

Introduction to

Animal Nutrition



Student Reference

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*In cooperation with the Agricultural Education Department and
the College of Agriculture, Food and Natural Resources
University of Missouri-Columbia*



Monogastric Digestive System

Feeding animals correctly, in terms of both the amount and type of feed supplied, is extremely important for production, since it helps to ensure that the animal is healthy and productive. It is therefore important to understand exactly how the digestive system processes feed so the animal can use nutrients properly. This lesson covers one type of digestive system, the monogastric system.

Monogastric Animals

The term “monogastric” refers to the structure of the stomach. In a monogastric digestive system, the stomach has a simple structure consisting of a single compartment. A number of species have a monogastric digestive system, including swine, horses, dogs, rabbits, and fowl. All of the mammals listed here have similar systems, although some minor differences do exist between them. Fowl, however, have a digestive system that differs from the others, including organs not found in the other species.

Parts of the Monogastric Digestive System

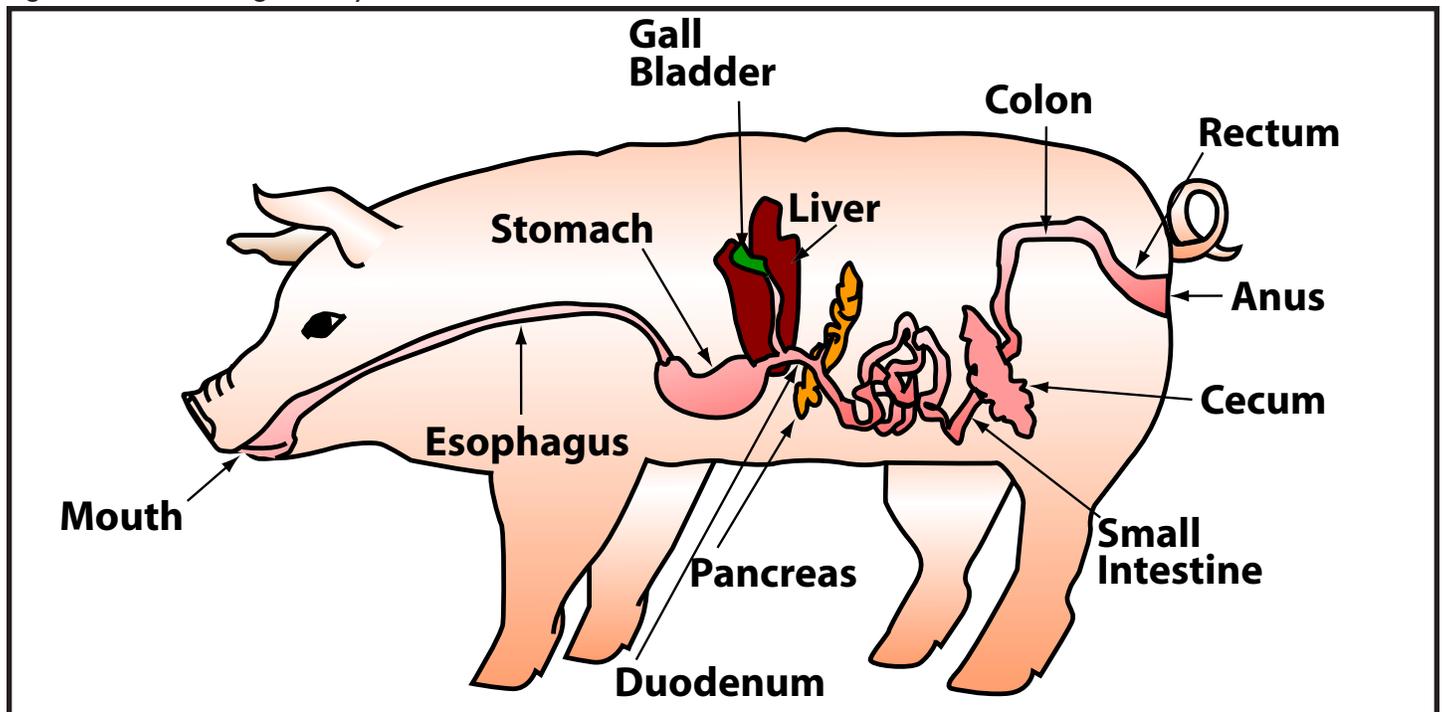
As feed moves through the monogastric digestive system (also termed the alimentary canal) of mammals, it passes through a number of different parts (Figure 1.1).

Digestion begins when feed enters the mouth. The feed is then carried through a tube called the esophagus to the stomach. When leaving the stomach, the feed moves into the first section of the small intestine, which is called the duodenum. After traveling through the rest of the small intestine, what remains of the feed is first emptied into the part of the large intestine named the cecum and then into the colon. Finally, the waste products are passed into the lower end of the large intestine, which is referred to as the rectum, and out of the body through the anus.

While they are not a part of the digestive system, the pancreas, gall bladder, and liver also play a role in digestion. They release substances that aid the digestive system in performing its function. However the horse, unlike the other animals, does not have a gall bladder.

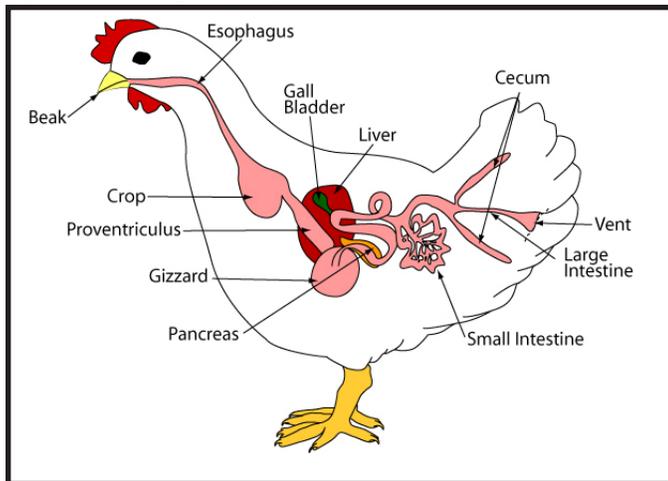
The path followed by feed in fowl differs somewhat due to the different parts of its digestive system (Figure 1.2). Feed enters the system through the beak and passes through the esophagus, which is called the gullet, to an organ referred to as the crop. From the crop it passes into the glandular stomach, or proventriculus, and then the gizzard, or ventriculus, before entering the small intestine. At the point where the small intestine and large

Figure 1.1 - Swine Digestive System



Introduction to Animal Nutrition

Figure 1.2 - Digestive System of Fowl



intestine join are two ceca. After passing the ceca, the undigested material moves through the large intestine to the cloaca and exits the body through the vent.

Functions of the Parts

The parts of the mammalian monogastric digestive system can be divided into four sections based on their functions. The sections consist of the parts leading to the small intestine, the small intestine, the large intestine, and the parts allowing the exit of solid wastes, or feces.

The parts leading to the small intestine reduce the size of feed particles. The process begins in the mouth as the teeth are used to grind feed into smaller pieces that are moved to the throat by the tongue. The tubelike esophagus carries these pieces to the stomach, a muscular organ that stores food before it passes into the small intestine. Digestion, which began in the mouth, continues in the stomach.

The primary function of the small intestine is to further break down and absorb the nutrients found in food. The digestive processes continue in the duodenum. Nutrients are absorbed into the bloodstream through the intestinal walls in the remainder of the small intestine.

The next section of the digestive system, which consists of most of the large intestine, is designed to absorb water and mold indigestible feed wastes into a solid form. The cecum, also referred to as the blind gut, contains microorganisms. Its function varies depending on the species. In

some species it has little or no effect on digestion. In the horse and rabbit, however, the cecum is enlarged, which allows the microorganisms to ferment roughage, which is feed (like hay, grass, and grass products) that has a lot of fiber and few digestible nutrients. The fermentation breaks down the roughage for absorption into the blood. These two species are therefore able to make efficient use of plant materials in their diets. After passing through the cecum, the feed enters the colon, which absorbs water and forms the feces. Some nutrients are absorbed in the colon as well.

The parts allowing the exit of the feces are the rectum and the anus. The rectum carries the feces to the anus. The anus passes the solid wastes out of the body.

The digestive system of fowl functions somewhat differently. Fowl have no teeth with which to chew and instead use the beak to break feed down for swallowing. After passing through the gullet, feed is stored in the crop and softened for digestion before it enters the stomach. Digestion begins in the glandular stomach. The feed then passes into the gizzard where it is ground by muscular contractions before entering the small intestine for digestion and absorption. The two ceca contain bacteria but have little role in digestion; fowl therefore cannot digest fibrous feeds like hay. The large intestine carries wastes to the cloaca, the junction of the reproductive and digestive systems. The vent allows wastes to exit the body.

Digestive Juices and Enzymes

Digestion is the breakdown of food into soluble particles that can then be passed through the intestinal wall and absorbed into the blood system for use by the animal. Digestive juices and enzymes play a major role in digestion.

Digestive juices are fluids that are secreted into the digestive system from glands or tissues. Substances called enzymes are found in these fluids. An enzyme speeds up chemical reactions, allowing feed to be digested and absorbed. Table 1.1 shows digestive juices and enzymes found in the monogastric digestive system.

In mammals, digestive juices begin to break down feed as soon as it enters the mouth. Saliva from the salivary

Monogastric Digestive System

Table 1.1 - Digestive Juices and Enzymes

Type of Digestive Juices	Enzyme
Saliva	Amylase
Gastric	Pepsin Rennin Lipase
Pancreatic	Amylase Lipase Trypsin Chymotrypsin
Bile	No enzyme present
Intestinal	Peptidase Maltase Sucrase Lactase

glands in the mouth lubricates the feed for passage into the digestive system. It also contains the enzyme amylase. As saliva mixes with the food, amylase begins the breakdown of starches into sugars that can be absorbed by the body. It continues to act until neutralized in the stomach.

Once the food moves into the stomach, other digestive juices begin to work on the feed. One of the chief components of the gastric juices secreted by the stomach wall is diluted hydrochloric acid (HCl), a corrosive substance that stops the action of amylase. Another component of the juices is gastrin, which stimulates the stomach to produce more gastric juices. The gastric juices also include the enzymes pepsin, rennin, and gastric lipase. Pepsin begins the digestion of proteins, rennin curdles a protein in milk, and lipase begins the breakdown of fats. Mucus is also present in the stomach to protect the stomach lining from the acidic environment that is created by the gastric juices.

Other digestive juices are released into the small intestine. For example, bile, which is secreted by the liver and stored in the gall bladder, is released into the duodenum along with digestive juices from the pancreas. Bile helps to liquefy fats for absorption. The pancreatic juices contain several enzymes, including pancreatic lipase, which is aided by bile in the further breakdown of fats; trypsin, which breaks down proteins; chymotrypsin, which also acts on proteins; and amylase, which continues to work on starch. In addition, intestinal juices containing

the enzymes peptidase, maltase, sucrase, and lactase are produced in the small intestine itself. Peptidase breaks down proteins, while maltase, sucrase, and lactase work on sugars and starches.

In fowl, digestive juices also convert the nutrients in feed into a usable form. Little saliva is present in the mouth, but saliva and secretions from the wall of the crop soften the feed for digestion. In the proventriculus, gastric juices containing HCl and pepsin are secreted, and the pepsin begins the digestion of proteins. The digestive juices are further mixed with the feed as it is ground in the gizzard. In the small intestine, bile and pancreatic juices with amylase, trypsin, and lipase are released; they function in the same way as they do in mammals. The intestinal juices, which contain peptidase, maltase, sucrase, and lactase, also have the same functions as in the mammalian system.

Summary

The stomach of a monogastric animal has a simple structure consisting of a single compartment. The various parts of its digestive system work together to digest food and absorb its nutrients into the body in a usable form. Digestive juices and enzymes play an important role in breaking down feed for absorption. Swine, horses, dogs, and rabbits have this type of digestive system. Fowl also have a monogastric digestive system, although the digestive tract found in fowl has several differences from that found in mammals.

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Ruminant Digestive System

In contrast to an animal with a monogastric digestive system, a ruminant has four stomach compartments and can utilize some feeds more efficiently than a monogastric animal. Ruminants are important to the animal industry because they can use hay and pasture productively.

Parts of the Ruminant Digestive System

Two common livestock species have a ruminant digestive system. Cattle, both dairy and beef, and sheep are ruminants. The digestive parts and their functions are similar in both species.

Some of the parts of the ruminant digestive system are the same as those of the monogastric digestive system, but other parts are very different. As in the monogastric digestive system, food enters into the system through the mouth and then passes through the esophagus to the stomach. In the ruminant, the stomach is divided into four compartments, called the rumen, reticulum, omasum, and abomasum. Depending on the type of feed, it may pass through all or some of these compartments as it moves through the stomach. When the stomach completes its functions, the feed moves to the small intestine and proceeds through the cecum, colon, and rectum of the large intestine to the anus. The digestive system of cattle is illustrated in Figure 2.1.

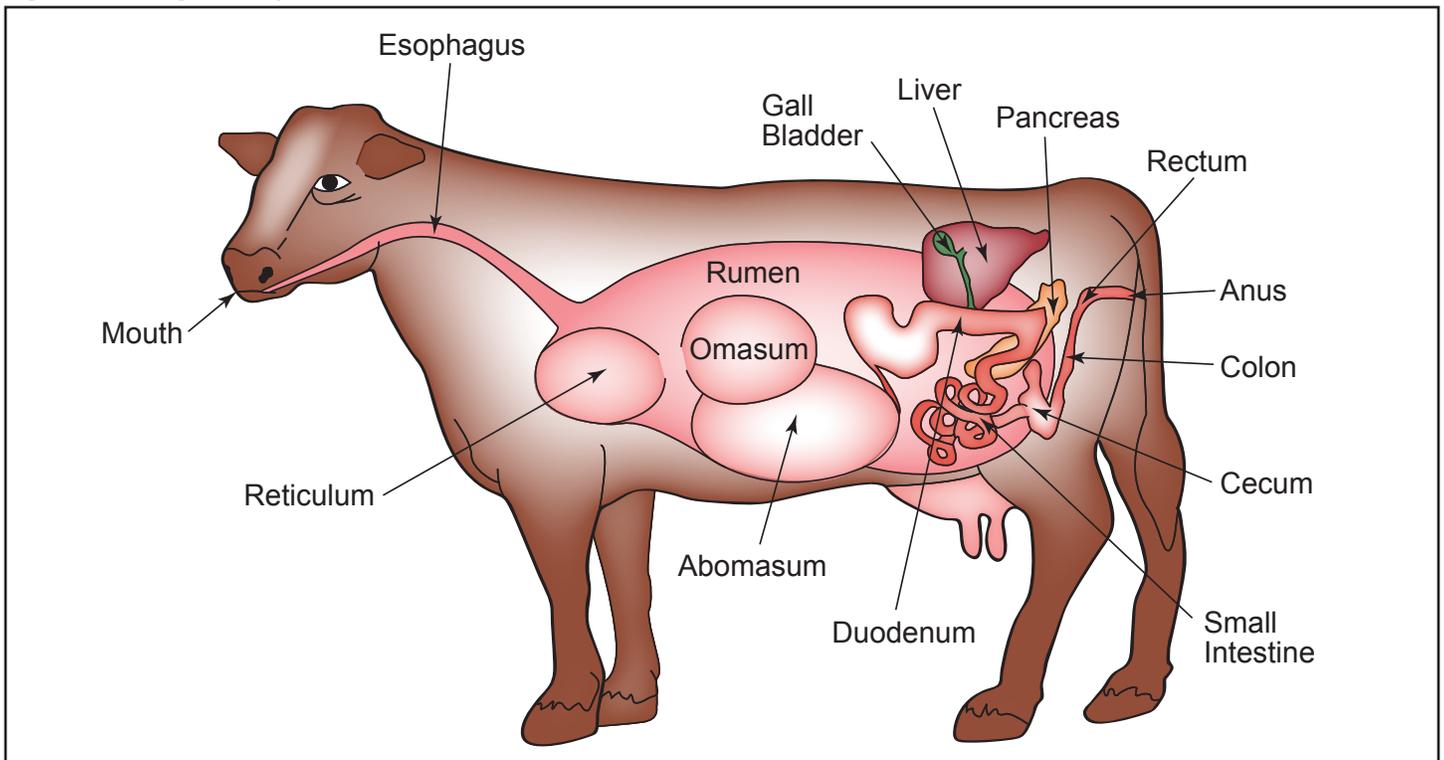
Functions of the Parts

Each of the parts of the ruminant digestive system aids in the process of extracting the nutrients needed by the animal from feed. Although the parts of the system have some similarities in function to those of the monogastric digestive system, the process of digestion is much more complex due to structure of the stomach.

Mouth – The mouth carries feed into the digestive system. In cattle, the tongue grabs the grass or other feed and brings it into the mouth. The tongue also moves feed to the throat. The cow has front teeth only in the lower jaw, with a dental pad in the upper jaw; when grass is pulled into the mouth, the teeth cut the grass against the dental pad. The mouth also has upper and lower back teeth for chewing cud and other types of feed. Sheep use their lips to bring food into the mouth when grazing.

Esophagus - Feed is transported back and forth from the mouth to the stomach through the esophagus.

Figure 2.1 - Digestive System of Cattle



Introduction to Animal Nutrition

Stomach – Like the monogastric stomach, the main function of the stomach of the ruminant is to break down feed. Each of the four stomach compartments has its own unique function. Figure 2.2 illustrates the four compartments of the stomach.

Rumen - The rumen, which is also called the paunch, is the largest of the stomach compartments. It helps to break feed down so that it may be digested.

Reticulum – The reticulum is also called the honeycomb because of the texture of the inner wall of the compartment. It pumps roughage back to the mouth through the esophagus for rumination, which is the razing of feed in the form of the cud. The reticulum also works with the rumen in the breakdown of feed.

Omasum – The function of the omasum, or manyplies, is not fully understood. However, scientists have found that the omasum absorbs some water and is involved in the absorption of nutrients.

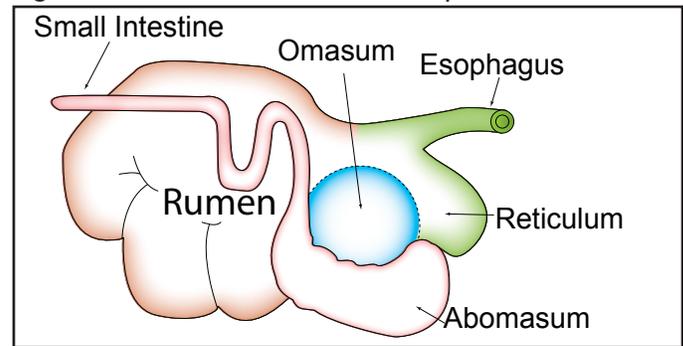
Abomasum – The abomasum is referred to as the true stomach. Its functions are very similar to those of the monogastric stomach. In the abomasum, digestive juices containing acids and enzymes are added to aid in digestion.

Small intestine – In the first portion of the small intestine, called the duodenum, the digestive process started in the stomach continues. Nutrients are absorbed into the bloodstream through the walls of the remainder of the small intestine. Once the nutrients enters the bloodstream, they travel throughout the body to fuel life processes.

Large intestine – The large intestine consists of three parts, the cecum, colon, and rectum. Within the large intestine of the ruminant, the cecum plays a minor role in the further breakdown of roughage. The colon absorbs water and forms undigested wastes into feces, some absorption of nutrients also takes place. The feces are stored in the rectum before being passed out of the body.

Anus – The anus is the opening through which undigestible solid wastes exit from the body. Any portion of the

Figure 2.2 - Ruminant Stomach Compartments



feed not absorbed into the bloodstream is excreted through the anus.

The Digestive Process

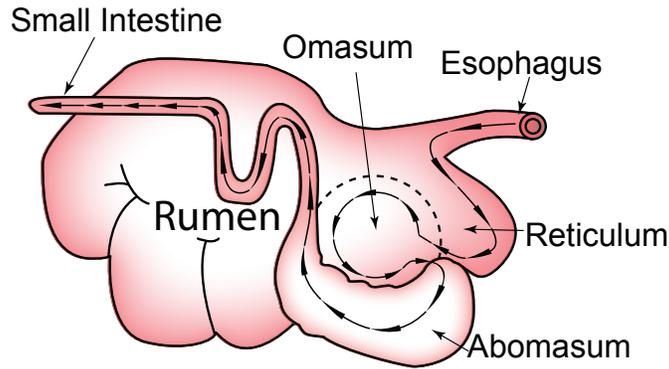
In ruminants, the breakdown of the nutrients in feed into a usable form is very complex. It involves not only the digestive juices and enzymes found in the monogastric system, but the activity of microorganisms found in the stomach. In addition, feed may take one of several paths as it passes through the stomach, depending on the nature of the feed.

In contrast to the monogastric digestive system, the process of digestion does not begin in the mouth in the ruminant, since enzymes are not present in the saliva of ruminants. Instead, digestion begins in the stomach.

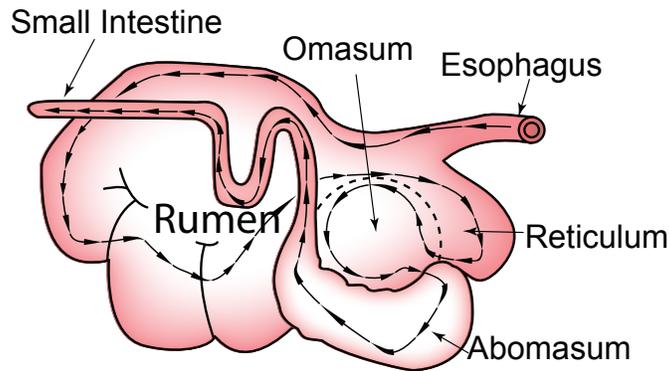
Before feeds pass into the omasum and abomasum, they move through either the reticulum or the rumen and reticulum. Three types of microorganisms are present in the rumen and reticulum—bacteria, protozoa, and fungi. These microorganisms help break down feed for digestion. Bacteria have the most important role in digestion. Some bacteria break down the more easily digestible sugars and starches. Other bacteria ferment the fiber found in roughage like hay, grass, and silage to break it down for use by the body. A second type of microorganism, protozoa, also aids the ruminant in digestion by storing sugars and starches, forming some microbial proteins from proteins in the diet, and fermenting fiber. The role of fungi, the final type of microorganism, is not clearly understood, but they play a role in the digestion of fiber. The action of all the microorganism converts sugars, starches and fiber into fatty acids.

Ruminant Digestive System

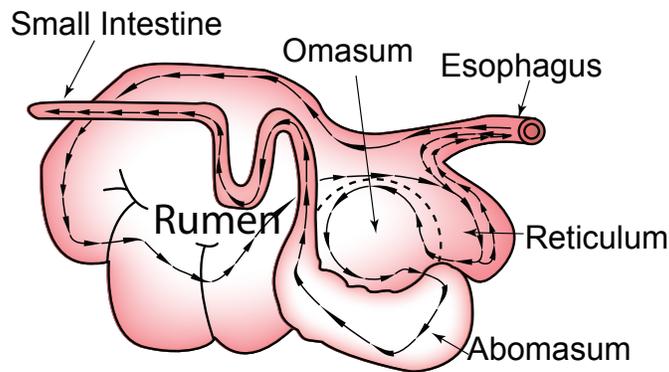
Figure 2.3 - Three Possible Routes of Feed



Ground Concentrates or Cud



Light Grain



Forages

Introduction to Animal Nutrition

In the stomach, feed may follow one of three routes, depending on the type of feed (see Figure 2.3). In the case of a ground concentrate or cud, the feed passes through the reticulum where the microorganisms act on it. It then passes through the omasum, where fatty acids are absorbed, to the abomasum. In the abomasum, gastric juices containing hydrochloric acid and the enzymes pepsin, rennin, and lipase are added to digest proteins and fats.

Light grains, such as oats and barley, require a slightly more complicated path to be utilized most efficiently. They first pass into the rumen, in which muscular action breaks the feed into smaller pieces. The microorganisms then assist in digestion, and the fatty acids that are produced are absorbed by the rumen. When the grain is sufficiently broken down, it passes through the reticulum and omasum into the abomasum.

The third route is that taken by forages. The combination of the action of the microorganisms and the path through the rumen and reticulum are what allows ruminants to better utilize forages, which have a high fiber content. As the forage passes into the rumen and reticulum, muscular action helps to break it down. The microorganisms then act on the pieces. After the microorganisms operate on the forage for a period of time, it moves to the reticulum. If the forage then needs to be broken down some more, the reticulum pumps it up through the esophagus into the mouth as cud to be chewed to break it into smaller pieces. After the cud has been chewed, the remains are again swallowed and enter the reticulum. They then pass to the omasum and abomasum.

After passing through the abomasum, the feed enters the small intestine. In the duodenum, pancreatic juices are added, which include the enzymes trypsin, chymotrypsin, lipase, and amylase (of which only a small amount is present). As in the monogastric system, trypsin and chymotrypsin act on proteins, lipase on fats, and amylase on starches. Bile from the liver is also added in the duodenum for the digestion of fats. Intestinal juices are added in the rest of the small intestine. The enzymes peptidase, lactase, sucrase, and maltase are found in the intestinal juices; peptidase works on proteins, while maltase, sucrase, and lactase work on sugars and starches. Maltase and sucrase are present in small amounts in ruminants.

Summary

A ruminant digestive system like that found in cattle and sheep has many parts that are similar to the monogastric digestive system. However, the stomach of the ruminant has four compartments instead of only one. These compartments are the rumen, reticulum, omasum, and abomasum. The structure of the stomach and microorganisms found in the rumen and reticulum enable the ruminant to digest forage much more efficiently than animals with a monogastric system.

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Importance of Meeting Nutritional Needs

Water and feed contain substances called nutrients that are needed by an animal for its body to function. The monogastric and ruminant digestive systems are able to extract these elements through digestion. To ensure proper growth and efficiency in production, it is important to provide the proper levels of nutrients for an animal's nutritional needs.

Nutrients

Nutrients are elements or chemical compounds that support the life processes of an animal. They allow the animal to maintain its bodily functions by entering the cells of the body and fueling their growth and function. Nutrients are found in water, grain, roughage, and other food substances taken into the digestive system through the mouth.

Six Basic Nutrients

Six basic nutrients are essential for the survival of the animal. They are water, proteins, carbohydrates, fats, vitamins, and minerals. The lack of any one of these nutrients could cause problems for the animal.

Water is a liquid combination of hydrogen and oxygen. Since the body is made mostly of water, water has many important functions. For example, it plays a role in biochemical reactions like respiration, digestion, and assimilation (the transformation of nutrients from feed into body tissues). The transportation of nutrients and wastes through the body is also done by water. Water regulates body temperature and gives the body its form.

Proteins are compounds made up of substances called amino acids that contain the elements carbon, hydrogen, oxygen, and nitrogen; iron, phosphorus, or sulfur are also sometimes included. Protein is the only source of nitrogen for an animal. The amino acids can be divided into essential and nonessential amino acids (Table 3.1). Essential amino acids must be provided in the diet because they are not found in animal tissues. Nonessential amino acids can be synthesized in animal tissues from other amino acids and therefore do not have to be supplied by the diet.

Protein has several functions. Protein is important because amino acids are the building blocks of body tissues. It develops and repairs body organs and tissues like muscles, nerves, skin, hair, hooves, and feathers. Protein is also used to produce milk, wool, and eggs. The fetus is developed and some enzymes and hormones are generated by the action of protein. It also forms a part of DNA.

Carbohydrates are made up of the elements carbon, hydrogen, and oxygen. A carbohydrate may be a sugar, starch, or fiber. Sugars and starches are easily digested, while fiber, which forms the cell wall material of plants, is more difficult to digest. The main function of carbohydrates is to provide the energy that powers muscle movement. Energy for muscular movement is required not only for exercise but for many essential functions of the body, such as breathing, digestion, and the beating of the heart. Carbohydrates also produce body heat, and extra carbohydrates are stored as body fat.

Fats, like carbohydrates, are an energy source. The elements found in fats are the same as carbohydrates – carbon, hydrogen, and oxygen. The difference between fats and carbohydrates is in the level of energy that they provide, with fats producing 2.25 times more energy than carbohydrates. In addition to serving as a valuable energy source, fats also provide body heat and carry some vitamins.

Table 3.1 - Essential and Nonessential Amino Acids

Essential Amino Acids	Nonessential Amino Acids
Arginine	Alanine
Histidine	Aspartic acid
Isoleucine	Citrulline
Leucine	Cysteine
Lysine	Cystine
Methionine	Glutamic acid
Phenylalanine	Glycine
Threonine	Lodogorgoic acid
Tryptophan	Proline
Valine	Serine
	Tyrosine
	Hydroxyglutamic acid
	Hydroxyproline

Introduction to Animal Nutrition

Minerals are inorganic elements that are utilized by the body. They include both macro- and microminerals; macrominerals are required in much larger amounts than microminerals. Minerals supply materials for building the skeleton and teeth and are a part of body regulators such as enzymes and hormones. They also assist in transmitting impulses through the nervous system, the development of the body tissues, and muscular activity. Table 3.2 provides a listing of the minerals needed by the body.

Vitamins are fat- or water-soluble organic substances. The fat soluble vitamins, carried by fats, are vitamin A, D, E, and K, which contain hydrogen, oxygen, and carbon. Water-soluble vitamins are vitamin C and the B-complex vitamins; they contain hydrogen, oxygen, carbon, chlorine, nitrogen, and cobalt or sulfur. Vitamins do not become a part of the body like the other nutrients. Instead, they regulate body functions. Vitamins regulate the digestion, absorption, and metabolism of nutrients. They also regulate the formation of new cells and the development of vision, bones, hair, feathers, skin and muscles. Vitamins help protect against diseases and develop and maintain the nervous system.

Nutritional Needs of Animals

Nutritional needs vary depending on the needs of the animal for health and the life stages of maintenance, conception and gestation, lactation, and growth and development. When a female is in the gestational period, for example, nutritional needs are different than during lactation. Figure 3.1 demonstrates how the nutrient requirements of a mature female vary through different life stages.

Of the life stages, simple maintenance has the lowest level of nutritional requirements, and they must be met before other nutrients needs are considered. At this level, nutrients are used to maintain vital life processes and normal body temperature, with no weight gain or loss and no production (such as reproduction or fattening). The amount of feed needed to maintain an animal depends on the size of its body.

The main concern during conception and gestation is meeting additional nutritional needs to ensure good fetal growth and maintain the health of the mother. Most of

Table 3.2 - Macro- and Microminerals

Macrominerals	Microminerals
Calcium (Ca)	Iron (Fe)
Phosphorus (P)	Iodine (I)
Sodium (Na)	Copper (Cu)
Potassium (K)	Cobalt (Co)
Chlorine (Cl)	Fluorine (Fl)
Magnesium (Mg)	Manganese (Mn)
Sulfur (S)	Zinc (Zn)
	Molybdenum (Mo)
	Selenium (Se)
	Chromium (Cr)

the growing done by the fetus is done in the last trimester. During this time the female needs additional nutrients for herself and the fetus. The amount needed is equal to the nutrient needs of the young animal after birth and the maintenance needs of the female.

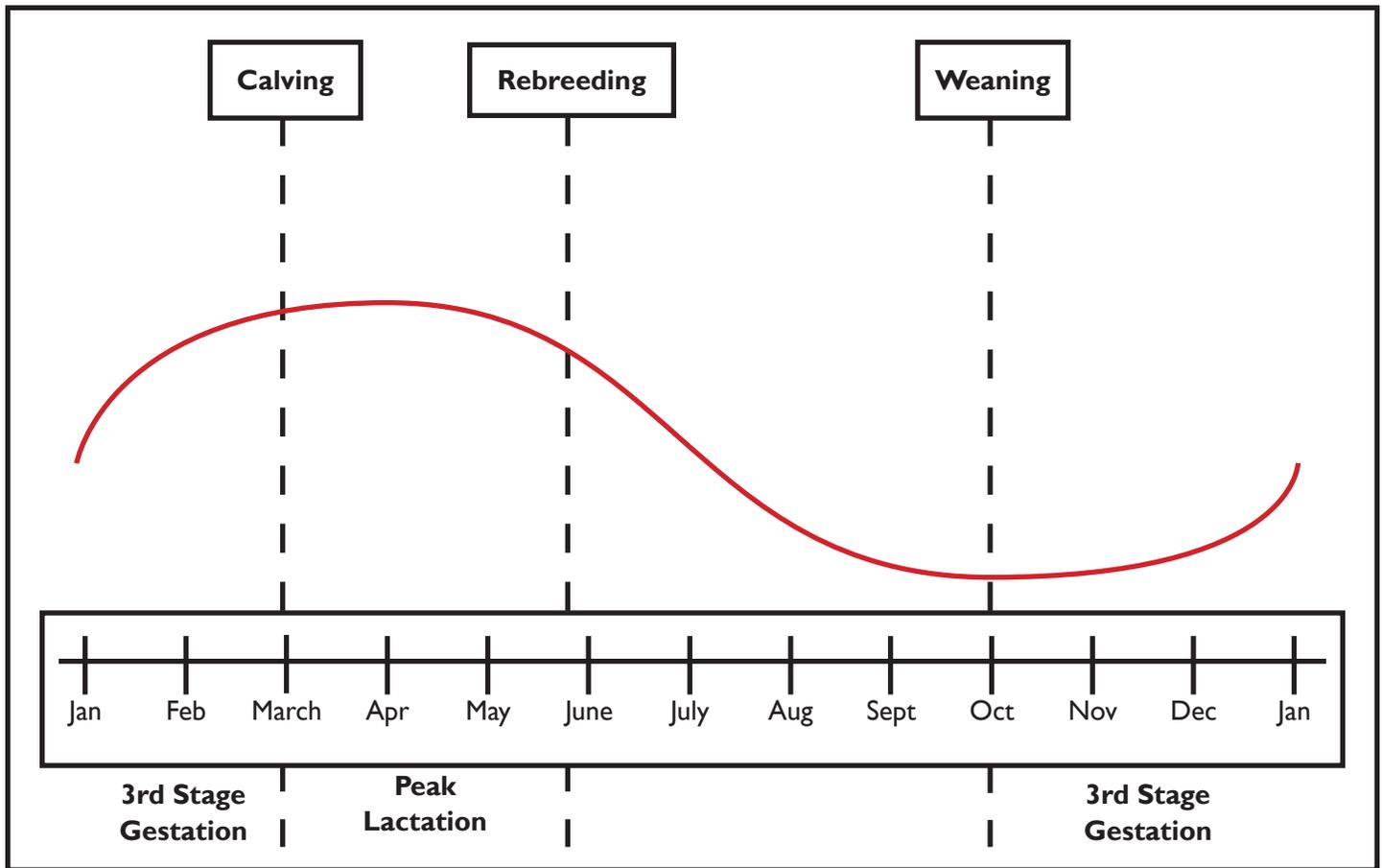
Lactation is milk production. Many additional nutrients are needed to produce milk, including proteins, minerals, vitamins, fats, and carbohydrates. Protein is important, since milk contains three percent protein. The energy supplied by fats and carbohydrates is vital for lactation. Water is also needed. Two minerals needed during lactation are calcium and phosphorus. Vitamin A and the B-complex vitamins are necessary as well when a female is lactating. If the animal is indoors, vitamin D may be needed.

An animal also has special nutrient requirements for growth and development. As it grows, the animal increases the number of cells at the tissue level. Muscles are built, and bone and connective tissues are produced. To accomplish this task, an increased amount of protein is needed. The minerals calcium and phosphorus are also required for bone growth. In addition, higher quantities of vitamins are required, especially vitamin D. An energy source is supplied by including more fats and carbohydrates in the animal's diet. If these nutrient requirements are not met while the animal is growing, the adult will be less productive.

Nutrients are important in maintaining the health or well-being of the animal in all of the life stages. Nutrients are needed to carry out vital bodily functions. An animal in the maintenance stage may not be gaining or losing weight, but it may not be as healthy as it could be.

Importance of Meeting Nutritional Needs

Figure 3.1 - Nutrient Requirements for a Cow through Life Stages



An animal must be healthy in order to be at its most productive.

Summary

Nutrients are elements and chemical compounds that nourish the body. The six basic nutrients are water, proteins, carbohydrates, fats, vitamins, and minerals. Each nutrient meets a specific need for maintenance, conception and gestation, lactation, growth and development, and health.

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Meeting Nutritional Needs of Animals

When trying to feed an animal appropriately in order to meet production goals, the producer needs to consider both the nutrients provided in the feed and the nutrients needed by the animal. In order to meet the animal's nutritional needs, the nutrients in the feed have to match the animal's requirements.

Information Sources for Nutritional Requirements

A number of sources provide information that the producer can use to help him or her meet an animal's nutritional needs. For example, University Extension has livestock and dairy specialists and agricultural publications that are good information sources on nutritional needs. Extension guides that list nutritional information based on the animal's life stage, size, and weight are available for many animal species. The information is usually based on the work of the National Research Council (NRC) as well as research conducted in Missouri.

Another source of information is textbooks on animal nutrition. Many textbooks have tables, often in an appendix, that provide such information. Like the University Extension publications, textbooks list the animal's nutritional needs based on research and other publications.

Often feed companies and feed dealers can supply a producer with information on nutritional needs. The main business of feed companies and dealers is to sell products for feeding animals. Companies often put out publications about nutritional requirements of animals. The individual dealer also may make recommendations to the producer.

Finally, the NRC has conducted research to provide information on the minimum nutritional requirements needed by an animal to function properly. The NRC puts out its own publications detailing research findings.

Steps in Meeting an Animal's Nutritional Needs

Some general steps should be followed in order to meet the nutritional needs of animals. The goal of the step-by-step process is to meet the animal's needs through the nutrients provided in the feed.

When trying to meet nutritional needs, the animal and the type of feed have to be taken into consideration.

1. Research needs to be done to learn the nutritional needs of the animal and the nutrient content of feeds. The first step is to find one of the information sources listed above. The source can then be used to obtain information on the requirements of that animal. Information on feeds may sometimes be found in the same source that provides data about the nutritional requirements of an animal. If information on feeds is not included, however, another source must be found.
2. After a source has been obtained, the nutritional needs of a particular animal need to be identified. This step has several parts. First, the life stage of the animal has to be identified. For example, a producer would have to know whether a cow was growing or breeding. Then the weight and frame size of the animal need to be determined. The producer next needs to determine the animal's desired performance, which is sometimes referred to as the rate of gain or average daily gain (ADG). Using this information, the producer can use the source to look up all the nutrients needed by the animal. Table 4.1 shows a section of a table that supplies information on nutrient requirements.
3. The next step in meeting an animal's nutritional needs is to identify the nutrients that are available in a specific feed. This part of the process is as important as identifying the animal's needs, since the feed must supply the required nutrients. This step also has several parts. First, the feeds that may be used must be identified. Many feeds may be available to the producer, such as corn, soybean meal, grass, and hay. Next, a version of a particular feed should be chosen to meet the animal's nutritional needs. For example, whole seed soybeans have a different amount of nutrients than dehulled soybean meal. The producer needs to pick the right one for his or her purposes. In order to pick the appropriate feed, the producer

Introduction to Animal Nutrition

Table 4.1 - Nutrient Requirements Table

Weight (lbs.)	ADG (lbs.)	DM ^b (lbs.)	Protein (lbs.)	Ne _m Mcal	Ne _g Mcal	TDN (lbs.)	Ca (lbs.)	P (lbs.)
Medium-Frame Steer Calves								
400	2.5	11.0	1.56	3.81	3.16	8.1	.074	.033
400	3.0	10.0	1.65	3.81	3.86	8.5	.086	.037
500	0.5	11.5	0.98	4.50	0.64	6.2	.028	.019
500	1.0	12.3	1.16	4.50	1.37	7.2	.039	.024
500	1.5	12.8	1.33	4.50	2.13	8.1	.051	.028
500	2.0	13.1	1.49	4.50	2.93	8.8	.061	.031
500	2.5	13.0	1.63	4.50	3.74	9.6	.072	.035
500	3.0	11.8	1.69	4.50	4.56	10.0	.081	.037
600	.05	13.2	1.08	5.16	0.73	7.1	.030	.023
600	1.0	14.1	1.26	5.16	1.57	8.2	.039	.026

*From *Nutrient Requirements for Growing and Finishing Beef Cattle (G2067)*, University Extension agricultural publications, University of Missouri-Columbia

has to know what level of nutrients is provided by that specific feed, which can be learned from the source used. Table 4.2 shows a portion of a sample feed nutrient composition table.

- The final step is to match the feed to the animal's nutritional requirements to meet its needs. This step is accomplished by balancing a feed ration, which is covered at length in the next lesson.

Sources of Nutrients

In order to be able to supply the appropriate nutrients to an animal, a producer needs to know the sources of those nutrients. The six basic nutrients needed in an animal's diet—water, proteins, carbohydrates, fats vitamins, and minerals—can be provided through various sources.

- Water – Found in fresh water or in feeds, which contain water

Table 4.2 - Feed Composition Table

	Dry Matter %	Crude Protein%	Ne _m Mcal/lb	Ne _g Mcal/lb	TDN %	Fat %	Crude Fiber %	Calcium %	Phosphorus %	Potassium %	Sodium %	Sulfur %	Zinc PPM
Concentrates													
Molasses													
Beet	78.0	6.6	0.68	0.45	62	0.2	0.0	0.13	0.02	4.73	1.15	0.47	14
Cane	75.0	4.4	0.58	.037	54	0.1	0.0	0.75	0.08	2.88	0.17	0.35	23
Cane, dried	94.0	9.7	0.70	0.44	66	0.8	6.3	1.03	0.14	3.38	0.19	0.43	31
Oats													
Grain	89.0	11.8	0.75	0.49	69	4.8	10.8	0.06	0.34	0.39	0.07	0.20	37
Mill Byproduct	89.0	7.1	0.34	0.00	29	2.3	22.3	0.11	0.21	0.53	--	0.21	--
Groats	90.0	15.9	0.95	0.65	85	6.2	2.5	0.07	0.43	0.35	0.05	0.20	0

*From *Feed Composition Tables (G2051)*, University Extension agricultural publications, University of Missouri-Columbia

Meeting Nutritional Needs of Animals

- Protein – Amino acids found in animal tissues, grains, and legumes
- Carbohydrates – Sugars, starches, or fibers found in grains and forages
- Fats – Fatty acids found in animal tissues, fats, and grains
- Vitamins – Found in grass, sun-cured hay, and commercial feeds
- Minerals – Found in plant and animal tissues and commercial feeds

Summary

Information on nutritional requirements of animals and the nutrient content of feeds can be learned from many sources. Once sources of information on requirements and the nutrients in feeds are found, the animal's needs may be met by identifying its requirements and then the nutrients of the available feed. Each of the six basic nutrients can be provided by a number of sources.

Credits

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Balancing a Ration

Once a producer has determined the nutritional needs of an animal and the nutrient content of feeds, the next step is balancing a ration. A balanced ration provides the needed nutrients for the animal by including the necessary amounts of the proper feeds.

Importance of Balanced Rations

A balanced ration provides the proper levels of nutrients for an animal. The objective of balancing a ration is to meet the animal's nutritional needs with feed that supplies each nutrient in the proper amount and proportion. See Figure 5.1.

Providing animals with balanced rations is important. Balancing rations will allow a producer to meet an animal's nutritional needs for health and the specific nutrient requirements of each life stage—maintenance, conception and gestation, lactation, and growth and development. By balancing rations, nutritional deficiencies that can harm the animal can be prevented. In addition, growth and production can be maximized.

Balancing Rations

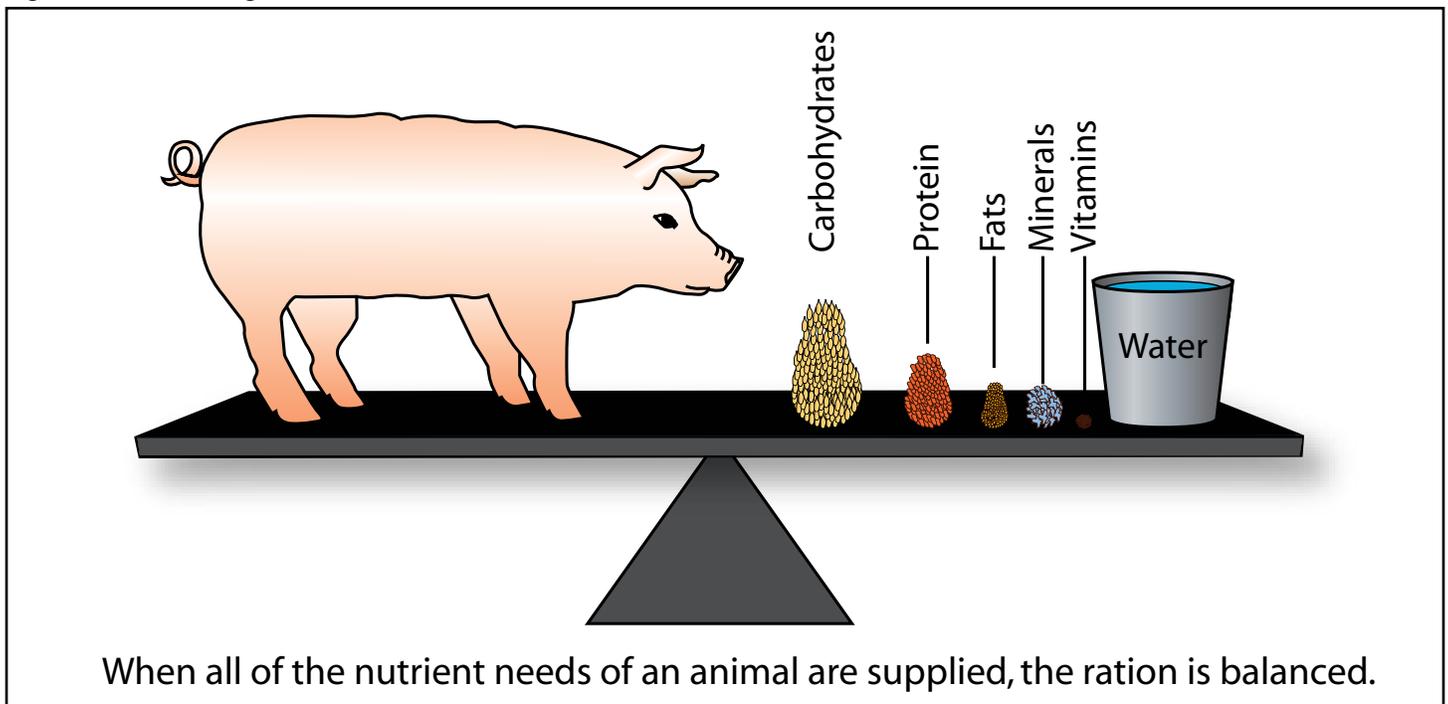
Several methods may be used to balance a ration. Special computer programs, trial and error, and the Pearson

square method may all be utilized by the producer when balancing a ration. In addition to these common methods, many other methods are available to producers.

Today, computers are widely used when balancing rations. Local feed dealers, cooperatives, companies, and producers may balance a ration using computers. Special programs have been designed to check that the feeds included in a ration meet all of the animal's nutrient requirements by making sure they are balanced. The computer does the figuring with the information provided about the animal and the type and amount of feed. It therefore requires complete information for accurate results. When this data is entered, the program will indicate whether the ration is balanced, the animal needs more of a certain nutrient or nutrients, or the ration is exceeding the animal's needs. If the ration is not balanced, the person using the program must alter the ration and enter the new information to allow the computer to check it. The operator of the program must therefore be knowledgeable about nutrition for accurate results. A general knowledge of nutrition is necessary because even if a ration balances, an animal will not eat it if it is not palatable.

Another method for balancing rations is referred to as the trial and error method. To use this method, a combination of feeds is selected that the producer believes will meet

Figure 5.1 - Balancing Nutrients in Rations



Introduction to Animal Nutrition

nutritional needs. The nutrient content of the diet is calculated and compared to the nutritional requirements of the animal. If the diet does not meet those requirements, a different combination of feeds must be selected and the process repeated. The producer attempts to meet all the animal's nutrient needs with this method.

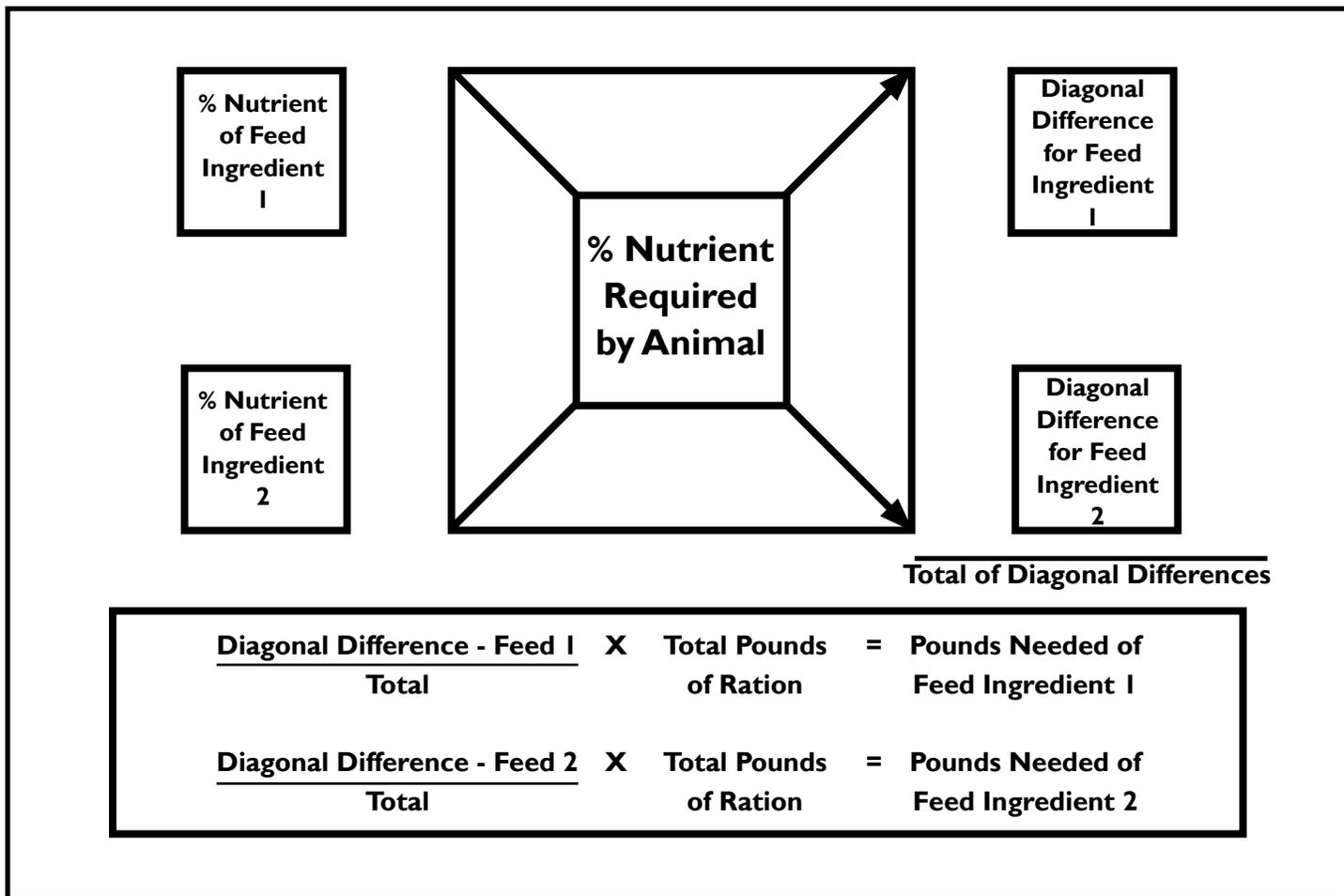
A third method, the Pearson Square method, can also be used to balance rations. This method balances for only one nutrient at a time; it is most often used for crude protein. In order to balance for other nutrients, a new Pearson square must be constructed. This method is sometimes utilized by a producer engaged in limited production. It is a good way to start learning how to balance rations.

The process for using the Pearson Square is quite simple. First, draw a square similar to that in Figure 5.2. Write the percent of the nutrient required by the animal in its

diet in the middle of the square. Next, assign each of two feed ingredients its own corner on the left side and write down the percent of the nutrient required found in that ingredient. Find the difference by subtracting diagonally through the square; always subtract the smaller number from the larger number. Write the results on the right corners of the square. The answer in the upper right corner represents the proportion of the ingredient in the upper left corner that will be included in the ration, while the answer in the lower right corresponds to the proportion of the ingredient on the lower left that is included. Next add the numbers in the right-hand corners and place a total at the bottom.

Once the square has been completed, some additional calculations must be done to determine the amounts and proportions of feeds needed. First, a percentage is found for the ingredients by taking the diagonal difference for

Figure 5.2 - Pearson Square Method



Balancing a Ration

each ingredient and dividing it by the total. This number is the percentage of that ingredient needed in the ration in order for the ration to balance. After the percentage of each feed ingredient is found, the number of pounds of feed can be determined by multiplying the percentage by the total number of pounds in the ration. After the ration is balanced for one nutrient using this method, the producer must still check to ensure that the proper amounts of other nutrients are supplied to the animal.

Figure 5.3 shows an example of the use of the Pearson Square method. Suppose that 12 percent crude protein is needed in a concentrate mix for steers. The producer has to determine how many pounds of corn, which has 9 percent crude protein, and how many pounds of a protein supplement that has 40 percent crude protein are needed for a 100 pound ration.

The producer first constructs a square showing the percentages. He or she then subtracts the smaller number from the larger and adds the two remainders; the calculations show that there are 28 pounds of corn and 3 pounds of supplement in 31 pounds of feed. The amounts of the two ingredients in a hundred pound ration are determined by dividing the number of pounds of each ingredient by 31 and multiplying the result by 100. The producer determines that 90.3 pounds of corn and 9.7 pounds of supplement should be included in the ration.

Factors Influencing Ration Ingredients

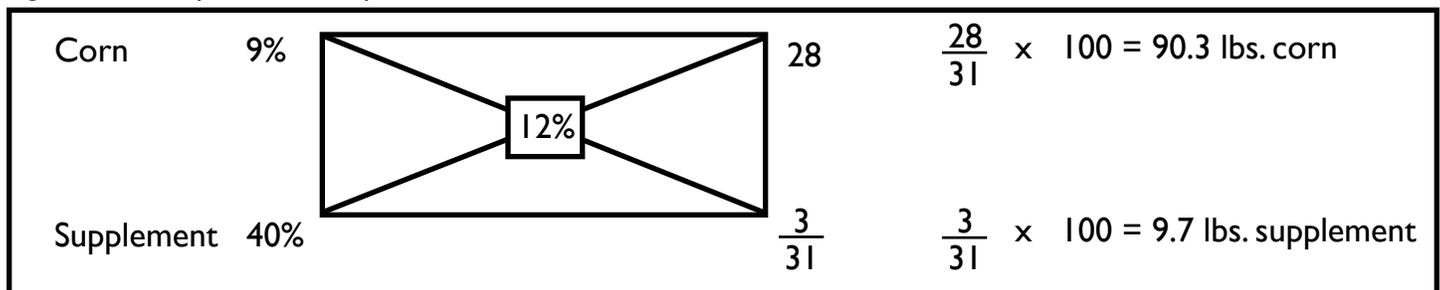
Many different feeds can be used to meet an animal's nutritional requirements. A combination of feeds can also be used. The selection of a feed or combination of feeds for the animal is influenced by two factors, least cost and ingredient availability.

The term "least cost" refers to getting the desired performance at the least cost to the producer. The type of nutrients needed by the animal cannot be ignored on the basis of cost, however. Suppose corn is \$2 a bushel, while wheat can be bought for \$4 a bushel. Which one should be fed? If the corn is chosen because it is cheaper and corn does not meet the nutritional needs of the animal, then in the long run costs may actually be greater, since growth and production are not maximized.

The process for determining least cost is not complicated. First, each feed ingredient in a ration has to be balanced. Once the amount of the particular feed ingredient is known, the total cost of the ration can be calculated by multiplying the quantity of each feed by its price and then adding to find total cost. The costs of balanced rations using different feed ingredients can then be compared. Choosing one ration over another ration that supplies the same nutrients to the animal will depend on which ration has the least cost.

The other factor that influences feed selection is ingredient availability. The availability of a particular feed depends on the geographical area. Areas vary in the types of feeds that are available. For example, in places where grains are grown extensively, corn will be more available as a feed ingredient. Areas with an abundance of good grazing, on the other hand, will utilize forages for feed. In addition, different types of manufacturing may produce byproducts that are available as feed to animals. Manufacturing byproducts that are fed to animals include items such as fish meal, blood meal, brewer's grains, whole cottonseeds, and soyhulls. Ingredient availability therefore depends on what is grown or manufactured in a certain area.

Figure 5.3 - Sample Pearson Square Calculation



Introduction to Animal Nutrition

Summary

A balanced ration provides the animal the proper amounts and proportions of nutrients. It is important to balance a ration to keep an animal healthy and provide the necessary nutrients for each life stage, to prevent nutritional deficiencies, and to promote maximum growth and production. A ration may be balanced using a variety of methods, such as computer programs, trial and error, and the Pearson Square method. Least cost and ingredient availability are factors to consider when choosing the ingredients of a ration.

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