## Introduction

Animal feed : Food of domestic animals comprising any naturally occurring ingredient or material fed to animals for the purpose of maintenance, growth and development.

There are two basic types: fodder and forage. Used alone, the word *feed* more often refers to fodder. Animal feed is an important input to animal agriculture, and is frequently the main cost of the raising or keeping of animals. Farms typically try to reduce cost for this food by growing their own, grazing animals, or supplementing expensive feeds with substitutes, such as food waste like spent grain from beer brewing.

Animal wellbeing is highly dependent on feed that reflects a well-balanced nutrition. Some modern agricultural practices, such as fattening cows on grains or in feed lots, have detrimental effects on the environment and animals. For example, increased corn or other grain in feed for cows makes their microbiomes more acidic weakening their immune systems and making cows a more likely vector for E.coli. While other feeding practices can improve animal impacts. For example, feeding cows certain kinds of sea weed reduces their production of methane, reducing the greenhouse gases from meat production .

When an environmental crisis strikes farmers, such as a drought or extreme weather driven by climate change, farmers often have to shift to more expensive manufactured animal feed, which can negatively affect their economic viability. For example, drought reduced the availability of grazing lands caused farmers to sell large portions of their herds. Additionally agriculture for producing animal feed puts pressure on land use: feed crops need land that otherwise might be used for human food and can be one of the driving factors for deforestation, soil degradation and climate change.

**Forage** is a plant material (mainly plant leaves and stems) eaten by grazing livestock. Historically, the term *forage* has meant only plants eaten by the animals directly as pasture, crop residue, or immature cereal crops, but it is also used more loosely to include similar plants cut for fodder and carried to the animals, especially as hay or silage.

While the term *forage* has a broad definition, the term *forage crop* is used to define crops, annual or biennial, which are grown to be utilized by grazing or harvesting as a whole crop.

**Diet:** A regulated selection of a feed ingredient or mixture of ingredients including water, which is consumed by animals on a prescribed schedule Ingredients.

## The evaluation of feedstuffs

(1) By chemical composition

(2) By animal experiments.

Most of data describing the nutrient makeup of feedstuffs are obtained by chemical analysis. For some nutrients and some feeds, this is adequate. But for most feedstuffs, the chemical compositions must be supplemented with figures based on animal utilization-with figures obtainable by biological analysis – by experiments, with both farm and laboratory animals.

Experimental animals the most accurate, <u>but the most time consuming and costly</u>, method of determining the value of feedstuff involves live animal trails, using laboratory and/or farm animals. Through such experiments, the <u>digestibility, availability of nutrients, and palatability of a feedstuff can be determined.</u>

## The feed nutrients

The proper feeding of livestock is for the most part, a matter of supplying them with the right amounts of those chemical elements and compounds essential for carrying on the different life processes. These elements and compounds are as a group referred to as the feed nutrients.

There are somewhere around 50 or more. The amount of each required varies but ranges for the different nutrients from less than a microgram/head/day for some to over several kilograms/head/day for others.

Feed materials supply livestock with these nutrients by serving as a source of the nutrients on the one hand and by serving as a carrier of the nutrients in facilitating the feeding operation on the other.

Of the over 100 known chemical elements, at least 20 enter into the makeup of the various essential feed nutrients. These 20 elements, their symbols, and their atomic weights are as following in table ( 1):

| Name | Symbol | Atomic wt. |
|---|---|---|
| Carbon | C | 12 |
| Hydrogen | H | 1 |
| Oxygen | O | 16 |
| Phosphorus | P | 31 |
| Potassium | K | 39 |
| Iodine | I | 127 |
| Nitrogen | N | 14 |
| Sulfur | S | 32 |
| Calcium | Ca | 40 |
| Iron | Fe | 55.8 |
| Magnesium | Mg | 24.3 |
| Sodium | Na | 23 |
| Chlorine | Cl | 35.5 |
| Cobalt | Co | 59 |
| Copper | Cu | 63.5 |

| | | |
|---|---|---|
| Fluorine | F | 19 |
| Manganese | Mn | 55 |
| Zinc | Zn | 65.5 |
| Molybdenum | Mo | 96 |
| Selenium | Se | 79 |

There is more evidence that chromium, silicon, tin, vanadium, and nickel, and possibly others, should be included in this group. These elements, either alone or in various combinations, go to make up what are known as the *feed nutrients*. (The term feed nutrient is applied to any food constituent which may function in the nutritive support of animal life.)

Many different feed nutrients those currently recognized are as follows:

1- Carbohydrates 2- Fats 3- Protein 4- Minerals 5- Vitamins 6- Water

Water is an important factor influencing feed value. Water in feed is of no more value to an animal than water from other sources. Hence, appropriate allowances must be made when buying or feeding feeds high in water content.

Water is important in feed storage, too much water will cause certain feeds to heat and mold or otherwise lose quality. Some approximate maximum tolerances are as follows:

| | | | |
|---|---|---|---|
| Ground feeds | 11% | Grass hay | 20% |
| Small grains | 13% | Molasses | 40% |
| Shelled corn | 15% | Silage | 75% |

## General Functions of Feed Nutrients

There are general functions that nutrients may serve in the animal body.Three of these may be classed as basic functions, the other as an accessory function(table2):

SUMMARY OF THE VARIOUS FUNCTIONS WHICH THE DIFFERENT NUTRIENTS MAY SERVE

| | Basic Functions | | | Accessory Function |
|---|---|---|---|---|
| | *As a Structural Material for Body Building and Maintenance* | *As Energy for Heat Production, Work, and Fat Deposition* | *As or for the Formation of a Body Regulator* | *As a Source of Nutrients for Milk (or Egg) Production* |
| Protein | Yes | Yes | Certain amino acids | Yes |
| Carbohydrates | Only as fat formed from carbohydrates enters into makeup of cellular growth | Yes | Yes | Yes |
| Fats | Only as fat enters into makeup of cellular growth | Yes | Certain fatty acids | Yes |
| Minerals | Yes | No | Yes | Yes |
| Vitamins | No | No | Yes | Yes |
| Water | Yes | No | Yes | Yes |

A- <u>The three basic functions are:</u>

1- As a structural material for building and maintaining the body structure. Just as boards, blocks, bricks, mortar, etc., are essential for building a house, so are certain nutrients required for development of the animal body.

2- As a source of energy for heat production, work, and/or fat deposition

3- For regulating body processes or in the formation of body –produced regulators.

B- <u>The accessory function-milk production</u>. The production of milk does not actually represent the ultimate use of nutrients but simply the shunting off of a portion of the nutrients, which an animal has consumed and digested into the product we know as milk.

Not until milk is consumed and utilized by another animal do the nutrients therein actually serve ultimate function. Since milk contains some of almost all of the essential nutrients, essentially all of the various nutrients function in its production. With poultry, egg production would fall into this same category.

## Different ways of expressing feed composition

A. In percent (%). This simply says that a feed contains so many parts (kilograms, grams, milligrams, micrograms, etc.) of a particular feed component per 100 parts of the overall feed.

B. In parts per million (PPM). This simply says that a feed contains so many parts (kg, g, mg, mcg, etc.) of a particular feed component per 1000000 parts of the overall feed. PPM differs from % only in the location of decimal point. Since one million is 10000 X 100, to change % to PPM, simply multiply by 10000 or, in other words, move the decimal point four places to right. To change PPM to %, simply divide by 10000 or move the decimal point four places to the left.

C. In milligrams per kilogram (mg/kg). This says a feed contains so many mg of some component per kg of the overall feed. Since a kilogram is equal to 1000000 mg, then “mg per kg” is the same as “mg per million mg” or “parts per million”.

D. In milligrams per pound (mg/lb). This says that a feed contains so many mg of some feed component per lb of the overall feed. Since 1 pound is equal to 453,600 milligrams, “mg per lb” is the same as “mg per 453,600 mg”.

Hence since 453,600 will go into one million 2.205 times, to change mg per lb to PPM, simply multiply by 2.205.

To change mg per lb to %, multiply by 2.205 and divide by 10000. To change PPM to mg/lb, divide by 2.205. To change % to mg/lb, multiply by 10000 and divide by 2.205.

**For example:**

**A feed has the following composition on a fresh basis:**

| | |
|---|---|
| Phosphorus | 0.16% |
| Carotene | 110 mg/kg |

1- How many mg /Ib and PPM of phosphorus are in the fresh feed?
2- What is the % carotene in the fresh feed?

Phosphorus 0.16% → mg/lb

0.16×10000/2.205=725.6mglb

Phosphorus 0.16% → PPM

0.16×10000=1600 PPM

Carotene 110.0 mg/kg → %

110/10000=0.011 %

**The composition of feeds may be expressed on any one or more of three dry matter bases**

A- As fed. Sometimes referred to as the *wet or fresh basis.* On this basis dry matter of different feeds may range from near 0% to 100%.

B. Air-dry. May be actual or an "assumed dry matter content" basis. The latter is usually 90%. This basis is useful for comparing the composition of feeds having different moisture contents. Most feeds, but not all, are fed in air-dry state.

C. Oven-dry. Based on a moisture-free or 100% DM state. Also useful for comparing a feeds of different moisture contents.

The different bases may be illustrated as follows:

| | *As fed* | *Air-dry* | *Oven-dry* |
|---|---|---|---|
| % water | May be any % | Usually 10% | 0% |
| % crude protein<br>% crude fat<br>% crude fiber<br>% NFE<br>% ash | This is dry matter—it is always 100% minus the % water | Usually 90% | 100% |

Composition figures expressed on one basis may be converted to another basis by the use of a simple ratio, as follows:

$$\frac{\text{\% of any component in a feed on any basis}}{\text{\% DM in that feed on the same basis}} = \frac{\text{\% of any component in the feed on another basis}}{\text{\% of DM in the feed on the same basis}}$$

Or

$$\frac{\text{\% nutrient (A)}}{\text{\% DM (A)}} = \frac{\text{\% nutrient (B)}}{\text{\% DM (B)}}$$

For example:

If a feed contain 4%crude protein on a fresh basis and 75%water, %of CP. On an air –dry basis would be calculated as follows:

100-75%=25% DM in the fresh material

$\frac{4}{25}=\frac{x}{90}$

25x=360

X=14.4 % CP (in feed on an air –dry basis)

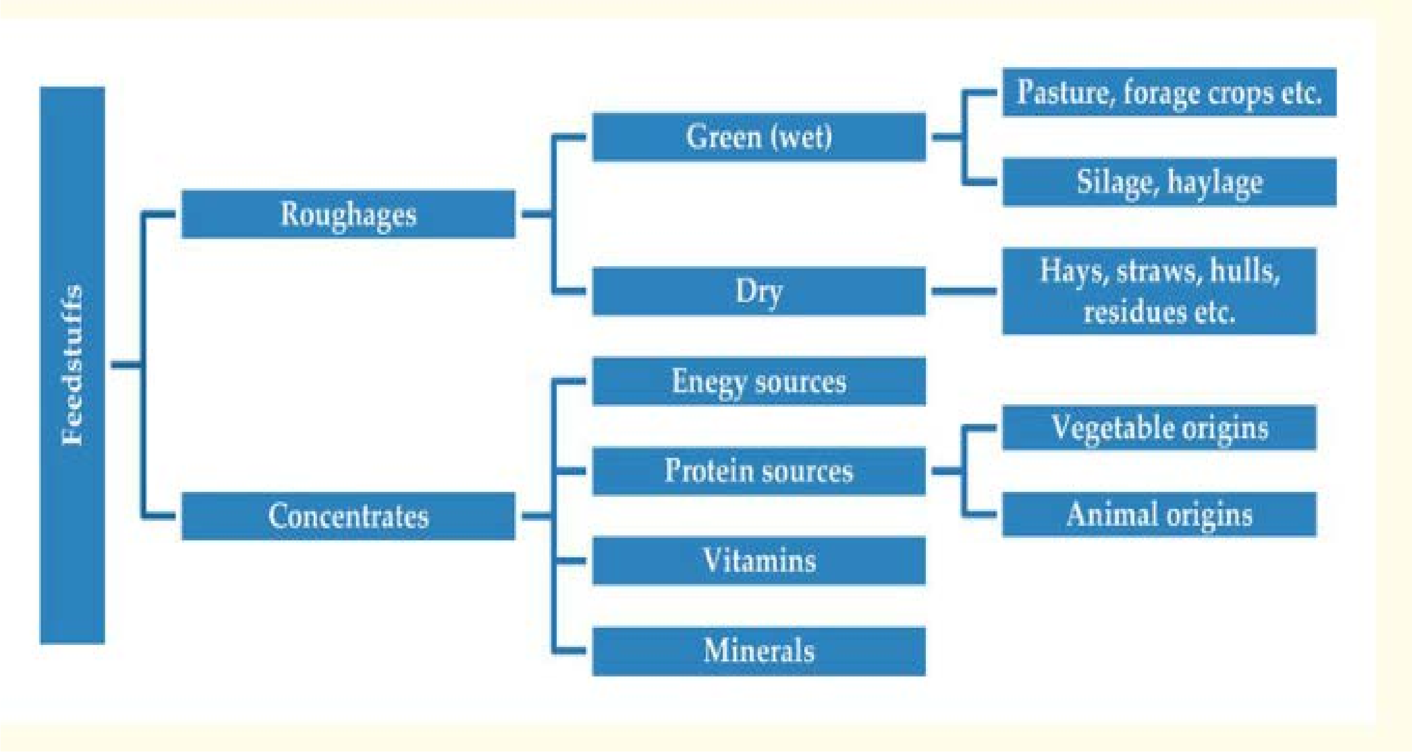
## Feedstuffs Classification

**Learning objectives:**

**1- Describe how feedstuffs are classified and identify the major categories of feedstuffs and their characteristics.**

**2- Identify the nutritive characteristics in various categories.**

**All feeds have been segregated into groups classified according to the scheme (1)**




## FEEDSTUFF CATEGORIES

**1-<u>Dry Forages and Roughages :</u>** Feeds placed in this category contain at least 18% crude fiber, with values ranging up to 50% crude fiber. Dry forages and roughages are high in cellulose, hemicellulose, and possibly lignin and low in readily digested carbohydrates such as starch and sugars (NFE).

Consequently, they generally have a lower digestibility and therefore lower energy values than do concentrates.

The protein content varies from nearly 30% for alfalfa to 2-3% for some straws. Since ruminants and cecal fermenters generally use these feeds, the quality of the protein is not usually a concern.

Examples of feeds in this category are legume hay, grass hays, wheat straw, cornstalks, corncobs, cotton-seed hulls, peanut hulls, and rice hulls.

**2-Pasture, Range Plants, and Green Forages (Succulent Roughages & Forages)**

Examples of feeds in this category are Bermuda grass pasture, sorghum-sudan grass, and wheat pasture. Many of these feeds could be harvested as dry feeds that would be classed in the previous category.

The moisture content of these feeds is usually between 50-85%, but can be quite variable. Wheat pasture can be as high as 90% moisture. Young, well fertilized wheat pasture can have very high crude protein and can be very digestible, whereas late season prairie hay is the opposite.

**3- *Silages***

The process of *ensiling*, the process of producing silage from forage plant material under *anaerobic* conditions (that lack molecular oxygen) produces silage. This is common storage method for livestock feed. The plant material undergoes a controlled fermentation that produces acids.

The acids then kill off the bacteria, molds and other destructive organisms. As long as the silage is left undisturbed, it will keep for years. Many different materials can be ensiled. Corn silage is produced by chopping and ensiling

Other grain-producing species also produce good-quality silage, as do legume forage species, cannery waste, and roots and tubers. One common misconception is that ensiling improves the nutritive content of a feed.

The opposite is actually true. The fermentation process uses nutrients and thus reduces the nutritive content of the material. This category of feedstuff also causes some confusion because the ensiling process can be used to preserve other products such as high-moisture corn.

**Characteristics**

The characteristics of good-quality forage generally include being relatively immature when harvested by manually or by mechanical means; being green and leafy; having soft, pliable stems; being free from mold or mustiness; being palatable; and being free from foreign material.

However, animals need feed all year long. Thus, a part of the growth must be retained to provide feed during the nongrowing months of the year. This feed is consumed as a mature, weathered, low-quality feed during the winter months and is thought of as roughage.

It is common to divide forages & roughages into legumes (e.g. alfalfa, lespedeza, soybeans, and clover) and grasses (e.g. prairie grasses, timothy, Bermuda grass, and wheat). Legumes are generally better quality feed than grasses because legumes have a lower stem and a higher leaf content. Of course there are exceptions. Although wheat pasture is a grass, it may contain from 20-34% crude protein when it is a young vegetative state. This protein level is higher than that of most legumes. For some nutrient parameters, there is actually little difference between legumes and grasses of equal maturity,

But for other parameters, legumes are much higher in nutrient value. As a general rule, legumes and grasses have about the same energy content, but legumes have much higher protein, calcium, and carotene contents. Many variables affect the nutritive content of forages and roughages. These include maturity at the time of harvesting, weather damage, soil fertility, plant species, and harvesting method. Maturity at the time of harvesting is perhaps the most important factor because all nutrients, except fiber, decrease in number with advancing maturity.

Fiber increases with maturity. Young plants may contain only 20% crude fiber, but mature plants may have 40% or more. *Lignin* (Polymers of phenolic acids found in plants as part of the structural components of the plant) also increase with advancing maturity and increasing fiber level.

The rate of change is much greater for some plants than for others. For example, timothy, brome grass, and buffalo grass retain good palatability over a wide range of maturities. Orchard grass and lovegrass are very palatable and digestible when young, but lose these characteristics quickly as they mature.

The effects of maturity are more pronounced for grasses than for legumes. Nutrient changes with advancing maturity and *weathering*.


Love grass

**4- Energy Feeds**

Energy feeds primarily include the cereal grains, by-product feeds made from cereal grains (e.g., corn hominy feed, wheat bran), and fruits and nuts. All are low in protein. Feeds placed in this category called concentrate that contain less than 18% crude fiber or less than 35% cell wall and have a protein content of less than 20%.

Seeds that have a fibrous outer hull are higher in crude fiber. The lower the fiber levels, tends to be the higher energy content because more readily digested carbohydrates, such as starch and sugars will be present. The energy value of grains is high, with TDN as high as 90% on a dry-matter basis.

These values are due to the high starch content (high as 70% or higher), low fiber content, and high digestibility. The by-product feeds in this category usually have somewhat lower energy content because they contain more fiber and less starch as a result of processing.

These feeds are fed to ruminants and cecal fermenters to increase the energy density of their rations.

Energy feeds are by definition below 20% in crude protein content. The cereal grains range between 8-12%. Some of the by-product feeds are higher.

The protein digestibility ranges from 50-80% but the protein quality is generally poor. This is because the essential amino acid content is usually poor for grains. Lysine, methionine, and tryptophan are frequently the *first-limiting amino acids* in these feeds. If not first, they tend to be second or third limiting.

As a general statement, cereal grains are invariably very low in calcium (Ca), modest in phosphorus (P), and low in most trace minerals.

Grains are very low in both vitamin D and carotene, which is a precursor for vitamin A. However, they are generally a good source of vitamin E and do contain some B vitamins.

**5- Protein supplements**

Protein supplements include feeds from three major sources:-

1- Plant origin (e.g., soybean meal, cottonseed meal, and corn gluten meal).

2- Animal origin (e.g., fish meal, dried skim milk, and tankage).

3-non-protein nitrogen (NPN) sources (e.g., urea, purified amino acids, and ammonium salts).

In some management and feeding situation, protein supplements are the largest out-of-pocket expense in the entire program.

Feeds placed in this category contain more than 20% crude protein. Some have high-energy contents as well. However, economics dictate that they be used to satisfy the protein needs of the animal.

Because ruminants can convert the poorer quality proteins to higher quality microbial protein, an effective cost-reduction strategy is to feed the NPN sources to ruminants and avoid the higher quality, and thus more expensive, of these very-high-quality, and thus very expensive, feeds must be used for some rations (e.g., baby pig rations, milk replacers).

The protein feeds of plant origin are primarily derived as an end product of the extraction of the oil from a group of seeds referred to as *oilseeds* because of their high fat content. These protein sources are thus referred to as *oilseed meals.* The most important of these sources are soybeans and cottonseed.

However, significant amounts of flax, peanut, sunflower, sesame, and others are available. The protein content is generally at least 40% and is highly digestible.

The *protein quality* ( A measure of the presence and digestibility of the essential amino acids in a feedstuff) varies but is generally good. Lysine, Cystine, and Methionine levels are commonly low.

Soybean meal is different in that its lysine level is usually higher. The essential amino acid content is usually poor for grains with lysine, methionine, and tryptophan frequently being first-, second-, and third-limiting amino acids in these feeds.

These amino acids may need to be provided as purified amino acids.

As a general statement, the oilseeds are low in Ca and high in P. Caution must be used when balancing rations for monogastrics because half or more of the P can be tied up as phytic-bound forms and is unavailable to the animals.

Oilseeds are low in carotene, which is a precursor for vit. A and E. They are low-to-moderate sources of vit. B.

The protein feeds of animal origin are primarily derived as end products of the meat packing, dairy processing, and marine industries. The most important of these are meat meal, bone meal, blood meal, feather meal, dried milk, and fish meal.

The milk products are the highest quality of the end products and are generally the most expensive. Good fish meals can rival milk products in quality. In addition, they generally contain much higher quantities of total protein.

The lysine content of fish meal is considerably higher than that of other commonly available protein sources. Fish meals are usually good mineral and B vit. sources.

The quality of the protein in the meat products is usually lower than that of milk and fish products. However, the quality is still good and their use is usually restricted to monogastrics. Some of the meat products have high mineral contents, depending on the percentage of bone they contain. The vitamin content is highly variable but generally low because of the types of processing required to make these feeds usable. Feather meal is a low-quality protein supplement, but it is very high in total protein content (over 90%). It is best used in ruminant rations, although it can be used as a part of monogastric rations.

The NPN sources technically include such a wide range of material that generalization are impossible

Urea and similar products must be used with functional ruminants only, and then very carefully. The ruminant microbes are able to use substantial amounts of NPN and, since they are frequently of lower cost than proteins, they are often used to cheapen a ration.

**Table (3 ) crude protein and amino acid contents of some commonly used protein supplements.**

| Ingredients | Dry Matter (%) | Crude Protein (%) | Methionine (%) | Cystine (%) | Lysine (%) | Tryptophan (%) | Threonine (%) |
|---|---|---|---|---|---|---|---|
| Blood meal, animal | 89 | 80.0 | 1.0(91) | 1.4(76) | 6.9(86) | 1.0 | 3.8(87) |
| Brewers dried grain | 93 | 27.9 | 0.6 | 0.4 | 0.9 | 0.4 | 1.0 |
| Brewers dried yeast | 93 | 45.0 | 1.0 | 0.50 | 3.4 | 0.8 | 2.5 |
| Canola meal | 91 | 38.0 | 0.7(90) | 0.47(75) | 2.3(80) | 0.44 | 1.71(78) |
| Casein, dried | 90 | 80.0 | 2.7(99) | 0.3(84) | 7.0(97) | 1.0 | 3.8(98) |
| Cottonseed meal, 41%, direct solvent | 90 | 41.0 | 0.51 | 0.62 | 1.76 | 0.52 | 1.35 |
| Feather meal, poultry | 93 | 85.0 | 0.55(76) | 3.0(59) | 1.05(66) | 0.4 | 2.8(73) |
| Fish meal, herring, Atlantic | 93 | 72.0 | 2.2 | 0.72 | 5.7 | 0.8 | 2.88 |
| Meat and bone meal, 45% | 92 | 45.0 | 0.53 | 0.26 | 2.2 | 0.18 | 1.8 |
| Milk, whole dried, feed grade | 96 | 25.5 | 0.62 | 0.4 | 2.26 | 0.41 | 1.03 |
| Peanut meal, solvent | 92 | 48.0 | 0.42 | 0.73 | 1.77 | 0.5 | 1.16 |
| Soybean meal, solvent | 90 | 44.0 | 0.65 | 0.67 | 2.9 | 0.60 | 1.7 |
| Yeast, Torula, dried | 93 | 48.5 | 0.80 | 0.6 | 3.8 | 0.5 | 2.6 |

[1]Numbers in parentheses represent percent availability.
*SOURCE:* Dale, 1997. Used with permission.

### 6&7 – Mineral and Vitamin Supplements

Virtually all feeds contain at least some vitamins and minerals. Animals need these nutrients in much smaller amounts than they do the other nutrients. Nevertheless, dietary needs must be met in a satisfactory manner to achieve good animal performance and economical production.

Depending upon the feeds used to balance the ration for the other nutrients, concentrated sources of vit. and/or minerals may be needed.

### 8- Nonnutritive Additive

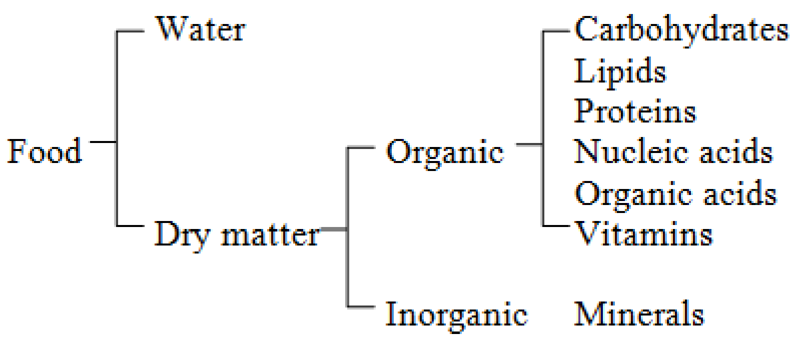
This is a catchall category for a large group of feed ingredients that are added to rations for some reason other than their nutritive value. <u>They may be used to stimulate growth or some other type of production, improve feed efficiency, enhance health, or alter metabolism.</u>

Feedstuffs in this category include <u>antibiotics, coloring agents, flavors, hormones, and medicants.</u> Examples of substances in this category include Monessen sodium (makes rumen fermentation more efficient), aluminum sulfate (used as an anti-gelling agent for molasses, monosodium glutamate (flavor enhancer used in pet foods), propylene glycol (emulsifying agent), .Not all additives are fed. Some can be given to the animal as an injection or implant.

The list of nonnutritive additives changes over time. Those additives classified as drugs must be approved by the Federal Drug Administration (FDA). A good reference to become familiar with is the *Feed Additive Compendium.* Updated yearly, this is an invaluable resource for nutritionists.

## The Measurement of Nutritive Value

### The main components of foods, plants and animals




### Feed Sampling

Sampling feeds is important to determine the nutrient value.

### Recommendations for Sampling Feeds

1-Collect a representative sample (20 tons of feedstuff   1lb sample sent to lab)

2-Sample 10 to 15 places from the feed

3- Probes may be necessary to obtain a good sample

4-Thoroughly mix the sample before taking a sub-sample to send to the lab, send the samples to the lab as quickly as possible.

**The Measurement of Nutritive Value**

**<u>Digestibility</u>**

Measurement of digestibility: In a digestibility trial, the food is given to the animal in known amounts and the output of faeces measured, and <u>More than one animal is used because:</u>

**Firstly** / animals, even when of the same species, age and sex, differ slightly in the digestive ability.

**Secondly/** replication allows more opportunity for detecting errors of measurement.

<u>In trials with mammals, male animals are preferred to females because</u> it is easier to collect faeces and urine separately with the male. They should be docile and in good health. Small animals are confined in metabolism cages which separate faeces and urine by an arrangement of sieves, but larger animals such as cattle are fitted with harness and faeces collection bags made of rubber or of a similar impervious material. Similar equipment can be used for sheep.

The direct estimation of NV involves at least the measurement of digestibility

**<u>Digestibility</u>**:Digestible part of foods or nutrients is the proportion which is absorbed by the animal and is not excreted in the faeces.

<u>Digestible compounds:</u>
Protein ⟶ amino acids
Starch ⟶ glucose
Fats ⟶ fatty acids, monoglycerides

**Digestible nutrient content = nutrient intake – nutrient excretion in the faeces**
Can be expressed as a coefficient or a percentage.

**apparent or true digestibility**

The faeces contains not only the unabsorbed part of food, but also some so called endogenous compounds (erosion of epithelial cells, enzymes etc.).

**Apparent digestibility**: without correction with the endogenous materials.

**True digestibility**: correction with the endogenous compounds.

$$\text{Apparent digestibility} = \frac{\text{Nutrient consumed} - \text{nutrient excreted in faeces}}{\text{Nutrient consumed}} \quad (\%)$$

$$\textbf{True digestibility} = \frac{\text{Nutrient consumed} - (\text{nutrient excreted in faeces} - \text{endogenous losses})}{\text{Nutrient consumed}} \quad (\%)$$

Taking into account endogenous losses is important mostly in the case of proteins and amino acids.

**Endogenous losses in the faeces:**

1-epithelial cells of the intestine

2-enzymes

3-products of bacterial fermentation

**Determination of digestibility**

There are multiple methods for digestion experiments:

**A/ Animal experiments ( in vivo digestibility**)

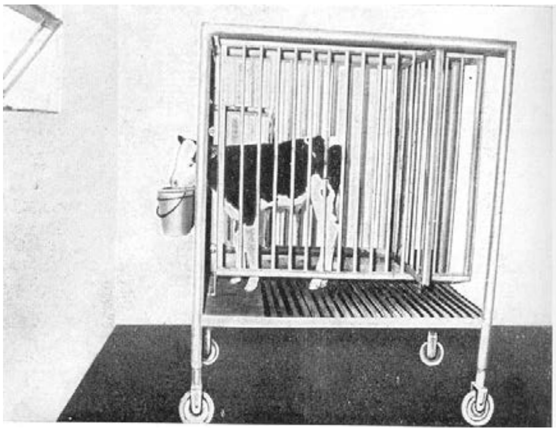
1- Simple digestibility trial (if the feedstuff could be given to the animals as the sole item of diet, such as corn with poultry species, hay for ruminants), and include two periods;

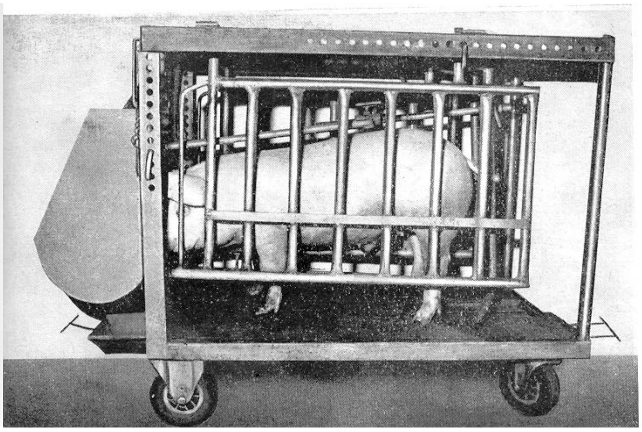
A-preliminary period (10-14 days)

B-experimental (collection) period (3-5 days)

In the experimental period the feed consumed and the faeces excreted must be measured exactly.

$$\text{Digestibility coefficient (\%)} = \frac{\textbf{Consumed nutrient content} - \textbf{excreted nutrient content}}{\textbf{Consumed nutrient content}} \times 100$$





**<u>2. Difference method</u>** (if the feedstuff can not be given to the animal alone, otherwise it can cause digestive disturbances; for example cereal grains with ruminants).

**<u>3. Indicator method</u>**

- If we do not have special balance cages (feeding boxes).
- Total collection is not possible.
- Taking representative excreta samples  enough.

**Indicators, markers**/are indigestible natural compounds of the feed (lignin, acid insoluble ash (silica) and $Cr_2O_3$ (chromium third oxide).

**Characteristic of good indicators:**

1- Should not be absorbed.

2-should not disturb digestion of nutrients.

3-its transit time should be steady.

4-its analysis should be easy .

$$\textbf{Digestibility of nutrients} = 100 - \left(100 \times \frac{\text{\%indicator in feed}}{\text{\%indicator in feces}} \times \frac{\text{\% Nutrients in faeces}}{\text{\% Nutrients in feed}}\right)$$

**<u>4- nylon bag technique</u>**

- Used to determine degradation of protein in basal feeds.
- Requires rumen cannulated animals.
- Feedstuffs contained in bags made from polyester (nylon) cloth are incubated in the rumen for a range of times, and the degradation loss for each incubation time is measured.

Figure 3. Sheep fitted with rumen cannula

**B/ Laboratory methods of estimating digestibility (in vitro)**

**1-Artificial rumen**

- It is not so laborious and expensive .

- The ground sample of feed is incubated for 48 hours with rumen liquor in a tube under anaerobic conditions. After that the bacteria are killed by acidifying with hydrochloric acid and then digested with pepsin for a further 48 hours. The insoluble residue is filtered off, and its nutrient content is subtracted from the nutrient content of the feed. The difference is the digestible part.

**<u>2-Near infra red spectroscopy (NIRS)</u>**

NIR has been used for measuring chemical composition ,invitro digestibility,in vivo digestibility and metabolisable energy.

## C/ Equation used in feed evaluation

$$\text{Digestible DM (\%)} = \frac{\text{DM intake (gm)} - \text{DM in feces (gm)}}{\text{DM intake (gm)}} \times 100$$

$$\text{TDN (\%)} = \frac{\text{(DM intake x Chemical comp. of feed)} - \text{(DM in feces x chemical comp. of feces)}}{\text{DM intake (gm)}} \times$$

**Digestible Energy (Kcal) = Energy intake (kcal) – Energy in feces (kcal)**

$$\text{DE (\%)} = \frac{\text{Energy intake (kcal)} - \text{Energy in feces (kcal)}}{\text{Energy intake (kcal)}} \times 100$$

# Animal Nutrition

- Chemical Analysis Scheme of Organic and Inorganic Nutrients: (K & Mg should be macro)