vitamins D & B
  - Isoacids
  - Branched chain fatty acids
  - yeasts

Classes of protein

		% bypass
Very low bypass	Urea, Casein	0 – 20
Low bypass	Soybean meal, Peanut meal	20 – 40
Medium bypass	Cottonseed meal, Alfalfa meal, Linseed meal, Corn Brewers dried grains	40 – 60
High bypass	Meat meal, Corn gluten meal, Blood meal, Feather meal Distillers dried grains	60 or above

Macrominerals and Trace minerals

Macrominerals

- Calcium, phosphorus, magnesium, sodium, potassium, and chloride are referred to as major minerals or macrominerals because they comprise a large proportion of body minerals and are required in much larger amounts in the diet than trace minerals.
- Mineral deficiency that can lead to PICA
  - Sodium
  - Potassium
  - Chloride
  - Phosphorus

Potassium

- Role
  - The main functions of potassium are to help maintain the intracellular osmotic pressure and to contribute to the membrane potential.
  - Potassium is also important in a number of electrically activated phenomena, particularly contraction of cardiac and skeletal muscle.
- Pathophysiology
  - Herbivors eating forage typically ingest large quantities of potassium. Potassium salts are water soluble, and much of the ingested potassium is absorbed. Surplus potassium is excreted via the kidneys.
  - Most of the K in the body is concentrated inside the cells as a result of the activity of the Na-K ATPase, which pumps K into cells and excretes sodium into the extracellular fluid.
- Requirements
  - For herbivors are on the order of 0.5% to 0.8% of the dietary dry matter.
- Deficiency
  - The first sign is decreased feed intake. With chronic deficiency, the hair coat becomes rough and emaciation develops.
  - Weakness and cardiac abnormalities are seen with severe deficiency.
- Supplementation
  - Rarely necessary.
  - In high risk situations, K deficiency can be prevented by increasing the amount of roughage in the diet, by mixing KCl with the grain portion of the diet, or by spraying solutions of KCl onto hay.

Sodium

- Role
  - Sodium is important in controlling the osmotic pressure of extracellular fluid, in the generation of the membrane potential, and the conduction of electrical impulses in nerve and muscle.
- Pathophysiology
  - Sodium is the only mineral for which a clearly defined appetite exists.
  - Sodium is one of the few substances that can be detected by taste buds in the tongue.
  - In times of sodium deficiency, animals actively seek out sources of salt and increase their salt consumption.
- Requirements

- Na is of great nutritional importance because grains and some forages are deficient in this element and there are no readily mobilizable stores within the body.
- Requirements are estimated to be about 0.1% of the dietary dry matter for most nonlactating farm animals, and these are close to the levels found in grasses and legumes.
- Heavily lactating or working animals require up to about 0.2% Na, and these levels are too high to be reliably met by unsupplemented diets.

- Deficiency
  - Na deficiency is more common in hot environments and in heavily lactating or strenously excercising animals (sodium is lost in milk and sweat).
  - The initial sign is usually increased salt appetite; animals seek out salt sources and may appear to have pica.
  - Serum Na concentrations are of limited use in diagnosis of sodium deficiency. In animals with excessive Na losses, water and salt are usually lost together, so the animal becomes dehydrated rather than hyponatremic.
  - Salivary Na and Na-Ka ratios are much more useful in diagnosis in ruminants.
  - Deficient ruminants have Na-K ratios that are always less than 10:1 and sometimes as low as 1:1.
- Toxicity
  - Na toxicity is influenced by the availability of water low in dissolved salts.
  - Sodium
  - There are at least two syndromes produced by salt intoxication – diarrhea and nervous signs.
- Supplementation
  - Na and chloride requirements are usually met by offering free-choice salt or by incorporating 0.5% of salt into the whole ration.
  - Sodium : free choice salt consumption of animals

Chlorine

- Role
  - Chlorine mainly exists in the body as the chloride ion. It is the principal anion of the extracellular fluid and an important intracellular ion. Chloride ions are important in the maintenance of osmotic pressure and in electrical phenomena.
- Requirement
  - Feed levels are satisfactory to meet requirements under many circumstances.
- Deficiency
  - Heavily lactating dairy cows appear to be particularly susceptible because of the losses of chloride in milk and because sodium bicarbonate is often added to buffer the feed.
  - Signs of deficiency include loss of weight, decreased food intake, and reduced milk production.
  - In advance deficiency, signs of dehydration and pica are seen.
- Toxicity
  - Free chlorine can be poisonous but only chloride ion and organically bound chloride are found in feedstuffs.
- Supplementation
  - Chloride deficiency can be prevented by ensuring that high-producing dairy cows fed sodium buffers also have access to sufficient chloride.

Calcium

- Role
  - Calcium accounts for about 1.5% of body weight and precipitated with phosphate and water, it forms hydroxyapatite, the major mineral of bone and teeth.
  - Small proportion of calcium that is found outside the skeleton plays a role in metabolic functions.
- Pathophysiology
  - Calcium homeostasis is maintained by three hormones: parathormone, calcitonin, and the vitamin D-derived steroid hormone.
- Requirements
  - Calcium requirements are particularly high in growing and heavily lactating animals.
  - Dietary concentrations of calcium are highest in legumes.
- Deficiency
  - Hypocalcemia
  - Parturient paresis or milk fever
- Toxicity
  - Calcium has a low toxicity. High concentrations in hay interfere with the absorption of other minerals.

- Supplementation
  - High grain diets should always be supplemented with calcium. Calcium supplements may also be needed for animals fed diets based on grass or corn silage, particularly if the animal is growing or lactating.

Phosphorus

- Role
  - Phosphorus is used throughout the body as a source of rapidly available chemical energy in the form of high-energy phosphate links in creatine phosphates, ATP and other highly phosphorylated nucleotides.
- Pathophysiology
  - Stimulation of calcium absorption by vitamin D also leads to a secondary increase in phosphorus absorption.
- Requirement
  - Grains contain reasonable amounts of phosphorus, particularly in the outer bran layers.
  - A particular concern to nutritionists has been the digestibility of phytate phosphorus
- Deficiency
  - Deficiency signs are mainly related to phosphorus's role in the skeleton and in energy metabolism.
  - Postparturient hemoglobinuria has been linked to phosphorus deficiency.
- Toxicity
  - High phosphorus diets may suppress the absorption of calcium and can predispose to urolithiasis.
- Supplementation
  - Diets are routinely balanced for phosphorus as part of ration formulation.

Magnesium

- **Role**
  - Magnesium is a minor component of bone, but about 70% of total body magnesium is found in the bone.
  - Magnesium is involved in membrane electrical phenomena and muscle contraction. It is also involved in energy metabolism as a cofactor for several enzymes.
- Pathophysiology
  - Plasma levels of magnesium are not under close hormonal control. They tend to be maintained around 1 mmol/L (2.5 mg/dl)
- Requirement
  - Requirements are greatest in heavily lactating animals. Most feeds contain sufficient magnesium to meet needs, but grains are lower in total magnesium
- Deficiency
  - If hypomagnesemia is sufficiently severe, it produces the disease hypomagnesemic tetany.
- Toxicity
  - Magnesium can be toxic at the very high oral intakes associated with therapeutic use. High serum magnesium concentrations depress neuromuscular transmission and cardiac contractility.
- Supplementation
  - Feeds are often supplemented by mixing with magnesium-containing minerals as part of ration formulation.

Trace minerals

- Awareness of the importance of trace minerals has increased as sophisticated analytical techniques have been developed.
- Overt clinical signs of trace mineral deficiencies or toxicities produce obvious losses in animal health and productivities, but subclinical deficiencies or toxicities can produce equally serious losses in production.

Normal function

- A trace mineral comprises less than 1% of total body ash and is required in the diet at less than 0.1%, or 1 g/kg, feed dry matter.
- Trace minerals act primarily as catalysts or activities in enzyme or hormone systems or as integral parts of the structure and function of metalloenzymes.
- The clinical sing or production criterion affected by a trace mineral deficiency depends on the specific physiological function of the metalloezymes.

Defining a deficiency state

- Most are based on clinical, pathological, and biochemical criteria of animals made deficient using purified diets in controlled studies.
- Dietary and tissue trace mineral levels give a good indication that deficiency exists.
- Defining a deficient state
- A trace mineral deficiency is considered
  - There is an absolute deficiency of the element in the diet.
  - More than 25 trace mineral–nutrient interactions are recognized.
- An example of preabsorptive antagonism is the impairment of copper absorption by excessive dietary zinc or iron.

- An example of postabsorptive antagonism is the effect of thiomolybdate on copper utilization by the ruminant.

Factors that influence trace mineral status

- Animal factors
  - Age
  - Breed
  - Sex
  - Species
  - physiological condition (maintenance, gestation, lactation, growth, and athletic performance)
  - Genetic selection
- Plant factors
  - Genetic selection and bioengineering of plant species can modify plant growth and the ability of food crops to absorb trace minerals from the soil.
- Soil composition, moisture, pH, organic matter, depletion or addition of trace minerals, and loss of topsoil modify trace mineral composition of local and regional plant crops.
- Irrigation has been related to a depletion of selenium in the topsoil and, consequently, reduction of selenium in the crops grown on these soils.
- Environmental factors
  - Difference in manual, seasonal, and regional precipitation and ambient temperatures can alter a plant's growth rate and its ability to absorb trance minerals.
- Changes secondary to inflammatory disease
  - Following an insult by an infectious or inflammatory agent, the leukocytes liberate interleukin-1 (leukocyte endogenous mediator).
  - Interleukin-1 stimulates hepatic synthesis of metallothionein, which binds zinc.
  - The subsequent depression in serum zinc is related to the degree of toxic insult and is accompanied by enhancement of neutrophil function. These events are followed by synthesis of acute phase reactants, including fibrinogen, haptoglobulin, and alpha-2 globulins (ceruloplasmin).
  - Increased synthesis of ceruloplasmin accompanies the movement of hepatic copper to peripheral tissues, which produces an elevation of circulating copper concentration.
  - In addition to changes in plasma copper and zinc, plasma iron concentration decreases because granulocytes release apolactoferrin, which binds iron.
  - The iron-lactoferrin then binds to hepatocytic receptors and is made unavailable for microbial growth and toxin production

Clinical problems

- Trace mineral status is not static but fluctuates throughout the animal's life.
- The changes occur in plasma and tissue trace mineral concentration and biochemical function as an animal progresses to a clinically deficient state. It is not until the deficiency results in biochemical changes that disrupt cellular function that clinical signs appear.
- The signs exhibited depend on the functions impaired and on the sequence of impairment, thus primary and secondary deficiencies can cause different clinical signs.

Diagnosing a deficiency

- Several criteria can be used to evaluate the trace mineral status of single animals or herds. These include the following:
  - A detailed history
  - A detailed physical examination

- A total dietary evaluation
- Tissue evaluation for
    - The specific trace mineral
    - Activity of metalloenzymes that involve the specific trace minerals, and products, or metaboltes in which the trace mineral or its metalloenzymes is involved.

History, clinical examination, and diet evaluation

- A thorough history and clinical examination are critical for diagnosis of a suspected trace mineral deficiency.
- The diet must be evaluated not only for the suspected trace mineral but also for potential nutrient and trace mineral interactions.
- Feed analysis is the most important tool in the diagnosis of trace mineral deficiency as low dietary concentrations indicate a potential for development of a deficiency.

Tissue and fluid evaluation

- Important aids to diagnosis of trace mineral imbalances include analysis of tissue, blood, serum, and plasma.
- Selection of the appropriate tissue is based on the normal distribution of a trace mineral within tissues
- Blood, serum, and plasma are the easiest body fluids to sample but may not always be the most useful tissues.
- These fluids are used to measure the concentration of the trace mineral directly or indirectly by evaluation of the concentration or the activity of enzymes or hormones altered by a deficiency.
- A critical factor in accurate measurement of trace minerals in blood is the use of appropriate collection tubes and anticoagulants.
- Use of serum rather than plasma can influence the quantification of certain trace minerals. For example, serum copper values for cattle may be lower than plasma copper values because of the precipitation of ceruloplasmin copper in the clot.
- Sample storage, sample preparation, and the analytical techniques employed by the laboratory also can alter absolute values obtained.

Supplementation

- Before recommending trace mineral supplementation, the veterinarian must determine the amount that is needed based on the trace mineral concentrations of the diet, the interactions that may exist with other nutrients, and the group to be supplemented.
- Oral supplements
- Parenteral supplements

Vitamins

- Vitamins are micronutrients because they are required in small quantities in the digesta.
- In general, vitamins function metabolically either as coenzymes or as hormones.
- Requirements are small because most vitamins are recycled within the body.
- Absorption is usually limited to the small intestine.
- Most vertebrates share similar requirements for the same vitamins.
- Ruminants and horses are unusual in that the microbial flora of the rumen and large colon produce large amounts of B vitamins.
- Vitamin deficiency impairs normal biochemical function within the animal's body.
- Vitamins are divided into two main categories, the fat-soluble and water-soluble vitamins.
- The fat soluble group consists of vitamins A, D, E, and K. Vitamin A and D function as hormones, whereas E is an antioxidant and K is an enzymatic cofactor.
- The water soluble vitamins are the B group vitamins, choline, and vitamin C.

Fat soluble vitamins

Vitamin A

- Forms. There are two types of compounds with vitamin A activity. Retinol (vitamin A alcohol) derivatives are the biologically active form of vitamin A in mammals. Plants contain no vitamin A but are rich in carotenoids, which are also known as provitamin A. There are a large number of carotenoids but beta-carotene is the most important.

Vitamin A: metabolism

- During digestion, carotene is split into two retinol molecules, esterified in the intestinal mucosa and transported to the liver. Liver stores vitamin A and regulates plasma retinol concentrations. About half the body's vitamin A content is found in the liver, stored as palmitate ester.

Vitamin A: Role

- In retinal, retinol is converted to the aldehyde and used for synthesis of visual pigments.
- A major role of vitamin A is maintenance of the functional integrity of simple epithelial surfaces lining the spinal canal, gut, and respiratory and urogenital tracts.

Vitamin A: sources

- The best sources of vitamin A are the carotenoids in green pasture. Carotenoids are reasonably conserved in the anaerobic condition found in silages.

Vitamin A: deficiency

- Is most likely to occur in rapidly growing animals fed preserved feeds.
- High grain diets with straw as a roughage are particularly apt to cause deficiency.
- Reduced growth rate is the early sign of deficiency.
- Night blindness and edema of the optic nerve.
- Vitamin A-deficient animals also tend to be prone to infections at mucosal surfaces, particularly in the enteric and respiratory tracts.
- Additional signs that may be observed in cattle are hydrocephalus in neonatal calves, anasarca, heat intolerance, and exophthalmos.
- Adult animals are quite resistant to vitamin A deficiency. The main effects appear to be confined to the gestating fetus and reproductive failure in adults.
- Diagnosis of vitamin A deficiency depends on the presence of clinical signs and the demonstration of vitamin A depletion.

Vitamin A: toxicity

- Toxicity occurs when excessive vitamin A intake saturates retinol-binding protein and free vitamin A circulates in plasma.
- Signs of toxicity include reduced feed consumption, reduced growth, skin erythema in pigs, and rough hair coats in horses.

Vitamin A: supplementation

- Routine vitamin supplementation of the grain portion of the diet of animals on high grain, poor quality roughage.

Vitamin D

- Forms: Vitamin D exists in two forms. Vitamin D_2, or ergocalciferol, is formed in plants by ultraviolet irradiation of ergosterol. Vitamin D_3, cholecalciferol, is produced in farm animals exposed to sunlight through the action of ultraviolet irradiation on endogenous 7-dehydrocholesterol

Vitamin D: metabolism

- Both forms of vitamin D are processed by the same enzymes located in the liver and kidney to produce the biologically active 1,25 dihydroxyvitamin D_2 or D_3. Farm animals can make good use of both forms.

Vitamin D: role

- 1,25 dihydroxyvitamin D is a steroid hormone. It circulates in the plasma bound to a binding protein, diffuses into target cells, and is transported to the nucleus, where it effects gene expression.
- Its major effect is to stimulate intestinal calcium absorption; it also improves phosphorus and magnesium absorption.
- A recently recognized function of calcitriol is immune regulation. It stimulates differentiation of myeloid stem cells into macrophages.

Vitamin D: source

- Most feedstuffs are low in vitamin D. However, much vitamin D_2 is formed when plant material is dried (cured) in the sun; in consequence, hay is a good source.

Vitamin D: deficiency

- The principal sign of vitamin D deficiency is rickets or osteomalacia (diseases characterized by poorly mineralized bone).

Vitamin D: toxicity

- Toxicity is seen following long-term administration of dosages that are above 10 times NRC recommendations.
- Vitamin D intoxication produces hypercalcemia, hyperphosphatemia, and soft tissue mineralization.

Vitamin D: supplementation

- Animals that spend most of their time indoors without access to good quality sun-cured hay should be supplemented with vitamin D.

Vitamin E: forms

- Vitamin E belong to the tocal group of compounds; d-alpha-tocopherol is the most common form of vitamin E found in farm animals and in plants. Only alpha tocopherol has significant biological activity.

Vitamin E: role

- The major role of vitamin E is as an antioxidant. Its protective effects greatly overlap those of the glutathione peroxidase system, a selenium-containing enzyme that inactivates oxidizing agents. Because of this overlap, symptoms of vitamin E and selenium deficiencies are often similar.
- Nutritional requirements for vitamin E are increased when the diet is high in polyunsaturated fat, which is susceptible to damage by oxidizing agents.
- Exercise increases free radical formation and cell membrane damage as well as susceptibility to vitamin E deficiency.

Vitamin E: sources

- The major dietary source of vitamin E is fresh green feed and sprouted grain. Hays, silages, grains, and oilseeds are all poor sources, containing 3 to 20 mg of vitamin E per kg.
- Colostrum is a rich source.

Vitamin E: deficiency

- Is most likely to be seen in growing herbivores during the winter feeding period or immediately after they are turned out to fresh pasture in spring.
- In all species, deficiency causes myodegeneration and steatitis, which is characterized by inflammation of the fatty tissues and results in hard, discolored fat.

Vitamin E: deficiency

- Degeneration of skeletal muscle (nutritional muscular dystrophy) appears to be triggered by exercise and is seen in lambs, calves, foals, and possibly horses, which are more active than pigs.

Vitamin E: toxicity/supplementation

- Is essentially nontoxic in animals.
- High grain diets are usually supplemented with vitamin E and selenium to prevent vitamin E and selenium deficiency.
- Vitamin E supplementation is essential when diets high in polyunsaturated fats.

Vitamin K: forms

- Vitamin K exists in three forms, K_1, K_2, K_3. K_1 is called transplylloquinone. K_2 exists in the form of a variety of menoquinones and is synthesized by bacteria. K_3 is a synthesis of naphthoquinone called menadione.

Vitamin K: role

- Acts as a cofactor in a post-translational modification of blood clotting factors and proteins involved in the control of calcification in bone.
- Reduced vitamin K_1 acts as a hydrogen donor in the hepatic conversion of serine protease to active enzymes of blood clotting cascade.
- The hydroxycoumarin type of anticoagulants, warfarin and dicoumarol, block the conversion of oxidized vitamin K_1 back to the active form.
- Factor II, V, VII, IX and X are activated by vitamin k, and the major effects of vitamin K deficiency or hydroxycoumarin poisoning are impaired blood clotting manifested as a bleeding tendency.

Vitamin K: deficiency

- Is uncommon. The vitamin is present in many green feeds. Ruminants synthesize vitamin K in the rumen and absorb it in the small intestine.

- The main symptom of dicoumarol poisoning in cattle is a bleeding tendency. This is usually manifested as hematoma formation and persistent hemorrhage. Hematomas tend to form at trauma points – over the widest part of the ribs, the brisket, and hips.

Vitamin K: toxicity

- K_1 is the least toxic.
- Horses appear to be particularly sensitive to vitamin K_3 toxicity.
- Acute renal failure, renal colic, and death were produced by the administration of a commercial vitamin K_3 supplement to horse at the manufacturer's recommended dosage.

Vitamin K: supplementation

- Is not normal required in farm animals. The combination of vitamin K_1 and enteric synthesis of vitamin K_2 meets requirements.

Water-soluble vitamins

Vitamins B

- B vitamins function as coenzymes and are water soluble. Many are conserved in the body through efficient recycling mechanisms. The nutritional requirements of farm animals for these vitamins vary. Functional ruminants rarely require supplementation because microbes synthesize large quantities of all the B vitamins in the rumen.
- Brewer's yeast is a good source of all vitamins except B_{12} and biotin. Rice bran and milk are also good sources of many the B vitamins

Thiamin or vitamin B_1: role

- In cells, thiamin is phosphorylated to the coenzyme thiamin pyrophosphate (TPP), required for the decarboxylation of the glycolytic end product pyruvate to acetyl CoA. This is then used for energy generation in the TAC cycle or for fat synthesis.

Thiamin: deficiency

- Clinical signs of thiamin deficiency are observed only when dietary thiamin is destroyed by heat or thiaminases in the feed. In ruminants, bacterial thiaminases or inorganic sulfates destroy thiamin in the rumen.
- In ruminants, destruction of thiamin is most common in young animals fed diets high in rapidly fermentable carbohydrate. These diet predispose to ruminal acidosis, which favors thiaminase activity.
- Thiamin destruction also occurs when the feed and water is rich in sulfate. In the rumen, this is converted to sulfite, which destroys thiamin.
- In ruminants, neurologic dysfunction is the principal sign of a tissue deficiency of thiamin. Pathological changes seen in the deeper layers of the cerebral cortex give rise to the alternative names for thiamin deficiency of cerebral cortical necrosis (CCN) and polioencephalomalacia.
- In ruminants, blindness is an early clinical sign. This is a cortical blindness caused by dysfunction of cerebral cortices. Pupillary light reflexes are usually intact. This helps differentiate the signs from those caused by vitamin A deficiency, in which the reflexes are absent.
- Opisthotonos (dorsiflexion of the head and neck) is an early sign of thiamin deficiency in small ruminants.

Thiamin: toxicity

- Is virtually nontoxic in an animals. High doses have been claimed to have a sedative effect in horses, but controlled, double blind studies showed no effect from thiamin injection.

Thiamin: supplementation

- Routine supplementation of diets with thiamin is not usually practiced. However, group supplementation is likely to be worthwhile when some members have shown clinical signs. Routine supplementation may also be indicated in areas with high-sulphate water.

Riboflavin or vitamin B_2 : role

- Riboflavin is a component of the flavin nucleotides, FAD and FMN. Flavin neucleotides are conenzymes for the flavoprotein group of enzymes. They also form part of the electron transport chain in mitochondria. Deficiency impairs cellular respiration.

Riboflavin: source

- Green foods such as grass, legumes, and hays are rich in riboflavin. Grains are poor sources and oilseed meals are only slightly better.

Riboflavin: deficiency/supplementation

- Deficiency of riboflavin leads to anestrus and early embryonic death.
- Deficiency is prevented by the routine supplementation of grain-base diet.

Pantothenic acid or vitamin B_3

- Pantothenic acid is a component of conenzyme A, which is required for tricarboxylic acid cycle function and fat metabolism.
- Pantothenic acid is found in high levels in alfalfa.
- True deficiency syndromes have not been described in ruminants or horses.
- In adults, poor reproductive performance is the main effect of deficiency.

Niacin

- Niacin and nicotinic acid are biologically active as nicotinamide, a component of the coenzymes NAD and NADP. These play a vital role in the TCA cycle and in glycolysis.
- Niacin is found in most common feedstuffs at levels of 10 to 200 mg/kg DM. Ruminants synthesize niacin in their rumen, and much of this is absorbed in small intestine.
- High producing dairy cows and rapidly growing beef cattle may benefit from niacin supplementation.
- Niacin reduce fat mobilization and decrease the incidence of ketosis and fatty liver.

Biotin

- Biotin is a coenzyme that takes part in biological carboxylation and decarboxylation reactions it is involved in the tricarboxylic acid, glyconeogenesis, and fat synthesis.
- Excellent levels of biotin are found in young green grasses, growing green cereals, and legumes.
- Deficiency affects the integument, particularly the hooves.
- Horses may benefit from supplementation if they are afflicted with weak, crumbly hooves.

Folate or folacin

- Folate is active in the body as tetrahydrofolate. Its main function is in the transfer of the single carbon units that are required for synthesis of purines and pyrimidines, which are components of DNA.
- Folate can also transfer methyl groups to homocysteine to form methionine.
- There are complex interrelationships between folate and the other B vitamins.

- Folate and vitamin B_{12} cooperate in the synthesis of methionine.
- Adequate dietary methionine partially overcomes the effects of folate deficiency.
- Source: green feeds are excellent sources of folate.
- Deficiency is not usually seen in animals fed traditional diets. The classical signs of deficiency are poor growth, fading hair coat, hypersegmented neutrophils, large platelets, and macrocytic anemia.
- The combination of dietary folate and synthesis in the gut uaually supplies sufficient folate to farm animals without the need for further supplementation.

Vitamin B_{12}

- Cobalamins consist of a nucleoside side chani and a corrinoid ring containing a central cobalt molecule. Only cobalamins are biologically active in animal tissue.
- Vitamin B_{12} functions as a coenzyme in transmethylation reactions, and deficiency impairs DNA synthesis. B_{12} is also required for TCA cycle function.
- Ruminants directly absorb vitamin B_{12} synthesized by rumen microbes. However, synthesis of vitamin B_{12} in the gut is dependent on an adequate supply of cobalt. Ruminants are particularly susceptible to cobalt deficiency.
- The major signs are a gradual loss of appetite, poor growth, and emaciation.
- In lactating cattle, cobalt deficiency produces ketosis.
- Dietarty supplementation with cobalamins is not required in monogastric large animals on conventional diets. Ruminants grazing cobolt-deficient pasture can be supplemented with vitamin B_{12}, but it is usually cheaper to supplement with cobalt.

Choline

- Choline is not a true B vitamin because it does not function as a coenzyme. It acts as a source of methyl groups and as a component of phospholipids and acetylcholine.
- Requirements are high but so is dietary intake. Methionine has a sparing effect on choline.
- Deficiency has not been reported in ruminants and horses.

Vitamin C

- Ascorbic acid functions as a water soluble biologic antioxidant. It also is required for cross-linking of collagen. Poor collagen cross-linking leads to the symptoms of scurvy in human.
- Farm animals synthesize vitamin C within their tissues. Most fresh forages and leafy plants contain vitamin C. Citrus fruits are particularly good sources of the vitamin.

Water: Requirements and Problems

- Water accounts for approximately 70% of total body mass.
- Animal's requirements for water are proportional to energy consumption; 1 ml of water for every kcal of metabolizable energy used.
- Lactation and high levels of minerals in water and feed also tend to increase water intake.

Guideline for water intake:

Expected mean water intake in temperate climates

Animal	L/day	Gal/day
Beef cattle	26 – 66	6.5 – 17
Dairy cattle	38 – 110	9.5 – 28
Horses	30 – 45	7 – 12
Sheep and goats	4 – 15	1 – 4

Water: Requirements and Problems

- Water per se is almost nontoxic, but problems with water arise from contamination with microbes, parasites, minerals, and various poisons.

Microbial contaminants

- Enteric organisms
- Mineral contaminants
  - Solubilization of minerals in water
  - Nutritive value
  - Water quality
- Pesticides and herbicides

Water requirements

- Water is one of the most important essential nutrients. Without good – quality water, production rapidly declined.
- Open surface waters are prone to microbial contamination; well waters are prone to mineral contamination. Closed surface water may suffer from poisonous algal blooms.

Control of feed intake

- **Regulation of body weight:**
  - Animals adapted to ad libitum access to a single ration usually consume amounts sufficient to maintain a constant "set point" body weight.
  - Intake varies according to individual physiological status and environmental conditions.
  - Animals that evolved in seasonally variable climates eat amounts sufficient not only to maintain lean body mass but also to store body fat for the lean winter months.
  - Dairy cattle and goats have such high nutrient demands for production that feed intake must be maximized in order to maintain adequate body condition.
  - Reduced intake during late pregnancy is a common problem, particularly in sheep carrying two or more fetuses.
  - Feed intake is controlled by a complex interplay of metabolic, gastrointestinal, and sensory cues.
  - The animal's current energy status, motivational, and in some cases, previous experience with the feed presented all affect feed intake.
  - The size and frequency of individual meals are under short-term control but are influenced over time by homeostatic mechanisms that regulate body weight.
  - It is important to recognize the upper limits of dry matter intake when balancing rations.
  - Animals may be unable to consume adequate amounts of a poor-quality forage to meet their nutrient requirements.

- Ruminants and horses appear to be able to compensate for sparsely available forage by increasing the rate and duration of eating activity.

- **Nutritional wisdom**
  - Domestic animals tend to lack "nutritional wisdom", which is the ability to select from a variety of feeds a diet that is balanced for all nutrients.
  - Specific appetites is the drive to seek out and consume specific substances based on nutritional deficits. Specific appetites exist for energy, salt, water, and perhaps phosphorus in all species.
- **Grazing and eating behavior**
  - Foraging behavior consists of both the pattern of meals and the selection of plant types.
  - Horses, cattle and sheep consume 8 to 14 discrete meals a day, rarely fasting for more than 3 or 4 hours.

- Appetite is the desire to seek out and consume feeds; it is not necessarily based on nutritional requirements.
- It is determined by a variety of exogenous and endogenous cues.
- **Oropharyngeal cues**
  - The taste, texture, and odor of a feed help to determine its acceptability to a hungry animal.
  - Flavor preferences differ between species and may be modified by previous experience.
  - Most domestic livestock prefer sweet and salty flavors, although excess salt (greater than 3%-5%) limits intake in most species.
  - Ruminants and horses generally consume more grain or pelleted feed in a single meal than if fed loose hay; more rapid consumption due to reduced chewing time, and faster rate of emptying of grain than hay particles from the rumen or stomach.
  - The increased rate of passage reduces overall digestibility in cattle, thereby reducing the benefit of greater intake.
- **Gastrointestinal cues**
  - The rate of gastric emptying of feeds appears to be a major limiting factor in the short-term regulation of feed intake.
  - Nutrients in the gastrointestinal tract stimulate nerves and the release of peptide hormones such as insulin, bombesin, cholecystokinin, and gastrin. These have been strongly implicated in the control of food intake.
- **Metabolic cues**
  - Postabsorptive stimuli generated by nutrients and nutrient status influence subsequent feeding activity. Peripheral blood glucose concentration per se does not regulate feeding activity but tends to reflect the degree of hunger.
- **Central nervous system cues**
  - The hypothalamus is considered to be the major integrative center for appetite control. The lateral hypothalamus generates sensations of hungers, and the ventromedial hypothalamus regulates satiety.
- Feed intake is governed by a wide variety of endogenous stimuli and environmental factors.
- It is necessary to consider the relative importance and contribution of each in order to maximize feed efficiency and productivity in large animals.

Effect of disease on nutritional needs

- Sick animals perform poorly compared with their healthy counterparts.
- Economic losses occur both from clinical and subclinical illness, particularly in a large proportion of the animals with a long lasting disease.

Disease and animal production

- Growth rates and feed conversion ratios often are reduced in animals with subclinical infections.
- In animals kept for meat production, the time to reach the desired finished weight is increased.
- Parasites reduce the efficiency of the utilization of nutrients through a number of mechanisms. They compete for nutrients within the gut. Some invade the gut wall resulting in inflammation which destroys glandular tissue and reduces the secretion of acid and digestive enzymes. This loss of GI function may reduce the digestibility of nutrients.
- Deworming is particularly important in sheep and growing cattle kept on pasture.
- Gastrointestinal infections can run a chronic course and adversely affect nutrient utilization.

Nutritional support

- Clinical nutrition can be defined as the dietary management of clinically ill animals.
- The primary goal of clinical nutrition is to optimize nutrient intake, minimize catabolism and utilization of body nutrient stores, and maximize would healing and immune competence in a sick animal.
- Recommendations for dietary management of clinically ill large animals are based primarily on data from other species because there are few studies of nutritional needs of injured or ill farm animals.

Alterations in nutritional needs

- Starvation alone usually decreases metabolic rate, nutrient requirements increase following trauma, sepsis, or stress, even in anorexic animals. The degree of alteration in metabolic rate is dictated by the severity of the insult to the organism.

Certain nutrients are of special concern in clinically ill animals

- Glucose
  - Tissue utilization of glucose is increased by inflammation.
- Fat
  - Severely injured or septic ruminants and horses may utilize volatile fatty acids from fiber fermentation more efficiently than simple carbohydrates from grain.
  - Horses are tolerate up to 10% total diet dry matter. Lower levels (<5%) are recommended for ruminants.
- Protein
  - Protein is greatly altered by inflammation. Activated macrophages release interleukin-1, which stimulates the catabolism of skeletal muscle protein.
- Minerals
  - Trace mineral concentrations are altered as part of inflammatory response.
- Vitamins
  - Thiamin, folic acid, and ascorbic acid are utilized and excreted in greater amounts than normal in the hypermetabolic animal.
  - Thiamin is not stored in the body and is normally obtained from the diet or bacterial synthesis. In stressd, anorexic animals, thiamin may be depleted.

- Serum folate is reduced in stressed or strenuously exercised horses, and during period of anorexia, disease, or stress.
- Vitamin C is stored, and is released during periods of stress, and may be depleted in prolonged illnesses.

Modes of alimentation

- Oral supplementation
  - This is the preferred mode because digestion, absorption, and metabolism of nutrients are enhanced if the animal is allowed to taste, chew, and swallow its feed.
  - If recommended intakes exceed the maximum voluntary intake of the animal, more concentrated sources of energy may be added to the ration.
  - Grains are excellent sources of energy but generally should not comprise more than 50% of the total ration.
  - Anorexia. Clinically ill animals are frequently anorexia. A variety of feeds should be offered in small amounts to determine preferences.
- Intragastric supplementation.
  - If an animal is unwilling or unable to eat and has fairly normal GI function, supplemental nutrients may be provided by stomach tube. Complete pelleted feeds soaked in water may be used.
- Intravenous alimentation.
  - Intravenous supplementation of energy and protein in adult large animals is possible when absolutely necessary.
  - Candidates for IV nutrient supplementation include animals with severe, acute diarrhea or anterior enteritis.
  - Complications associated with intravenous feeding include septicemia, thrombosis, hyperglycemia, and glucosuria.

Feeding the beef cow for optimal production

- The four principal factors influencing the profitability of a cow-calf operation are
  - Weaning weights
  - Percentage of cows weaning calves
  - Cost of maintaining the cow per year
  - Price of calves
- Factors controlling the kg of calf weaned per cow are
  - The reproductive efficiency of the cows
  - Calf survival
  - Genetic growth potential of the calf optimized by the cow and measured as weaning weight.

Effect of nutrition on reproduction and calf growth

- Nutrition plays a key role in influencing both conception rates and the percentage of cows cycling during the breeding season.
- The quality and quantity of pasture and range has a dramatic influence on the overall conception rate of the cows.
- Prepartum nutrition

- The level of prepartum nutrition – both protein and particularly energy – has a major impact on how soon the cows cycle after calving.
- Also impact on the birth weight, calf survival, subsequent milk production, and growth rate of the calf.

- Postpartum nutrition
  - Postcalving nutrition, particularly energy, has its greatest effect on calf growth and cow conception rates.
- Factors influencing nutritional requirements
  - Effect of stage of production on nutrient requirements
  - Cow condition
  - Cow size and milk production
  - Environmental effects

Colostrum and feeding management of dairy calf and nutrition of dairy replacement heifers

Heifer inventory and the economics of replacement rearing

- The early development period is critical to a healthy heifer.
- Ration should be specifically formulated for weight gains during strategic time periods of development.
- Heifers should weigh 775 to 800 pounds at 14 to 15 months for breeding to calve at 24 to 25 months.
- Heifers should gain 1.8 pounds per day of age to calve at 24 months weighing 1,350 pounds.
- Use superior AI sires on replacement heifers for breeding.
- Weight is more critical than age at calving in relation to milk production
- Monitor weight, height, body condition score at calving to reflect heifer development.

Should I raise my own heifers or have them custom-raised?

1. Do you currently have enough labor to raise your own replacements?
2. Are your facilities adequate to raise heifers? Do you have adequate housing, land, and feed resources to do a good job? Should I raise my own heifers or have them custom-raised?
3. Under your current system are your heifers freshening at 24 months of and at 1,250 lb (for Holsteins)?
4. Do you have enough capital to pay someone else to raise your heifers?
5. How could you use your current facilities that are being used to raise heifers?

Management Component

- Calf care from birth to weaning.
- Heifer care from weaning to calving.

Calf care from birth to weaning

- Facilities
  - housing
  - individual pens
- Feeding and nutrition
  - colostrum management
  - calf nutrition
  - water
- Health care and management
  - umbilical cord.
  - sanitation.

  - preventive health care programs.
  - extra teat removal.
  - dehorning.
  - parasites.
  - identification.

Heifer care from weaning to calving

- Facilities
- Feeding and nutrition
- Health care and management
  - age at weaning.
  - breeding.
  - Identification and records.
  - vaccination programs.
  - parasite and fly control.
  - treatment facilities.

Monitoring Dairy Heifer Growth

- Insure that calves are on target to reach
  - a weight of 1,350 pounds at calving
  - a height of 53 inches at the shoulder
  - a BCS of 3.25-3.5 at 24 months of age

Nutrition during the first 3 wk of life

- Timely feeding of adequate quantities of high-quality colostrum is essential to the future well-being of the calf.
- The whole milk requirement for maintenance of a 45-kg calf is calculated to be 3.3 L/day.
- For 450 g of growth/day, 5 L or about 600 g of DM are required.
- Rumen function develops in response to solid feed consumption.
- The rumen can be functional as early as 2 wk and is functional in all calves by 6 to 8 wk of age if they are offered solid feed.

Milk and milk substitues

- Colostrum
- Fresh cow milk – milk secretion from cows in the first 3 days of lactation
- Whole milk – ideal feed for the first 3 wk of life
- Mastitic milk – if possible, it should be fed only to older calves.
- return milk – is probably best feed to the calves over 3 wk-old
- Milk replacer – digestibility is dependent on the protein source and the processing of the milk protein
- Quantity of milk – newborn calves should be fed 8 to 10% of their BW of whole milk or its equivalent. Twice-a-day feeding leads to better daily gain than once-a-day feeding
- Calf starter – should supply at least 18% CP (NPN should not be used), CF should be 6 to 8%

Nutrition from 3 wk to weaning

- A period of increasing starter consumption and decreasing dependence on milk
- Concentrate intake increases from 0.5 kg at 3 wk of age to 3 kg at 12 wk of age
- Concentrate consumption increases rapidly when milk feeding is stopped.
- Milk feeding may be stopped as early as 30 d of age – more common to continue for about 55 d
- Hay may be fed to calves before weaning, but it is optional

Nutrition from weaning to breeding

- Newly weaned calves should continue to get calf starter – grower mix containing 16% CP is fed.
- Do not overfeed with forages.
- Heifer may be fed straight forage during this period, provided that the basic nutrient requirements are met. The CP level of the total ration should not be less than 12%.

Feeding the dairy cow for optimal production

Energy needs

- Missmanagement of energy feeding in dairy rations can be costly.
- Overfeeding during late lactation and dry periods causes excessive fattening and subsequent metabolic problems.
- Undernutrition in early lactation is another common mistake made on dairy farms.
- Sources of energy also affects milk yield and composition.

Early lactation

- Provide an adequate balance of necessary nutrients (protein, minerals, and vitamins).
- Ensure that fiber is sufficient to maintain optimal rumen fermentation (20-22% ADF on a DM basis)
- Make sure ration chewy and sweet.

Mid to late lactation

- Milk production decrease → energy concentration of the diet may be decreased, depending on production and body condition score.

Grouping of cows for maximum milk production

- Large herd → practical ; small herd → not
- Nutritional requirement → managed
- Milk production → satisfied
- Routine milking process → beneficial

Body condition scoring (BCS)

- When?
- Timing of body scoring is arbitrary.
- Convenient to score cattle at the time of feed level changes.
- At freshening, peak lactation, mid lactation, and drying off.

  Body condition score (BCS)
  1 - 5 scale
  1 = very thin
  5 = excessively fat

- Condition scoring scale
- Look at example cows
- Discuss research on condition scoring
- Recommendations for condition score at various stages of lactation

Goal :

- To minimize body condition fluctuation throughout lactation.
- To minimize the number of problem cows (too fat or too thin)

Condition score 1
Individual vertebrae are distinct along the top line; ends of short ribs are prominent, and give a distinctly shelf-like appearance. Hips and pin bone are sharp; severe depressions show between hips and pins, and between hooks. A deep V-shaped cavity is below the tailhead and between the pin bones.

Condition score 2
Short ribs can be seen, and the 'shelf' still is visible. While hips and pins still are prominent, individual vertebrae along the top line are not distinct to the eye. The depression around the tail head and pin bones is more V-shaped.

Condition score 3
The short ribs appear smooth, with no shelf effect. The backbone is a rounded ridge; individual vertebrae are rounded and smooth; the area between pin bones and tail head has smoothed out.

Condition score 4
Short ribs are smooth and rounded; no shelf effect. The chine region is rounded and smooth; loin and rump appear flat. Hips are rounded and flat in-between. There is a rounded appearance over the tail head and pin bone area, with evidence of fat deposit.

Condition score 5
The backbone is covered by a thick layer of fat, as are the short ribs. Hips and pins are not apparent, and the areas between them are rounded; the tail head is surrounded by fat.

Target scores for stages of lactation:

Cows at calving

- Recommended score: 3+ to 4-
- Nutritional objective: allow cows to calve with adequate, but not excessive, body-fat reserves.
- Score below 3+ indicate inadequate energy supply during late lactation and/or the dry period. Failure to replenish energy reserves will limit milk production during the upcoming lactation.
- Score above4- indicate too high energy intake during late lactation and/or the dry period. Separate dry cows from the milking herd and feed them a low-energy ration with adequate, but not excessive, protein, minerals, and vitamins.

Early lactation

- Recommended score : 3- to 3
- Nutritional objective : maximize intake of a high-energy ration to minimize changes in body condition and counteract negative energy balance. Ration must contain adequate protein to support peak milk production.
- Scores below 3-
    - very high producers may drop to 2+ and are not a problem.
    - Thin cows that are not high producers are not getting enough energy. Be sure that all nutrients are balanced properly and that dry-matter and water intakes are adequate.
- Cows have good body condition (3 to 3+), but production is not as high as expected. Check for inadequate intakes of protein, minerals, or water.

Mid-lactation

- Recommended score : 3
- Nutritional objective : maintain body condition at this score to maximize milk production.

- Scores below 3 indicate inadequate energy. Check early lactation ration, because problem began there.
- Scores above 3+, reduce energy intake to avoid overconditioning.

Late lactation

- Recommended score : 3 aim for 3+ and 4- at time of dry off.
- Nutritional objectives :
  - replenish energy and fat reserves to prepare cow for next lactation.
  - Avoid overconditioning.
- Scores below 3+ at dry off mean cows are receiving inadequate energy. Check to see that early- and mid- lactation cows are receiving enough energy, since problem may have begun there.
- For scores above 4- at dry off, reduce energy intake during late lactation.

Dry

- Recommended score : 3+ to 4-
- Nutritional objectives :
  - Maintain body condition in recommended range.
  - Feed low-energy ration that provides adequate, but not excessive, amounts of protein, vitamins, and minerals.
- Scores below 3+
  - Increase energy intake. Inadequate body-fat reserves can decrease milk production in upcoming lactation.
  - Increase energy content of late-lactation ration. Body-fat reserves should be replaced at that time.
- Scores above 4-
  - Reduce energy intake of dry cows while maintaining adequate levels of protein, vitamins, and minerals.
  - Reduce energy intake of late-lactation cows, because the problem may have begun there.

Heifers

- Recommended score : 3- to 3+
- Nutritional objectives:
  - Maintain body condition in recommended range.
  - Feed a balanced ration that provides adequate but not excessive amounts of energy, protein, vitamins, and minerals.
- Scores below 3- may indicate a nutritional problem. If heifers are allowed to become too thin, they will not grow at the proper rate and may have reproductive problems later on.
- Score above 3+ have been shown to be associated with a greater fat infiltration in the mammary glands of heifers at puberty.

Good nutritional management guidelines to keep metabolic disease low include:

- Feed a ration balanced for protein, energy, fiber, vitamins and minerals.
- Group cows according to production and adjust body condition accordingly during lactation.
- Dry cows off at a 3.5 body condition score, the desired score for the dry period and at weaning. Maintain this condition throughout the dry period, avoiding the fat cow syndrome and related metabolic disorders.
- Provide exercise for dry cows.
- Limit grain feeding prior to calving to about 0.5 kg increase per day starting about 15 days ahead of calving. By the 15th day you'll be feeding 6 kg.

- Maintain a balance of forage-to-concentrate in the total ration after calving to maximize intake but to prevent digestive upsets during adaptation to the peak lactation ration.
- Feed grass hay, haylage or pasture to dry cows to minimize calcium intake to prevent milk fever.
- Limit corn silage fed to dry cows to 15-20 kg daily, and feed 5 kg of grass hay or equivalent forage.
- Limit concentrate feeding after peak lactation and conception have occurred.
- Maintain a 12- to 13-month calving interval to avoid long dry periods by providing good health and nutrition measures and expert reproductive practices.

การจัดการโคระยะแห้งนม

- แม่โคควรได้รับอาหารหยาบในช่วงนี้ประมาณ 1% ของน้ำหนักตัว เพื่อให้กระเพาะรูเมนสามารถทำงานได้เป็นปกติ
- พืชอาหารหยาบที่มีโปรตีนสูงควรใช้ประมาณไม่เกินครึ่งหนึ่งของอาหารหยาบทั้งหมด
- ข้าวโพดหมักควรใช้อย่างจำกัดในระยะนี้เพื่อป้องกันแม่โคได้รับอาหารพลังงานมากเกินและจะส่งผลให้แม่โคอ้วนมากเกินไปในระยะนี้
- แม่โคควรได้รับอาหารข้นอย่างน้อย 1 กิโลกรัมเพื่อเป็นแหล่งวิตามินและแร่ธาตุที่จำเป็นสำหรับแม่โค
- แม่โคอาจได้รับอาหารข้นเพิ่มขึ้นตามคะแนนร่างกาย ความต้องการสารอาหาร คุณภาพและการกินได้ของอาหารหยาบ สภาวะเครียดจากสิ่งแวดล้อม

การจัดการโคระยะใกล้คลอดและระยะหลังคลอด

- Transition period เริ่มตั้งแต่ 3 สัปดาห์ก่อนคลอดจนถึง 3สัปดาห์หลังคลอด เป็นช่วงที่มีการเปลี่ยนแปลงทางสรีระวิทยาและเมตาโบลิซึมของร่างกาย ตลอดจนการเปลี่ยนแปลงทางด้านโภชนาการ
- ชีววิทยาของโคในระหว่าง transition period
- การกินได้ แม่โคในระยะนี้จะมีการกินได้ลดลง ซึ่งสาเหตุมาจากการเติบโตอย่างรวดเร็วของลูกโคที่เบียดบังพื้นที่ของกระเพาะรูเมน นอกจากนี้การเปลี่ยนแปลงของฮอร์โมนในช่วงนี้ยังทำให้ความอยากอาหารของแม่โคลดลงด้วย

ปัจจัยที่มีอิทธิพลต่อการกินได้ของโค

ชีววิทยาของโคในระหว่าง transition period

- การเปลี่ยนแปลงทางสรีระ การเติบโตอย่างรวดเร็วของลูกในท้อง การพัฒนาของเต้านมเพื่อเริ่มขบวนการสร้างน้ำนม ส่งผลต่อขบวนการเมตาโบลิซึมของแม่โค การลดลงของระดับกลูโคส อินซูลิน ในเลือด การเพิ่มขึ้นของระดับกรดไขมัน และสารคีโตนในเลือด
- การทำงานของกระเพาะรูเมน การปรับตัวของกระเพาะรูเมนต่ออาหารที่แม่โคได้รับในระยะนี้โดยสัมพันธ์กับการจัดการอาหาร การปรับตัวของกระเพาะรูเมนเพื่อให้คุ้นเคยกับอาหารข้นจะใช้เวลาประมาณ 3-4 สัปดาห์
- ชีววิทยาของโคในระหว่าง transition period
- ปัญหาสุขภาพที่สัมพันธ์กับช่วง transition period
  - ความผิดปกติที่เกี่ยวข้องกับเมตาโบลิซึม ได้แก่ ปัญหาการสะสมไขมันในตับ คีโตซีส ภาวะรูเมนเป็นกรด เป็นต้น
  - ความผิดปกติที่เกี่ยวข้องกับแร่ธาตุ ได้แก่ ไข้น้ำนม เป็นต้น
  - ความผิดปกติที่เกี่ยวข้องกับระบบภูมิคุ้มกัน ได้แก่ รกค้าง เต้านมอักเสบ เป็นต้น

การจัดการอาหารในช่วง transition period

- ความต้องการพลังงานและภาวะพลังงานขาดสมดุล
  - แม่โคตั้งท้องระยะสุดท้ายมีความต้องการพลังงานตั้งแต่ 1.3-1.5 เท่าของพลังงานเพื่อการดำรงชีวิต
  - ความไม่สมดุลกันระหว่างพลังงานที่แม่โคได้รับจากอาหารกับพลังงานที่ต้องการเพื่อการสร้างน้ำนม ทำให้แม่โคเกิดภาวะพลังงานขาดสมดุล (negative energy balance)
  - ความรุนแรงของพลังงานขาดสมดุลในช่วงหลังคลอดขึ้นอยู่กับปริมาณการกินได้ของโคและคะแนนร่างกายของแม่โคในระยะก่อนคลอด

อาหารผสมรวม : สุขภาพและการให้น้ำนม

- อาหารผสมรวมหมายถึงอาหารที่มีการผสมชนิดของวัตถุดิบอาหารที่ใช้ประกอบกันเป็นอาหารโคทั้งหมดเข้าด้วยกันโดยมีโภชนะที่โคต้องการอยู่อย่างสมดุล
- อาหารผสมรวม
- อาหารข้น + อาหารหยาบ + อาหารเสริมอื่นๆ

ภาวะกรด-ด่างในกระเพาะหมัก

- กระเพาะหมักจะมีสภาวะเป็นกรดเพิ่มขึ้นในระหว่างที่โคกินอาหารข้น และความเป็นกรดจะลดลงภายหลังจากโคได้รับอาหารหยาบหรือระหว่างกินอาหารหยาบ
- โดยปกติภาวะกรด-ด่างในกระเพาะหมักจะมีค่าประมาณ 5.5-7
- ภายหลังกินอาหารข้นใหม่ๆ ค่าความเป็นกรด-ด่างอาจลดลง และมีค่าประมาณ 4-5

การควบคุมภาวะกรด-ด่างในกระเพาะหมัก

- การเคี้ยวเอื้องจะช่วยปรับภาวะกรด-ด่างในกระเพาะหมักให้อยู่ในสภาวะที่การทำงานของเชื้อจุลินทรีย์ต่างๆ สามารถเกิดขึ้นได้อย่างเป็นปกติ
- การเคี้ยวเอื้องลดลงจะทำให้กระเพาะหมักมีภาวะเป็นกรดเพิ่มขึ้น ทำให้เกิดสภาวะที่เรียกว่าแอซิโดซีส ซึ่งจะส่งผลต่อการผลิตและสุขภาพของโค

สรุป

✒ โคนมที่มีสุขภาพดีจะให้ผลผลิตน้ำนมที่ดีและมีคุณภาพ
✒ โคนมที่มีสุขภาพดีจะมีความสมบูรณ์พันธุ์ดี

อาหาร → สุขภาพ → ผลผลิต
↓
ความสมบูรณ์พันธุ์

Feeding for optimal production in goat and sheep

Goat nutrition

- The best management and health program is accentuated with a nutritional program that matches nutrient needs to production purposes
- Goats are ruminants, which means they can derive a substantial portion of nutrients from plants
- Goats are selective browsers, eating a wide variety of shrubs, woody plants, briars and even weeds.
- The availability of browse material in goat pens appears to enhance contentment.
- Goats should be fed good-quality forages along with the needed supplemental nutrients to achieve desired goals such as milk or meat production or a well-conditioned show goat.
- The nutritional program is dependent on type of goats (meat, milk, mohair/cashmere, hobby) and production stage.
- Due to milk production needs, lactating dairy goats have higher nutrient requirements than dry or gestating does.

Goat nutrition : forage

- Hay and/or pasture (good-quality) can be used to provide primarily energy and some protein.
- Since the goat is a ruminant, it needs to consume fiber (forage) in the form of hay or pasture or browse to maintain rumen health.
- For dairy goats, fiber is needed to maintain milk fat test.
- Rarely, if ever, will forage alone provide all nutrients needed by the goat.

- The need for supplemental feeding will be dictated by the type of goat (meat, milk, mohair/cashmere, hobby) and production stage

Goat nutrition : water

- The dairy water requirement of goats is affected by level of milk production, environmental temperature, water content of feedstuff consumed, amount of exercise, and salt/mineral content of the diet.
- Fresh, clean water should be available at all time.
- Goats are often more reluctant than other species to drink foul-tasting water.
- Low-quality and/or inadequate water supply will reduce feed intake and lower goat performance.

Goat nutrition : protein

- Protein supplies amino acids for protein synthesis and serves as a source of nitrogen for rumen microorganisms.
- Inadequate amount of protein in the diet can affect growth rate, milk production, reproduction, and disease resistance.
- The amount of protein needed varies depending on production stage.
- Young, fast-growing goats need a high level of protein in the diet to deposit muscle mass, and lactating goats need more protein for milk production.
- Mature goats can effectively utilize non-protein nitrogen (NPN)
- Rumen microorganisms need protein to effectively utilize forage.
- Inadequate protein leads to inefficient utilization of forages and reduces forage intake.

Goat nutrition : energy

- Energy deficiency in goats reduces growth rate, delays puberty, reduces fertility and depresses milk production.
- Fiber, starch, and sugar from forages and grains are the primary sources of energy in goat diets.
- Fat can also be used to supply energy, but should be limited to no more than 5% of the diet.
- Energy requirements are affected by body size, growth, reproduction, and lactation.
- A deficiency of energy will result in loss of body condition, poor growth, reduced milking ability and reduced reproductive performance.
- Obviously, goats that consume more energy than needed become fat.
- Goat nutrition : minerals and vitamins
- Proper mineral and vitamin supplementation make it possible for goats to achieve the most economical gains possible from the forages and grain fed.
- Minerals are needed in very small quantities, yet are critical components of overall nutritional package fed to goats.

Goat nutrition : minerals and vitamins

- Minerals play a vital role in nutrition digestion, reproductive performance, immune system function, and development of muscle, bone and teeth.
- Vitamins are needed in small quantities for normal body processes.
- Vitamins A, D and E are likely to be the most deficient in the normal diets of goats.
- Vitamin K and the B-complex vitamins are normally synthesized by rumen microbes and are not considered essential for goats.
- A diet consisting of forage, even with added grain, will not provide the proper levels of minerals and vitamins for optimal performance or production.

- The amounts and ratios of certain minerals are also important in promoting the health and productivity of goats.
- Due to the rumen microbial population, a synergistic effect on digestive efficiency occurs when protein and minerals are provided to ruminants
- Nutritional requirement of goats

Sheep nutrition

- Feed represents the largest single costs in all types of sheep production.
- Ration must be formulated to support optimum production, must be efficient and economical to feed, and must minimize the potential for nutrition-related problems.
- A producer must know the animals' nutritional requirements during the different phrases of production, the nutrient composition of available feedstuffs, and how to provide the available feedstuffs to meet animals requirements.

Sheep nutrition : nutrition of the ewe

- A ewe's nutritional needs are not static; they vary largely with her stage of production. For 16 to 20 wk of the year, the ewe's energy needs are very critical (such as during breeding, immediately before lambing, and while lactating).
- Feed levels can be lowered to reduce the feed cost during the early stages of gestation and when ewes are dry.
- Maintenance of the ewe is generally thought of in terms of her nutritional requirement when dry, because at that time her requirements are the lowest of the year. However, wool production is a continuous process that must be considered as part of the nutrient requirements throughout the year.
- The energy requirements are a function of the animals' basic metabolic rate. However, several factors affect maintenance requirements
  - Age
  - Exercise
  - Climate
  - Body condition
  - Reproductive requirement
  - Flushing
- Age
  - Yearling tend to have about a 20% higher energy requirement than adult sheep. This is probably due to the yearlings' additional requirements to support growth. This is of particular importance to producers who breed ewes to lamb first at 12 to 18 months of ages.
- Exercise
  - Grazing sheep may use from 10 to 100% more energy than do sheep in drylot conditions.
- Climate
  - Temperature, wind velocity, and humidity can jointly affect energy requirements. The length and density of the fleece also affects energy requirements
- Body condition
  - It takes more feed to maintain a fat sheep at a constant weight than it does a thin sheep.
  - Keeping the sheep excessively fat is not only expensive because of the feed, but also it is determined to the ewe's reproductive capabilities and overall production efficiency.

  - A ewe should lose 5 to 7% of her BW during lactation and recover this weight loss during the dry period.
- **Reproductive requirements**
  - Reproductive efficiency depends largely upon proper nutrition before and during the breeding season.
  - Large-bodies ewes tend to produce more lambs per ewe.
  - Usually excessive fat ewes have lower conception rate and higher embryonic mortality.
  - Sheep nutrition : nutrition of the ewe
- Flushing
  - Flushing can improve the ewe's body condition just before and during the breeding season.
  - Generally, the practice is thought to increase ovulation rate.
  - Flushing has more effect early in the breeding season.
  - Flushing may be achieved by moving the ewes to a better pasture shortly before breeding.
  - The length of flushing period can vary, but it probably should begin 21 d before the breeding season and continue through one estrous cycle (17d) into the breeding season if possible.
- During early gestation, a ewe's nutrient requirements are only slightly higher than they are for maintenance.
- Ewes in good condition at the end of the breeding period can loose some weight without hindering normal production.

Sheep nutrition : requirements during gestation

- If the weight loss is entirely recovered before breeding, lack of gain for the first 60 to 90 days of gestation should not have a negative affect on subsequent production.
- Sheep nutrition : requirements during gestation
- The last 6 wk of gestation is the most critical period in ewe nutrition. Approximately 70% of the fetal growth occurs at this time.
- Nutrient restrictions during this period may result in lighter lambs at birth, increased postnatal lamb losses, lower levels of milk production, and possibly pregnancy diseases.
- In late pregnancy, ewes require about 50% more feed than they do earlier in gestation. If protein is limited during late gestation, lower birth rates and lighter ewe fleece weights can be expected.
- Very often inadequate phosphorus intake occurs during this period, especially with ewes on pasture or with ewes consuming hay.
- Ewes in late pregnancy sometimes have difficult consuming enough feed because of the space occupied by the fetus, particularly when they have twins or triplets.
- If the ewe is fed a high-roughage ration, she may not be able to consume enough to supply the necessary daily energy requirements. For ewes in late pregnancy consuming high roughage rations, it is generally advisable to feed supplemental grain.

Sheep nutrition : requirements during lactation

- During the first few weeks following lambing, a lactating ewe requires about the same feed as in late gestation, provided she is nursing a single lamb.
- If the lamb does not consume all the milk produced daily, the ewe produces less milk and uses any excess energy to store fat.
- Ewes suckling twin lambs normally do not deposit fat because the nutrient supply (primary energy) does not meet the requirements of the lactating ewe. For maximum rate and efficiency

of lamb gains, separate ewes nursing twin lambs from those nursing singles and feed accordingly.

- It is practically impossible to provide high-producing ewes nursing twin lambs enough feed during lactation to prevent loss of body weight.
- From a practical standpoint, these ewes must have reserves of body fat to maintain high levels of milk production. It is imperative that high-producing ewes are of acceptable body condition prior to lambing.

Feeding horse for optimal health

Performance horse nutrition

- nutrients : energy sources
  - Hardworking horse needs more energy than the average horse on pasture.
  - Carbohydrates and fats are the most concentrated and efficient sources of calories for horses.
  - Fibers is the safest sources.
  - Substances used directly in energy pathways are : glycogen and glucose from carbohydrate or amino acid metabolism, long chain fatty acids and glycerol for lipid metabolism, and volatile fatty acids from large intestine fermentation of fiber and carbohydrates.
  - The energy pathways utilized are either aerobic (requiring the presence of oxygen) or anaerobic (utilizing no oxygen).
  - Fuels and by products for aerobic and anaerobic work differ.
  - Aerobic sources of energy include long-chain fatty acids, volatile fatty acids, and glucose.
  - Metabolic by-products of aerobic metabolism are primarily carbon dioxide, water, and variable amounts of heat.
  - Only glucose and glycogen are utilized in anaerobic work, which generates heat and lactic acid as the major by-products.
  - Diet influences the energy sources utilized during work.
  - Most feeds contain variable amounts of carbohydrate, fat and fiber.
  - The choice of diet should be based on the type of performance expected of the horse and availability and economics of feeds available.
  - Nutrients emphasized depend on the percent aerobic versus anaerobic work expected of the horse.

Examples of type of work, body type, and primary energy sources theoretically utilized by performance horses

Type of competition	Primary type of work	Body type	Primary energy sources
Flat racing	Anaerobic (speed)	Lean, minimal fat	Glycogen, glucose
Harness racing	Anaerobic, aerobic (speed, stamina)	Lean, some fat reserves	Glycogen, glucose (fat, VFA)
Showing, jumping, steeplechase, rodeo, polo	Anaerobic, aerobic (speed, strength, stamina)	Muscular, moderate fat reserves	Glycogen, glucose, fat, VFA
3-day event, dressage, distance riding	Aerobic, anaerobic (stamina, some strength, speed)	Lean, muscular but adequate fat reserves	Fat, VFA (glycogen, glucose)

Protein

- Absolute need for protein is slightly increased in the hardworking horse.
- Percent of protein in the diet need not be above maintenance (8–12%).
- Horse will be eating more to meet its energy needs and thereby taking in more protein.
- Commonly used feeds that are high (above 14%) in protein include alfalfa, clover, soybean meal, and brewer's grains.

Electrolytes and water

- The important electrolytes are potassium, sodium, chloride, magnesium and calcium.
- If the horse sweats for a prolonged period of time during training or competition, it will need to ingest more water and electrolytes than normal to replace its losses.
- Grasses and legumes are high in potassium. Legumes are also high in calcium and magnesium.
- Most grains are deficient in all of the major electrolytes.
- Both grains and hays have low levels of sodium.
- Performance horses should have free access to sodium chloride.
- Additional electrolytes are not usually necessary except after prolonged sweating (more than one hour) during training or competition.
- Water requirements are not adequate met by any horse fed.
- A separate source of clean, ice-free water is necessary for optimal performance.
- A horse fed only dry hay and grain needs more water than a horse on lush pasture.
- Water consumption may increase to as high as 30 to 40 L/day in hardworking horses.
- The only time water intake should be restricted is if the animal is very hot, the water is very cold, or the horse is not going to continue to work after drinking
- Under these circumstances the horse should be offered 2 to 3 L of water every 15 to 30 min until it is no longer thirsty or it is completely cooled.
- Under conditions of prolonged sweating, such as endurance races or 2 to 3 h of intense training ,significant amount of water and electrolytes are lost.
- If not replaced by allowing the horse to drink, graze, or consume 60 to 90 g of electrolytes supplement every 2 to 3 h, severe losses may result, necessitating intravenous therapy.

Vitamins and minerals

- Stress and high energy expenditure increase the levels of B vitamin and possibly ascorbic acid and vitamin E required in an athlete's diet.
- Fresh grass, alfalfa, and grass hays contain moderate to high levels of vitamins A, D, E, and B-complex.
- There are a multitude of vitamin-mineral supplements on the market, and the levels must be read carefully.
- Trace mineral needs (i.e., copper, iron, zinc and iodine) are not known to be increased by exercise.
- Supplementation of these may interfere with absorption and metabolism of other minerals.

Nutritional and feed-induced diseases in horse

- Metabolic disorders with multiple etiologies.
  - Colic
  - Laminitis
  - Hyperlipemia and hyperlipidemia
  - Azoturia and rhabdomyolysis

Classification of colics in horses

Category	Potential causes	
	Nutritional	Other
Gastric impaction	High intake of cracked corn or foreign objects low-digestibility feed	Poor dentation Parasitic damage to the gut
Large intestine impaction	Large amounts of pelleted feed Sudden switch from low fiber to high fiber diet Inadequate water Ingestion of foreign materials or sand	
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Dietary recommendations for clinically ill horse

Clinical problem	Nutritional objectives
Trauma, sepsis, burns	Increased protein, energy, vitamins B, C, and E
Chronic diarrhea	Increased water and electrolytes
Renal failure	Increased water and salt, Decreased protein, calcium and phosphorus
Hepatic disease	Increased simple sugars, B vitamins, and short-branched-chain amino acids

“....... มหาวิทยาลัย มุ่งมั่นสั่งสอนนักศึกษาให้เป็นคนเก่ง ซึ่งเป็นการดี แต่นอกจากจะสอนให้เก่งแล้วจำเป็นอย่างยิ่ง ที่จะอบรมให้ดีพร้อมกันไปด้วย ประเทศเราจึงจะได้คนที่มีคุณภาพพร้อมคือ ทั้งเก่งและทั้งดีมาเป็นกำลังของบ้านเมือง ....”

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