Animal Protein Sources

Meat and fish byproducts

The principal animal by-products used for feeding stock include meat meal, meat & bone meal, bone meal, fish meal, dried blood or blood meal.

Meat byproducts

Meat byproducts used come from three sources:

1- From meat scrap, fat trimmings and offals at the meat packing plants & slaughter houses.
2- From meat scrap of butcher shops.
3- From dead animals processed for soap grease.

Processing of meat byproducts

The raw byproducts are heated so as to separate out the fat and also to cook to the point of sterilization. Putrid material is not included. The biological value of animal protein is higher but when the flesh is subjected to high temperature for the purpose of sterilization its nutritive value is reduced.

The fundamental in the production of these by-products from animal tissues is the removal of the moisture and part of the fat content by the application of heat or solvent. Thus producing a concentrated product of fairly long keeping quality.

Three processes are possible:

1- The newer dry-rendering method

In this method steam which is used for heating does not come into contact with the feed. The waste meat by-products are cooked in an open steam jacketed vessel until the moisture has evaporated. Then the fat is drained off, the solid residue is pressed to remove much of the fat as possible and the dry residue is granulated or ground into meal. The product is called meat meal or scrap or sometimes dry-rendered tankage. It is lighter colored and does not have so strong an older as wet - rendered tankage.

2- The older wet-rendering method (Digester method)

The food comes in contact with the steam. It is thoroughly cooked by steam under pressure in closed tanks, the fat is then skimmed off, the soapy liquid is evaporated until become gluey (stick) then added to the solid residue where the mixture is dried and ground. This product is designated as digestor tankage or feeding tankage, or meat meal tankage. Dry-rendering process is more efficient than the wet method. Sometimes partly dried blood is added before drying in order to increase the protein content of the product.

3- Solvent extraction method

As the case with oil meals the solvent – extraction method yields the food of lowest fat content.

Meat meal or meat scrap and meat and bone meal

Meat scrap is likely to be largely muscle trimmings. Owing to the nature of the by-products obtained from carcass residue there is a considerable degree of variation in the composition of the product. The feeding meat meal should contain not less than 55 % protein , and not more than 4 % common salt, obtained by drying animal carcasses excluding horn & hoof to which no other matter has been added . Good quality M. meal usually contains 60 - 70 % protein.

Much of the protein, in meat meal and meat-and- bone meal, is derived from collagen, a protein that is a major constituent of connective tissue, including bone. Collagen has an unusual amino acid composition, characterized by a high content of hydroxy-proline and complete absence of cysteine, cystine, and tryptophan. Hair, wool, horns, and hooves are composed of keratin, a poorly digested protein with a very high content of unavailable cystine. Thus the relative amounts of collagens and keratins can have a pronounced effect on its protein quality. In general, meat and bone meal is less palatable and has a lower protein quality than SBM. Usually it is given in conjunction with another animal or vegetable protein to make good its low content of methionine and tryptophan

The fat content varies, depending upon the method of preparation and the nature of the raw material, from about 15-3 % (a useful sample of general feeding purposes usually contains 9 %. Considerable care is required in storing the meat products to prevent the development of rancidity and loss of vitamin potency.

Meat and bone meal is made from condemned carcasses of food animals or from slaughtered ones not intended for human food. It contains not less than 40 % protein and not more than 4 % salt, obtained by drying and grinding animal carcasses and bones excluding hoofs and horns. It is very valuable for breeding & growing young animals as they supply not only protein of good biological value but also the constituents for bone building.

M.S. and tankage are used chiefly as protein supplement for swine & poultry, and may be given at levels up to 10 -15 % of the diet. Their protein effectively corrects the deficiencies in the protein of the cereal grain. Since corn & other grains are low in tryptophan, meat scrap or tankage gives the best result when combined with protein supplement that is higher in this AA.

They are excellent sources of the vitamins of the group especially B_2, B_5, choline and B_{12}. They also supply certain unidentified vitamins that are important in poultry and swine rations. They don’t supply vitamin A or vitamin D. They are rich in Ca & P, chiefly because of the bone content. Meat and bone meal contains 7 -10 % Ca and 3.8 % P. When, because of added bone, tankage or meat meal contain more than 4.4 % P, the word bone” must be inserted in the name, and they must be designated, according to the method of processing, as either meat and bone meal tankage or meat and bone meal. They do not have the special value for dairy cows, beef cattle, sheep or horses that they have for swine or poultry.

Bone meal (Sterilized bone meal)

After boiling to remove the fat and nitrogenous matter, the bones are ground and then sterilized by steam under pressure. The product is a fine powder containing 45 – 84 % calcium oxide and 34 % phosphorus penta-oxide. Sterilized bone flour can be used as a source of Ca & P, for including in the ration for practically all classes of animals.

Blood meal (dried blood)

It is made from the blood of healthy animals. It is the highest in protein of all the packing plant by-products (may reach 80% or more and is high in lysine) but the protein is less digestible. This is due to the fact that the hemoglobin is resistant to proteolytic enzymes perhaps because of the effect of high heat in drying the blood. Processing methods using low temperatures have improved the feeding value. Also the effective biological value of its protein is low as compared to high grade tankage or meat scrap. It is especially low in the EAA isoleucine and low in calcium and phosphorus.

It is a suitable protein food for all classes of stock. If large amounts are given to start with they are liable to cause trouble, some intestinal disturbances with diarrhea. It should be used at levels not exceeding 6-8 % of the diet, because of the AA imbalance.

Concerns inherent in the utilization of the animal feeds

When making use of any of the above products it should be understood that they are complementary foods, the primary purpose of which is to make good efficiency in ordinary mixed rations, therefore it is neither necessary nor advisable to give large quantities.

The following concerns are inherent

1- Susceptibility to autoxidation: As most supplements contain large amounts of fat they are, therefore, vulnerable to autoxidation and rancidity.

2- They are difficult to be processed and stored without some spoilage and nutrient loss. On the other hand, protein availability will be reduced and some nutrients lost if the feed is heated excessively.

3- Sources of bacterial contamination: To prevent this contamination many of the products must be processed and stored in such a way as to prevent bacterial growth. They may be a source of infection as will be mentioned thereafter.

4- Cost: Most are more costly than either plant protein or non- protein nitrogen. The cost will need to be more competitive.

5- Livestock producer should purchase tankage or other products from a reputable source.

Deleterious factors in meat product

It is very important that meat and bone meal and other animal byproducts be properly heat sterilized during processing. Contamination of the product with Salmonella species is a potential hazard. In 1988 - 1989, major problems occurred in the United Kingdom from improperly processed renders products. Contamination of meat meal with Salmonella infected poultry by-products resulted in widespread Salmonella contamination of eggs and broiler meat when the meat meal was used in poultry feeds. An even more serious problem also occurred. The disease agent that causes scrapie in sheep was transferred to cattle through the feeding of meat meal prepared from condemned scrapie-infected sheep. This has resulted in a new disease of cattle, bovine spongiform encephalopathy (BSE) or "raging cow disease". The disease turns normally docile cows into dangerously aggressive creatures. There is now concern that the disease agent could enter the human food supply via the consumption of dairy products and meat. As a result , in 1989 , the British Ministry of Agriculture banned the use of animal protein in cattle and sheep feeds until the situation has been resolved , and the animal protein processing sector of Britain’s livestock feed industry is resigned to the fact that it has lost this market for good . In 1990 nineteen cases of BSE, products, and feeds & feed additives of animal were recorded in Ireland where importation of live animal origin from the United Kingdom was prohibited.

Now corn-soybean meal diets are standard for swine and poultry production. Except for very young pigs, the nutritional needs of all classes of swine can be met be a simple mixture of corn and SBM, supplemented with salt, minerals, and vitamins.

Fish meal

Fish meal, a by-product of the fisheries industry, consists of ground whole fish or fish cuttings, either or both, with or without the extraction of part of the oil. If it contains more than 3 % salt – the salt content must be a part of the brand name. In no case shall the salt content exceed 7 %. An excess of salt is toxic to pigs and poultry.

The feeding value of fish meal varies according to the method of drying (vacuum steam, or flame dried). The older flame drying method exposes the product to a higher temperature which makes the protein less digestible and destroys some of the vitamins. The second factor is the type of raw material used.

Fish meal made from offal containing a large proportion of heads is less desirable because of the lower quality and digestibility of the proteins. A high - fat content may impart a fish taste to eggs, meat and milk. Also such meal is susceptible to be rancid in storage.

Fish tissue contains abundant amounts of amines, which have a “fishy “smell. Fish meal should not be fed to swine and poultry in the immediate period before slaughter, because the flesh may have a fishy flavor. The same is true for laying hens; if they are fed fish meal, the eggs may have an undesirable fish flavor. Fishy flavor is not a problem if the fish meal has been properly and promptly processed, avoiding putrefaction.

The sources of the commonly used fish meals are:

- Menhaden fish meal made from menhaden herring, which is a very fat fish not suited for human food, caught primarily for their body oil. The meal is the dried residue after most of the oil has been extracted.
- Sardine meal or pilchard meal made from sardine canning waste and from the whole fish.
- Herring meal which is a high-grade product.
- Salmon meal which is a by-product of the salmon canning industry.
- White fish meal is a by-product from fisheries making cod and haddock products for human food. Its proteins are of very high quality.

Fish meal is made by drying and grinding the flesh and bones of white fish, and this means that white fish meal contains not only protein but due to the presence of bone, also large quantities of minerals particularly Ca & P. It has on the average 5.36 % Ca and 3.42 % P with a total mineral content of 18.3 %. It also contains an appreciable amount of iodine. In case of fish cuttings that are high in fat or oil, most of the oil is expressed from the product because it is a valuable commodity. A high fat content in the fish meal is undesirable as such fish meal may produce a fishy taste in eggs, meat or milk. Also fish meal high in fat is more apt to become rancid on storage. High fat fish meals may heat in storage and spontaneous combustion may even occur.

Herring meals which are manufactured from fishes which have an oily nature with strong smell must be fed with great care than white fish meal. The meals are more suitable if it contains less than 10 % oil.

Fish meal of good quality has an especially high value for swine & poultry, because of the excellent quality of its protein. However the protein quality in different samples of fishmeal varies decidedly. If decomposition of the fish waste takes place before it is processed, the fishmeal may be injurious and entirely unsuitable for feeding.

Fish meal nutritive value

Protein

Fish meal is very rich in protein containing up to 60.9 %. The protein of good quality fishmeal is of high nutritive value, tending to be more efficient than the protein of tankage or meat scrap as a supplement to the grains. If fish meal contains too large proportion of fish heads, the value of protein is decreased because much of the protein in the heads is less digestible and of lower nutritive value than that of flesh. Fishmeal should be purchased from a reputable company on the basis of protein content.

The protein of a good-quality fishmeal is 92 to 95 % digestible. If it is poorly processed or improperly stored, the digestibility of protein decreases dramatically. Since fish meals are cooked, there is danger that certain amino acids – notably lysine, cystine, tryptophan, and histidine will be denatured, but these losses are minimized when proper processing techniques are used.

Fat

Fish meal usually has 6-10% fat but some is now made which has only 3-4 % fat. Fish is of course a good source of “fish oil” or omega-3 fatty acids, which are of interest in human nutrition. Some have shown that use of fish meal in poultry diets can markedly increase the omega -3 fatty acid content of the chicken meat.

Vitamins

Fishmeal is one of the richest sources of B_{12} among common feeds and also one of the richest sources of unidentified vitamins required by poultry. It is also fair in riboflavin and has considerable niacin. Fishmeal processed under practical vacuum may contain considerable vitamin A & D but other fish meals has little as it is dried in flame driers in which the material is exposed to high temperature. Most of the fat-soluble vitamins are lost during the extraction of oil, but a fair amount of the B vitamins remain.

Value for animals

- ***F.M. for swine:*** Fishmeal gives very satisfactory results as the only protein supplement for pigs, brood sows on pasture. If not on pasture, field cured legume hay should be included to make sure that there is a plentiful supply of vitamin A & D, and B complex vitamins.
- ***F.M. for poultry:*** It is an excellent protein supplement.
- ***F.M. for cattle, sheep and horses:*** It is not palatable for cattle & sheep and is occasionally fed to horses.

There has been interest in the use of fish meal in diets for ruminants as a source of bypass protein. Because of its high protein content, excellent amino acid balance, and low degradation rate in the rumen, fishmeal is a very effective source of bypass protein.

It was noted that fish meal supplementation of a molasses urea diet for cattle markedly increased cattle growth because of its bypass protein contribution. Fish meals are often very expensive, and are employed mainly in diets for poultry and young animals where high quantity and quality of protein are needed.

Other fish processing byproducts

- Fish residue meal: It is the dried residue from the manufacture of glue from non-oily fish.
- Condensed fish soluble: It is a semisolid by-product obtained by evaporating the liquid remaining from the steam rendering of fish. The glue water that comes from processing contains about 5 % total solids. After this liquid is evaporated or condensed, it contains about 50 % total solids. It contains approximately 30 % protein and is a rich source of B vitamins and unknown factors. They are particularly rich in pantothenic acid, niacin and vitamin B_{12}.
- Dried fish solubles: They are obtained by dehydrating the glue water of fish processing. It contains at least 60 % crude protein.

Use of fish in diets of fur animals

Mink and foxes, being carnivores, require high protein diets generally based on animal products such as meat and fish. “Trash fish" are often sold to fur ranchers; these are fish not marketable for human consumption for some reasons. Some are very bony, others are unattractive in taste, flavor, or physical texture. Fish of the carp family, among others, contain an enzyme (thiaminase) that split apart and destroys vitamin B_1, (thiamin). Feeding raw fish to mink or foxes may induce a thiamin deficiency known as Chastek’s paralysis, named after the Minnesota fox farmer who first observed it. Thiamin deficiency results in signs such as convulsions, head retraction (star-gazing posture), reduced body temperature, paralysis and death. Affected animals respond very rapidly to thiamin administration. It is interesting that the thiamin –destroying enzyme occurs not only in fish, but also in some plants such as bracken fern and horsetails, and in rumen microbes (e.g. Clostridium spirogenes).

Mink fed certain marine fish may become anemic and have unpigmented hair, producing a condition called cotton fur syndrome. Fish such as Pacific hake contain an amine, trimethylamine, and its oxide, trimethylamine oxide, which during cold storage of the fish are converted to formaldehyde. Formaldehyde and trimethylamine oxide impair iron absorption and cause iron deficiency anemia. Because iron is a co-factor of enzymes that convert the amino acid tyrosine to the hair pigment melanin, iron deficiency result in achromatrichia (lack of hair pigmentation).

Fish are sometimes preserved at sea by the use of nitrates. Nitrates react with amines in fish to produce nitrosamines, which are carcinogens. Outbreaks of liver cancer in mink and foxes in the US, Canada, and Norway have been traced to nitrosamines in nitrate-preserved fish.

Other fish and marine products

1- Liquefied fish prepared by allowing fish or fish by-products to liquefy as a result of hydrolytic enzymes in the fish. The fish is ground and mixed with acid (e.g. formic acid at

3.5 % of total mix.) to lower the pH to a level (pH 2 to 4) that prevents bacterial spoilage. Liquefied fish can be used as a protein supplement for wet (slop) diets for pigs and can be used in liquid feeding systems.

2- Fish silage made by the addition of lactic acid bacteria such as Lactobacillus acidophilus to ground fish, resulting in fermentation and stabilization by the organic acids so produced. Liquefied fish and fish silage are stable and may be stored for extensive periods. Because of the extensive degradation of the fish proteins to short peptides and amino acids in these products, the bioavailability of the protein is very high.

3- Shrimp meal is dried waste of the shrimp industry. Shrimp, crabs, other crustaceans, and many insects have an exoskeleton composed of chitin, a cellulose-like polysaccharide which is of low digestibility in animals. Chitin contains nitrogen, which is nutritionally unavailable. The protein content should be corrected to account for the chitin content. For e.g. the protein content of shrimp hulls is 45 to 46 %, but the non-chitin content is only 23 %. A crude fiber determination on these products provides a reasonable estimate of the chitin content. Chitin contains 7 % nitrogen (43.75 % crude protein equivalent). Chitosan is a derivative of chitin, prepared chemically by removing acetyl groups from the acetylglucosamine groups in chitin.

4- Crab meal (shells, viscera, unextracted meat) feeding value depends largely on the chitin. It has a very high Ca content. There is some evidence that feeding a source of lactose (e.g. whey) will increase microbial digestion of chitin in the gut of poultry. Chitin can be used fairly well by ruminants because of the chitinase activity of rumen microbes. It is recommended to constitute not more that 10 % of the total ration of beef cattle or 15 % of the concentrate mixture and a period of adaptation is necessary to obtain adequate levels of chitin-utilizing microbes in the rumen.

Hydrolyzed feather meal, hair meal, and leather meal

- Feathers are almost pure protein (85 – 90 %), however is primarily keratin, which has a very low digestibility. Raw feathers are almost completely indigestible. If they are cooked with steam, internal bonds in the keratin molecule are broken and the product, hydrolyzed feather meal, is of high digestibility. It is deficient in lysine, histidine, tryptophan and methionine but has high cystine, and somewhat unpalatable. Those amino acids which are present are readily available. It should not be fed at more than 5 to 7 % of the diet for swine and poultry. The addition of fish meal or meat meal tends to complement feather meal and facilitates its use. Ruminants can utilize feather meal rather well. Levels up to 10 % have been used successfully in concentrated feeds for dairy cattle. Feather meal should be included in ruminant feeds gradually since sudden addition of it may decrease feed intake.

- Hydrolyzed hair (about 95 % CP) is similar in feeding value and they compare favorably with cottonseed meal as nitrogen sources for ruminants. Hydrolyzed hair is prepared from clean undecompsed hair by heat and pressure. At least 80 % of the CP content must be digestible by the pepsin digestibility method. The protein is extremely deficient in the AAs methionine, lysine, and tryptophan, thereby dramatically reducing its feeding value.
- Hydrolyzed leather meal is a byproduct of the tanning industry. It is a poor quality protein consisting largely of collagen. Chromium compounds are used in the tanning process. The chromium poisoning is a concern when tannery byproducts are used. The chromium level should not exceed 2.75 % of the by-product. Hydrolyzed leather meal contains

approximately 75 % CP and can be used successfully at levels up to 6 % in diets for ruminants.

Synthetic Amino Acids

Sources of feed-grade lysine, methionine, threonine, and tryptophan have become available. They are produced by bacterial fermentation.

Only the L-form is used in protein synthesis. In some cases, the D–isomer can be converted to the L – (e.g., methionine), whereas in other cases (e.g., lysine) it is not utilized. Thus the common forms available in the feed industry are DL – methionine and L- lysine. Methionine is also available in a form called methionine hydroxyanalog (MHA), which has a hydroxy group instead of amino group. MHA is converted to methionine in the liver. MHA is available in a liquid form. On a methionine equivalency basis, allowing for the difference in molecular weights, there is no appreciable difference between MHA and DL – methionine in their nutritional value.

Another amino acid like compound available commercially is taurine. Taurine is not a dietary essential for livestock, but it is for cats. Deficiency results in cats in degeneration of the retina of the eye and impairment of vision. It is a S-containing compound (an amino sulfonic acid) that is a derivative of sulfur amino acids. Taurine is added to pet foods.

An interesting concept for meeting amino acid needs is the use of genetically modified bacteria that excrete large amounts of a specific amino acid (genetically altered Lactobacilli secrete lysine). The last can be used to produce fermented grains with superior lysine contents. It should be possible, using biotechnology techniques, to introduce genes such as these into normal intestinal flora so that amino acid supplementation could be provided by the gut microflora.

When synthetic amino acids are used, consideration should be given to the adequacy of the diet for meeting metabolic requirements of the nonessential amino acids. Nonessential AAs are not required per se in the diet, but they are required metabolically for protein synthesis.

There may be a shortage of amino acids for interconversions to form the nonessentials. The amount and source of nonessential nitrogen may influence the performance of chickens. Under certain conditions, such as heat stress, it may be desirable to minimize the level of excess nonessential amino acids, as energy is required to deaminate them and shunt them into pathways of carbohydrate or fat metabolism.

Bypass, Escape, Nondegradable proteins

Microbial protein has a less favorable amino acid balance than many dietary proteins. Thus, in many cases, protein would be used more efficiently if it “bypassed" rumen fermentation and went directly to the small intestine. The terms “bypass" “escape" and “nondegradable" protein are used synonymously.

There has been interest in attempting to determine the bypass potential of protein supplements, however total success has not been achieved to date.

Corn has the greatest bypass protein potential, but the protein is deficient in lysine and methionine. Some animal protein sources have the greatest bypass potential; blood meal, meat meal, and fish meal are among the highest.

Another material with bypass potentially is MHA, which is quite stable in the rumen and is absorbed from the small intestine and converted to methionine in the liver.

Factors increasing the bypass potentials

Physical factors

1- Drying of forages causes denaturation of the soluble cytoplasmic leaf proteins.
2- Heat treatment, SBM and CSM prepared by the mechanical expeller or screw press process, in which considerable heat is generated, have greater bypass activity than those prepared by solvent extraction.
3- Controlled nonenzymatic browning, by reacting SBM with xylose in the presence of heat may offer potential as a processing method to improve bypass activity of proteins.
4- Treatment of proteins with whole blood, possibly coating them and providing a physical barrier as blood protein is not easily degraded in the rumen. A similar but lesser effect was achieved by using fish hydrolysate (resistant to rumen degradation).
5- Coating proteins with calcium soaps of long – chain fatty acids (rumen inert fats). This procedure supplies both bypass protein and energy.

Chemical factors:

1- Treatment of proteins with formaldehyde or tannins renders them resistant to rumen digestion without impairing intestinal digestion.
2- Sodium hydroxide (2 g/ 100 g DM) treatment may result in cross linkages between AAs in proteins , thus protecting them from microbial attack.

New and Unconventional Sources of Protein

Leaf protein concentrates (LPC)

Leguminous plants as alfalfa are rich in protein and unfortunately when sun- cured for hay, losses of 15 to 40 % of the DM are incurred, most of which are leaves, and if ensiled, many of the water-soluble nutrients are lost due to leaching. Leaves could then be separated, thereby yielding a high protein leaf meal and stems could then be fed ensiled or dehydrated or form a medium-protein dry roughage. Unfortunately this is not economically feasible and due to the high cost of processing, alfalfa meal is currently being used primarily as a supplement to provide vitamins, xanthophylls, and unidentified factors.

There is also a great potential for LPC development from vegetable packinghouse by-products and field wastes.

The protein in forages (as alfalfa contains large amount) has a good amino acid balance for nonruminant animals and humans. However, it is in a package unsuitable for direct use except to ruminants and other herbivores. Forages are unpalatable to swine, poultry, and humans, their fibrous nature makes them of low digestibility, and the digestive tract cannot accommodate a large volume. The challenge can be met by fractionation of forages to separate the protein from the fiber. Fractionation involves pressing or squeezing the juice out of green plants, followed by coagulation of protein in the juice by heat to produce a protein curd. The curd can be separated from the solubles by settling, filtration, or centrifugation. The protein fraction is referred to as leaf protein concentrate (LPC). About 25 to 50 % of the protein in the leaves can be found in the juice. The high protein liquid concentrate can be fed to animals in its crude form or coagulated and used as a solid protein supplement. It can be fed in the wet form, especially to pigs. The dried has a CP of 50- 60 %. It is equivalent to SBM but the economics of production are not favorable. LPC is a bright green color, but, by appropriate processing, can be bleached to be suitable for direct incorporation into human foods.

Alfalfa juice as the sole protein supplement (swine) gave very poor results, with poor growth and signs of salt toxicity. The juice has a very high K concentration, which along with its high content of other cations such as Na, Ca and Mg, causes toxicity due to electrolyte overload. Alfalfa juice is thus unsatisfactory as a protein source for non-ruminants, except at low levels.

The deproteinized juice remaining after removal of the protein to produce LPC can be used as a feed for ruminants and referred to as alfalfa molasses. It has a feeding value of about 78 % of that of cane molasses for feedlot steers.

Single cell protein (SCP)
It refers to bacteria, yeast, algae, and fungi. These organisms have high protein content. Single – cell organisms can be used to purify sewage and animal and industrial wastes. Because of rapid rate of cell division, they have a high DNA content and a high nucleic acid level. Nucleic acids are digested in the rumen and small intestine by nucleases. In ruminants, nucleic acids can be used as a source of NPN, whereas in simple non-ruminants they are not useful nutritionally. Nucleic acids are excreted by being metabolized to uric acid. In most animals, uric acid is further metabolized to allantion, a more water – soluble compound, which is excreted in the urine. In some humans, the conversion of uric acid to allantion is insufficient. Uric acid may precipitate out of the blood and cause accumulation of uric acid crystals in the joints. Thus condition known as gout is aggravated by consumption of foods with high nucleic acid content.

The green algae Chorella has been evaluated as a feedstuff and as an organism for purifying wastes. It can be grown in lagoons or vats fertilized with sewage, swine manure or other animal wastes. Algae production might be a feasible way of recycling human wastes in spacecraft or extended missions or on permanent space colonies. They have a high concentration of protein and are excellent sources of xanthophyll and carotene pigments.

The blue-green algae; Spirulina maxima has been used as food by people in Chad in Africa and in Mexico. It is sold in “health food “stores as a food supplement for humans. It contains 65 to 70 % CP and can be grown in lakes and waters too alkaline to be used for irrigation. The high pH insures an abundant supply of CO_2 for photosynthesis. It can produce 125 times as much protein per acre as corn, 70 times as much as fish farming, and 600 times as much as cattle production. The major expense in use of algae as an SCP source is the harvesting of the small cells, by centrifugation, precipitation, or flocculation. Another problem is that cultures tend to “crash” with infection by wild species thus it requires constant management skill.

Other SCP sources include bacteria, fungi, and yeasts. In Britain, bacteria have been grown commercially on by-products of petroleum refining, such as paraffin. Yeasts have also been produced on substrates of petroleum hydrocarbons and wastes of sulfite process paper manufacture.

Mixed populations of microbes are produced in waste water treatment processes by yielding activated sludge that might be employed as feeds. So long as toxic heavy metals or other toxic wastes are not introduced into the system, activated sewage sludge can be a potentially useful feedstuff.

Aquaculture – produced products

Aquaculture may be used in the purification of waste water. In the Orient, carp have been used for thousands of years in an integrated system whereby human and animal organic wastes are used to fertilize fish ponds, thereby providing an effective waste treatment system and fish for food or feed.

A polyculture of carp species is used, so all ecological niches of the pond are utilized. For example, grass carp consume filamentous algae and aquatic plants, silver carp utilize phytoplankton, bighead carp feed on zooplankton, and the omnivorous common carp feed on molluscus, bottom organisms, and fecal matter of other fishes. This kind of system is high – yielding without the need of inputs of expensive feedstuffs. Tilapia species fast- growing warm - water fish, are also useful in polyculture systems.

In developing countries , where there is a greater need for maximizing efficiency of food production , such as aquaculture system could be used in recycling animal wastes to produce high –protein fish that could be also fed to swine and poultry . The enriched water is useful in crop irrigation.

Insect meals

They have been used as food sources by humans in some parts of the world. Fly meal (dried housefly pupae) has been tested as a feedstuff for poultry (insects are readily consumed by free – ranging poultry). The main interest in fly pupae has been as a means of disposal of poultry manure, with the production of fly meal as a secondary consideration. Fly meal can substitute for SBM in poultry diets.

Silkworm pupae are a by-product of the silk industry and have been utilized in poultry feeding. Because insects are part of the natural diet of poultry, they might utilize insects more efficiently than other animals. Chitinase, the enzyme capable of hydrolyzing the chitinous exoskeleton of invertebrates, does occur in the stomach of some insect eating birds.

Soldier fly larvae grown on cattle manure were an acceptable protein source for swine. The larvae contained 42 % CP and 35 ether extract. Dried bee meal containing 62 % CP has also been tested.

Milk and Milk by-products

Milk is practically indispensable for young mammals during the earliest stage of growth. Whole milk containing the fat has the following nutritive varieties:-

1- It is easily digested and assimilated, has a very high nutritive value per one Ib of dry matter.
2- It has an abundance of high quality protein.
3- It is rich in Ca and P.
4- It provides plenty of energy in the fat & milk sugar.

5- It is high in vitamin A value if produced by animals fed good rations. It is rich in riboflavin and is a good source of niacin, B_{12} and other B- complex vitamins.

The milk sugar tends to increase the assimilation of Ca and P, and to prevent putrefaction in the digestive tract. Milk is not a perfect food for exclusive feeding to animals over long periods. It has but little iron and Mg. The content of vitamin D is rather low & it is not rich in ascorbic acid.

Colostrum

The milk yielded by the mother for a short time after birth differs greatly in composition from ordinary milk and it has very important functions, the most indispensable of these is to supply antibodies to protect the newborn animals against certain diseases especially of the digestive tract. Colostrum is very rich in protein (17%). A large part of the protein consists of globulins which are present only in traces in ordinary milk. For short time after birth the globulins carry the antibodies can pass through the intestinal wall and enter the blood stream however in a day or two the intestine becomes impermeable to the globulin. Colostrum is also much richer than ordinary milk in vitamins especially vitamin A and in minerals.

Whole milk: (NR of buffalo's milk 1:3.9 & cow's milk 1: 3.6)

Whole cow's milk is too valuable for human food to be given to livestock under usual conditions except in the case of young dairy calves until they become old enough to live on other feeds. It is not necessary to continue the feeding of whole milk to calves longer than 2 -4 weeks if a plentiful supply of skim milk is available.

Skim milk: NR 1: 1.5

Because of the removal of most of the fat skim milk is slightly higher than whole milk in content of protein, milk sugar and minerals. Because of the low fat content (0.1%) skim milk supplies but little vitamin A value. Skim milk also furnishes considerably less energy than the whole milk per 100 lbs. Skim milk is rich in riboflavin and is a good source of vitamin B_{12} and other B-complex vitamins.

In feeding skim milk it should be kept in mind that it is very high in protein on dry matter basis. Because of this there is no need of having other protein supplement in the ration when sufficient skim milk is used. It should be fed with cereals or other concentrates low in protein. It is used chiefly for dairy calves, pigs and poultry. It has especially high value for poultry because of their richness in riboflavin.

Skim milk for poultry:

It has a high value for poultry not only does milk furnish excellent protein but also its high content of riboflavin is of particular value for poultry. Also milk supplies niacin, vitamin B_{12} and certain of the unidentified vitamins. In addition milk is rich in Ca & P. It has also a beneficial effect deduced by milk sugar in helping to prevent the development of undesirable bacteria in the digestive tract.

Whey

In making cheese practically all the casein and most of the fat go into the cheese leaving into the whey the milk sugar, the albumin and a large part of ash. Whey has only about one third as much Ca and P, as that of skim milk. It is nearly as rich in riboflavin as skim milk.

Whey for dairy calves

It can be successfully used for calf feeding if it is fed with a suitable protein – rich grain mixture and if it is of sanitary quality.

Whey for poultry

Whey in liquid from is not often fed to poultry but when available it can be given as a drink or used to moisten the mash. It must be remembered that whey is low in protein however it will fully take care of the riboflavin requirements.

Animal protein source

Blood meal

Meat and bone meal

Fish meal

Forages-green fodders

Legumes

Advantages of legume forage

1- They are the richest in crude protein of all common forages. Therefore their use greatly reduces the amount of protein supplement needed to balance a ration and they serve especially for building the muscle and other body tissues.
2- Their protein corrects the deficiencies in the proteins of the cereal grains.
3- They are the highest in Ca among all feeds. Calcium is required in large amounts by growing, lactating and pregnant animals. If dairy cattle, beef cattle, sheep or horses get plenty of good legume forage there is no need to add a Ca supplement to the ration. Legume roughages are not rich in P, containing less than the cereal grains, however their P content is generally a little higher than that of forage from corn, sorghums, or the grasses.
4- They are rich in vitamin A value.
5- Good quality field-cured hay is the richest source of vitamin D among common feeds (only 5 % of field –aired hay in the ration will generally furnish enough vitamin D for pigs).
6- Legume forage is rich in other vitamins. Plenty of good legume hay will usually supply ample amounts of the other vitamins needed by livestock except in the case of poultry which have especially high requirements for riboflavin & other B- complex vitamins.
7- Legumes are highly important in maintaining soil fertility. Through the action of the legume bacteria in the nodules on their roots, legumes use during their growth free nitrogen gas from the air. Not only do legume crops aid in maintaining nitrogen supply in the soil but also they increase the yield of succeeding crops by rendering the soil nitrogen more active and available, and by producing other benefits (improving soil structure as its roots open up soil layers and furnishing organic matter to keep the soil particles aggregated and porous).Through the proper utilization of roughage from the legumes, the amount of concentrates needed to provide balanced rations may be greatly reduced. Indeed for many classes of animals mere legume hay and cereal grains furnish a most suitable combination.

1- Berseem or Egyptian clover or Trifoluim Alexandrinum: N.R. 1:4

It is one of the most important crops in Egypt given to livestock either green or hay, chiefly grown in Lower Egypt with very large areas in middle Egypt.

Immature berseem is exceedingly watery but when cut at full bloom, the berseem yields the largest amount of derris (hay) that contains more ash, CP, NFE, and fat. After full bloom the fiber increases and the other nutrients decrease due to withering and dropping of the leaves. This points to full bloom is theoretically the best time of cutting derris. The practical experience, however, places the time somewhat later, or when about one third of the bloom heads have turned brown.

There are four varieties of berseem in Egypt

1. Miscawi

It is the most important one. It gives 3-5 cuttings. It has a long stem (but less than fahl) which has many branches, begin directly from under the ground.

2. Fahl

It gives one cutting only. It has a thick, strong and long stem which branches along its length. The fahl is the best kind for making hay.

3. Saidi

It gives two or three cuttings. It has a thin weak stem which branches from below as well as along its length. They have less leaves.

4. Khadrawi

It is not largely grown as it needs more water supplies. It looks like Miscawi as it is an improved kind of Miscawi. It gives one or two cuttings more than Miscawi. It has plenty of leaves.

The berseem season begins usually in Egypt at the end of November and terminates at the beginning of May. Watering berseem after the elapsing of the tenth day of May is forbidden (so cotton worm cannot get a suitable media for its growth). The time elapsing between sowing and 1st cutting is about 45 – 60 days, and the second cutting appears in from 35 to 40 days. One feddan yields from 25-30 tons of berseem per year. One kerat yields per one cutting an average 250 – 300 kg berseem. Cultivated space allowed for each of our animals is approximately as follows:

Buffalo: 2/3 feddan	Donkey: ¼ feddan
Horse or mule: ½ feddan	Ox: ¼ feddan
Cow: 14 kerat to ½ feddan	Camel: 14 kerats

Sheep usually pickup what is left by the other animals and are usually not allowed uncut berseem. The water in green berseem is about 85 to 86 % and on this account care must be taken in starting animals on berseem after the exclusively dry summer rations. In localities where fogs occur the damp young berseem in the early morning is particularly liable to cause bloating which is extremely dangerous especially to sheep. Some tibn or derees may be given beforehand. Quick help must be resorted to by puncturing at once the bloated rumen with a trocar and cannula.

2- Berseem hegazi (medicago sativa): NR 1:3.4

It is superior to ordinary berseem in feeding value. The plant roots may remain in the soil for 7 years. It is not so largely grown in Egypt. As the plant grown also in summer time the cotton worm then finds a suitable green plant to feed on, thus spreading to the adjacent cotton fields. The plant roots penetrate deeply in the soil. It looks like Miscawi but the stems are somewhat tougher.

3- Kashrengaig or Lablab

It is a leguminous plant grown mainly in Upper Egypt. The green plant is used as a valued fodder for feeding animals. Its seeds are boiled and eaten by the Upper Egypt farmers or they may be ground either mixed with millets or alone and consumed as bread or its green pods may be cooked and relished as a vegetable. There are two local varieties:

1- Baladi **2- Sudani**

The latter is preferred if green fodder is to be obtained as its stems and leaves are larger, and more abundant than those of the baladi and its seeds are also bigger in size.

The baladi is grown for the production of seeds which are mainly used as a food for the farmers in those regions. The first cutting is taken from 40 – 60 days after sowing, then a cutting each month or each three weeks according to the method of watering. Four cuttings may be obtained in one season. The growing season is from August till the end of October. So we can have a green fodder for our animals in summer when berseem is not present. Its seeds have a N. R. of 1:2.4 and they may be advantageously given to farm animals instead of beans when the latter are expensive.

Grasses

1-Green corn or Darawah: NR 1:24.8

It is a grass usually of the kind known as "Dhowra shami ". It should be green, freshly cut, not exceeding 130 cm in length and not less than 60 cm. (lest poisoning from the hydrocyanic "prussic" acid which forms one of the components during the plant growth). All the cereal grains can be utilized as forage, by harvesting for hay, silage, or use as pasture. Young, rapidly growing areas of plants and areas of regrowth after cutting often have high cyanogenic glycoside content.

Darawah is the green ration available during the non-berseem season in most parts of Egypt. It makes a good and pleasant addition to the dry feed. It can be fed in the same quantities and in a similar manner as berseem.

Darawah contains 12.9 % TDN, 0.5 % DCP. If it is fed as delivered, the coarse stems are often left by the animal, to avoid this, the coarse portions should be cut off, chopped in the chaff cutter and fed mixed with the grain ration.

Like corn grain, corn forage is high in carbohydrates and low in protein. It is fair in Ca especially if grown on soil well supplied with Ca; it has 0.25% or more on dry basis. It is low in P and also depends somewhat on the P supply in the soil. Green corn forage even from white corn is high in vitamin A value. Also it may supply considerable Vitamin D found in the dried parts as leaves or husks. In giving darawah it must replace part of the tibn in the ration at the rate of 3 lbs darawah instead of 1 1b tibn.

2-Sudan grass

It is a close relative to the sorghums, is tall annual grass introduced recently into Egypt, the stems are fine, being seldom larger than a lead pencil. It furnishes fair pasture, but should be used with caution on account of the danger from prussic acid poisoning as with the other sorghums. The prussic acid largely disappears from the sorghum when it is cured. Normally the full grown sorghums and Sudan grass are entirely harmless, for they contain no prussic acid or only such small amounts that no poisoning is produced.

It furnishes dairy animals with green fodder in the non-berseem season. Its feeding value is similar to that of green darawah.

3-Swamp, barn-yard grass

It is grown in some areas in Lower Egypt as green fodder. It is also grown naturally on the banks of canals and ditches. It may grow so abundantly that if may block water courses especially the narrow ones. It is rich in carbohydrates and contains about 24 % TDNs and about 74 % water content.

4-Deccan grass

It grows naturally as a weed in the cultivated land. The farmers gather and offer it to rabbits, which like it so much, that it is sometimes called rabbit grass. It has about 28 % TDNs and about 68.5 % water content.

5-Bermuda grass
It grows in gardens & in cultivated land as a weed. It may be suitable as a grazing grass in semi-arid areas for animal raising. It has about 30 % TDNs and about 67 % water content.

Silage

Silage is the material produced by the controlled fermentation of a crop of high moisture content. The purpose of making silage is to preserve the green fodder to be used in summer season. Ensilage is the name given to the process and the container is called the silo. The fermentation is controlled either by encouraging lactic acid formation by bacteria present on the fresh herbage, or by direct addition of a weak acid solution. A wide variety of crops may be preserved by ensiling; these include grass, grass clover mixtures, legumes, green cereals, root tops, sugar beet pulp, potatoes & fruit residues. Grass, however, is the commonest crop to be made into silage.

Principles of ensilage process

When green fodder of suitable crop is placed in a compact mass in a silo, the following changes will take place:

a. For a time the plant cells will still living and respiration continues using the oxygen entrapped in the mass & produce carbon dioxide.
b. Within 5 hours practically all the oxygen disappeared and this prevents the development of moulds which are unable to grow in the absence of oxygen.
c. Acid –forming bacteria multiply enormously in the silage and at the end of 2 days each gram of silage juice may contain one hundred billion bacteria attack the sugars in the green forage, producing organic acids, chiefly lactic acid, with some acetic acid and traces of other acids and also alcohol. The production of acid is the most important change in the process, for the acidity prevents the growth of undesirable bacteria.
d. When enough acid has been formed the fermentation is checked and finally the action practically ceases. If air does not gain entrance, the silage will then keep for long periods with but little changes. If air does penetrate, as through a crack in the silo, the silage will mold and spoil around this spot.
e. The amount of acid formed depends chiefly on the percentage of sugar in the crop. If the forage does not contain enough sugar, sufficient acid may not be produced to prevent spoiling of the silage.

So it is important in making silage to:

1- Reduce respiration to the lowest possible level by exclusion of air. This can be done by careful and thorough treading and sealing.
2- Stimulate lactic acid fermentation in order to suppress all other forms of fermentation.

Different processes of making silage

1- Making silage without addition of accessory material

"This is for crops reached maturity and subsequently low in protein"

a. Warm or sweet fermentation process

In this method the temperature of the mass of fodder is permitted to rise by allowing the retention of certain amount of air during ensiling. The temperature may rise to 120˚F but not more. If that temperature rises, the respiration increased with loss of carbohydrate and the lowering of their digestibility.

b. Cold fermentation process

This process depends on the exclusion of air and the temperature is not allowed to exceed 80˚ F. Special silo must be used and the material pack tightly and the silo sealed with layer of soil.

Both these process depend upon the carbohydrate in the crop to supply the material for fermentation to lactic acid. In order to ensure an adequate supply of carbohydrates the crop must be cut at a fairly advanced stage of maturity. If grass or silage crops are cut in young stage, they have not sufficient carbohydrates for rapid lactic acid fermentation and so other undesirable organic acid will be formed, and the result will be sour silage with high percentage of butyric acid.

II- Making silage with addition of accessory materials

"Suitable for young crops high in proteins"

a- Regulation of the acidity of the mass by addition of acids

The presence of lactic acid in concentration of 1 – 2 % in good silage and its preservative action have led to the addition of both organic and inorganic acids to raise the acidity to such a level that undesirable changes occurred.

The A.I.V. method

This Finnish process named after the originator A. I. Virtanen. The fodder must be made in special container or silo to exclude air as far as possible. The mixture of acids used in this process varies, but generally consists of hydrochloric and sulphuric acids. These acids are added to material during ensiling in sufficient quantity to lower the pH value below 4.

Drainage facilities must be provided to allow fairly free escape of the effluent which is too acid to retain. The fodder is filled into the silo in layers 4-6 inches in depth, each layer being sprayed with appropriate volume of diluted acid solution. When the silo is full, the whole is sealed off with a layer of soil.

Since molds are liable to develop at an acidity of pH 3 - 4, the degree of acidity to which the mass is brought, a special anti-mould preparation is sprayed on the surface before it is sealed. When the fodder is fed, an allowance of Ca carbonate is added to ensure that the ration is not too acid and that the Ca carried away in the effluent is replaced in the animal diet.

b- Stimulation of lactic acid formation

The molasses method:

The addition of sugar is the obvious way of hastening the formation of lactic acid. As in the A.I.V. method, the air tight silo is required. Crude sugar or molasses are added during filling at the rate of ½ - 1 lb of sugar /100 lbs. of fresh fodder. The best way of adding the sugar is in solution since even distribution is ensured. When molasses are used, the quantities 1- 2 % are doubled. The solution is sprayed on the material in layers. After filling is complete, the silo is carefully sealed off with a layer of soil. There must be no free drainage.

Silage of excellent quality can be made in this way where the losses in the feeding value are low. It is also possible, using a combination of the acid and molasses methods, using less acid than in the A.I.V. and supplemented by small quantity of molasses.

The nutritive value of silage is governed by three factors:
1-Chemical changes occurring within the mass
2-The nature of the crop ensiled
3-The degree of effluent production

Feeding of silage

Ordinary silage as usually made has a feeding value on a dry matter basis equivalent to average hay; generally 2 – 3 lbs. of ordinary silage will replace 1 lb of grass hay. A.I.V. fodder or molasses silage made from high protein young plant may have double this value. Also silage may replace part of concentrated food 56 lbs A.I.V. fodder made from young plant and 4 lbs. hay would keep a cow giving 20 lbs. milk during summer months.

Properly made silage is yellow green in appearance and has a fruity smell. Sweet dark brown silage which is to be found in some parts of a silage stock is possible, but has become less digestible.

Sour silage due to butyric acid is unpalatable and harmful to the stock. During making, the temperature of the silage rises and until this has subsided, it should not be fed to stock. As general, 8 weeks should elapse between the time that filling has been completed and time it is fed to stock up to 60 lbs/ head / day. After silage is removed from the silo, it should be fed at once, for when exposed to air any length of time it becomes mouldy.

Dry, coarse forages

Straw or tibn

As any plant matures, a large part of the more valuable nutrients are transferred from the leaves and stems to be stored in the ripening seeds. Therefore the straw which consists of mature stems and leaves, without seeds has relatively little protein, starch, or fat while the content of fiber and lignin is high. Straws are also low in Ca and most vitamins especially vitamin A & probably it generally has considerable vitamin D.

Because of its low nutritive value, straw is more useful as part of the ration for animals not being fed for high production. The tibn should be made of well-harvested wheat, barley, or oats etc. and broken into chaff. It is chaffed either by machinery or by Nurag. The length of the separated pieces must be not less than 5 cm lest coalescing and blocking of the esophagus. The most up - to - date method of manufacture is chaffing by machinery which has the advantage of producing clean tibn but has sharp ends. Good Nurag tibn is well broken with blunt ends and therefore easily masticated, digested and it is to be preferred to machine cut tibn.

Tibn is the bulk diet used for all classes of animals. The quality of it depends firstly on the quality of the straw, and secondly on the chaffing and cleaning.

Coarse cut and indifferent quality tibn is often used as bedding which makes good soft bed, but it attracts flies. Tibn can be made more appetizing by sifting and thorough mixing with the grain, the addition of salt, sprinkling of water and the addition of treacle. Both treacle & salt are best given dissolved in water and sprinkled over and well mixed with the tibn. As an example wheat straw has 0.7 % DCP and 36 % TDNs; its N R is 1:51.

Tibn must be of good color, sweet smelling, dry, free from dirts, stones, or any foreign matter. Straws from leguminous crops as beans have the drawback in its constipating effect. Cereal straws can be stored longer than leguminous straws.

Lentil and bean hulls

Previously described under title horse beans.

Hay and hay making

Hay making is an effective method to preserve forage without spoilage. If it is desired to secure prime hay it must have been made from plants cut at a sufficiently early stage of maturity. Hay cut late has a lower feeding value. The chief decline in nutrients comes after the crop reaches full bloom, and especially when the seed has developed. Therefore to make good hay the berseem is cut when it is in full bloom or just after the flower is partly dried.

High quality hay has the following properties

1- Bright green color (but not yellow)
2- Crisp to the feel
3- Good aroma
4- Leaves & other finer parts are retained
5- Free from dust , moulds , weeds and other poisonous plants

High quality hay is of high nutritive value and palatable. Most kinds of hay of the same quality supply about the same amounts of TDNs regardless the kind, however, legume hay is of course much richer in protein, Ca and vitamins than in grass hay of equal quality.

The primary object in hay making is to dry the green plants enough so that the hay can be safely stored without heating unduly or becoming moldy. To keep the hay safely in the barn or the stack the water content must be reduced to not more than 25 %, lest undergoes pronounced fermentation and becomes very hot . Spontaneous combustion may occur.

Among the various rapid methods devised for determining whether hay is dry enough for storage, the best is the testing by salt. Also for testing the moisture content a wisp of the hay is twisted in the hand. Slightly brittle hay with no evidence of moisture can be stored safely. With age, hay deteriorates and therefore it should not be too old. In the process of making hay, even under ideal conditions, must necessary involve losses of nutritive value.

The losses are through:

1- Respiration
2- Action of enzymes

3- Mechanical losses through the shedding of leaves.
4- Fermentation in which sugars & starch are oxidized to carbon dioxide & water. Also it has a destructive effect on carotene.
5- leaching
6- The main loss in value is due to the fact that the fiber in hay requires more energy for digestion than the fiber of the fresh green plant.

Factors affecting nutritional value of hay

1- Action of plant enzymes

In warm, dry windy weather, the wet forage, if properly handled and mechanically agitated, will dry rapidly and losses arising from plant enzyme activity will be small. The main losses occur in the soluble carbohydrate fraction as a result of respiration, in which sugars are oxidized to carbon dioxide and water. This loss results in a concentration of cell wall constituents, especially cellulose and lignin, which is reflected in the higher crude fiber content of the dry matter of hay compared with that of the original herbage. Although the major changes during haymaking occur in the carbohydrate fraction, proteins are also likely to be altered by the action of plant enzymes. Immediately after cutting, proteolysis occurs resulting in the formation of amino acids. This change will not affect the value of the crude protein unless the soluble nitrogenous compounds lost through leaching.

2- Oxidation

When herbage is dried in the field, a certain amount of oxidation occurs. The visual effects of this can be seen in the pigments, many of which are destroyed. The provitamin carotene, is affected and may be reduced from 150 – 200 mg/Kg in the dry matter of the fresh herbage to as little as 2 -20 mg/kg in the hay. Rapid drying of the crop by tripoding or barn drying conserves the carotene more efficiently, and losses as low as 18 % in barn dried hay have been reported. On the other hand sunlight has a beneficial effect on the vitamin D content of hay because of the irradiation of the ergosterol present in the green plants.

3- Leaching

Losses due to leaching by rain mainly affect the crop after it has been partly dried. Leaching causes a loss of soluble minerals, sugars and nitrogenous constituents, resulting in a concentration of cell wall constituents which is reflecting in higher crude fiber content. Rain may prolong the enzyme action within the cells, thus causing greater losses of soluble nutrients, and may also encourage growth of moulds.

4- Mechanical damage

During the drying process the leaves lose moisture more rapidly than the stems. The leaves become brittle and shatter very easily when handled. Excessive mechanical handling is liable to cause a loss of this leafy material, and since the leaves at the hay stage are richer in digestible nutrients than the stems, the resultant hay may be of low feeding value. Baling the crop in the field at a moisture content of 30 – 40% and subsequent drying by artificial ventilation will reduce mechanical losses considerably.

5- Action of micro-organisms

If drying is prolonged because of bad weather conditions, changes brought about by the activity of bacteria and fungi may occur. Mouldy hay is unpalatable and may be harmful to farm animals and man. Such hay may contain actinomyces which are responsible for the allergic disease affecting man known as “Farmer’s Lung”.

6- Stage of growth

The stage of growth of the crop at the time of cutting is the most important factor determining the nutritive value of the conserved product. The later the date of cutting the larger will be the yield, the lower the digestibility and net energy value, and the lower the voluntary intake of dry matter by animals. It follows that if their drying conditions are similar, hays made from early –cut crops will be of higher nutritive value than hays made from mature crops.

7- Plant species

Hay made from legumes is generally richer in protein and minerals than grass hay. Cereals are sometimes cut green and made into hay, and this usually takes place when the grain is at the “milky” stage. The nutritive values of cereal hays cut at this stage of growth are similar to those of hays made from mature grass, although the protein content is generally lower.

Poor quality hay made from mature herbage harvested under bad weather conditions may have a negative digestible crude protein content and a starch equivalent as low as 20, this hay is little better in feeding value than straw. Excellent quality hay has a digestible crude protein of 12 % and starch equivalent value of 50.

8- Changes in the stack

The chemical changes and losses associated with haymaking do not completely cease when hay is stored in the stack or barn. The stored crop may contain from 10 – 30 % moisture. At the higher moisture levels chemical changes brought about by the action of plant enzymes and micro -organisms are likely to occur. There may be degradation of sugars due to oxidation, although hexoses may also combine with amino acids or proteins. This chemical combination is probably responsible for the dark-brown color observed in overheated hay. Browning has been observed at temperature as low as 32˚C. Respiration cease at about 40˚C, but the action of thermophilic bacteria may go on up to about 70˚ C. Also chemical oxidation can cause further heating.

Losses of carotene during storage depend to a large extent on the temperature. Below 5˚C little or no loss is likely to occur. The changes that take place in the stack are likely to result in a lowering of nutritive value and an increase in the proportion of cell wall constituents. The feeding value of heated hays is relatively low, since high temperatures lower the digestibility of proteins. Digestibility coefficients for protein as low as 2.6 % have been reported for black overheated hay.

The changes which take place in the stack depend to a large extent on the moisture content of the hay at the time of storing. If the moisture in the stored crop is less than 15 % then little or no change will take place during storage.

Different methods for curing hay

1- The most rapid is the drying in the swath (its drawbacks are shattering of leaves and leaching is by air).
2- Drying in windrows which need an unduly long time. Fermentation and molding may occur.
3- For the production of high quality hay the plant is moved as soon as the dew is off in the morning, let the crop lie in the swath for a few hours, until it is partly cured. Rake it into small loose windrows. As long as the leaves remain alive, they may perhaps help to dry out the stems.
4- Curing in cocks preserves the color but requires too much labor.
5- After hay is partly cured, it is put in tripods (3 poles joined at the top and generally with cross pieces at right angles, to keep the hay off the ground), sometimes single pole with cross pieces is used.
6- Hanging hay on temporary fences
7- Barn – drying method

In our country to secure prime hay it is moved and allowed to dry in the swath until dry on the surface, then turned by hand or by hay tender or raked into loose windrows. As the climate in our country is not changeable and always bright and dry no further precautions are needed except frequent turning during the day and piling it at night and then spreading, frequent tedding and turning the next morning and so on till complete dryness is effected.

In making the stack the hay is put on in layers and tramped down so that no cavities will remain, for in them molds would form. The stacks are afterwards covered with a thatch of straw.

Sometimes the heating of the stack goes so far that there is danger of it taking fire. The more the temperature rises during hay making and the darker the color, the less digestible are the proteins found in. The stacks are best to be permeated vertically by holes for proper ventilation.

Derees is easily broken up small by hand and can then be fed either in mangers for horses during hard work than during the idle season when tibn should then form the largest part of the bulk ration.

Berseem hay contains

NR 1:4 – 7 (1:5)
11 – 20 % protein
20 – 30 % fiber

Grass hays have

NR 1:15
5 – 7 % protein
30 % fiber

Most of hays contain 12 % water content

Green fodders

Berseem (blooming stage)

Darawah Alfalfa plant (Lucerne or Medicago sativa)

Silage processing

Silage

Roughages

Hay making

Straw (tibn)

Feed additives

Minerals block

Common Salt

Processing of feeds

Corn flakes

Corn grain (ground)

Pellets

Cubes

Crumbles

Extruder

Feeding standards and ration formulation

Today, the vast majority of commercial poultry or animal is produced in large units wherein the maximum of science and technology exists.

The current trend is toward controlled environment, the lowered feed consumption is often taken into consideration and the nutrient content of rations varied so as to compensate for the reduced feed intake and meet the requirements.

To formulate a ration, on the animal's side the following questions must be answered

a- The requirements and its adequacy according to the expected productivity.
b- The amount of ration the animal will eat, and by turn the density of nutrients could be determined.

Appetite varies with health, size and level of production. Poultry as an example may have the capacity to eat more each day in order to match intake to requirement. Then it could be useful to specify ingredient not per unit weight of food but per unit of energy. High temperatures, those in excess of, say, 27 ˚C seriously affect this balance by reducing appetite. In this case, whilst perhaps ration is not needing to be more dense in energy, would certainly need to be formulated with higher proportions of protein especially methionine and lysine, vitamins and minerals.

Some types of laying chickens especially strains of heavier body weight, show less control and overeat to the point where production may suffer. So a "standard ration 'and a fixed feeding system is unlikely to be equally suitable for all strains all the time.

And on the ration's side the following must be answered

a- Availability of feedstuffs
b- The manufacturing of the ration at a favorable cost

As a general, ration formulation is a complex process and involves not only balancing across the equation but also making balances between the main classes of nutrients within the ration, and then further, within nutrient groups, especially between the amino acids. It is like deriving sets of simultaneous equations in algebra and then solving them. Recently computer is used in solving these repetitive equations.

Feeding standards

They are tables listing the amounts of one or more nutrients required by the different species of animals for specific productive functions, such as growth, fattening and lactation. They are necessary guides in balancing rations.

Most feeding standards are expressed in either 1- quantities of nutrients required per day, and / or 2- concentration in the ration which is only valid if the estimate of the daily consumption of the ration is accurate.

Today, the most widely used ones in the United States are those published by the National Research Council (NRC) of the National Academy of Sciences. In England, similar standards are issued by the Agricultural Research Council (ARC). In NRC, the TDN system is gradually giving way to net energy evaluation systems. England uses ME, adjusted according to the efficiency with which a feedstuff or diet is used for a particular purpose. Others are based on SE, Scandinavian feed units, and other methods.

NRC standards

For beef and dairy cattle the requirements are presented in terms of TDN, ME, NE, CP, Ca and P; for sheep TDN, DE and ME; and for swine DE, ME. The NRC has established feeding standards for beef cattle, dairy cattle, sheep, swine, poultry, horses, rabbits, mink, foxes, trout, catfish and dogs.

Limitations of feeding standards

1- They are excellent guides but sometimes needs cannot be specified with great accuracy.
2- It tells nothing about economy, palatability, and possible digestive disturbances of a ration. Neither to individual animal differences, effects of such stresses as weather, diseases, parasitism, and surgery. These variables are difficult to include quantitatively even when feed quality is well known.
3- The values reported, whether established or estimated, have not been increased by a margin of safety. The nutrient composition of the feedstuffs is variable, inadequate feed mixing, improper processing, unfavorable storage; all may reduce effective concentrations of dietary nutrients below those calculated to be present. Thus a "margin of safety "should be added in arriving at nutrient "allowances "to be used in feed formulations. The margins of safety may be plus 50 % for the fat-soluble vitamins and 20 % for the water soluble ones, in poultry, is an example, in case of foods have to be transported long distances in hot climates, higher margins of safety still required.

Ration formulation

When formulate a ration you should consider the following:

1- Ingredients should be available for at least 3 – month rations.
2- Ingredients should be cheap , locally produced and buying is better to be in its season of production.
3- They should include all needs –plant proteins, animal proteins, high – energy feeds, low-energy feeds, fats, vitamins, minerals ….etc.
4- Energy or protein should be supplied by several ingredients in order to balance the amino acids. The amino acids which are commercially produced are methionine and lysine.
5- Mixing should be through the use of high efficiency automatic mixers. Hand mixing is not preferred.

Considerations of ration ingredients:

1- Feeds are a-concentrates , b- roughages , c-supplements
2- Rations can be formulated whereby a-all three components are mixed together to form a complete feed b-each component is considered as a separate entity. Most rations for non-ruminants without functional cecums are formulated by the first method. Many ruminants and non-ruminant herbivores are fed concentrates and roughages separately with vitamin and mineral supplements free-choice. In the latter type of feeding program, careful consideration must be given to how much of each class of feed is offered in order

to prevent animals from eating too much concentrate and not enough roughage , or vice versa.

3- For ruminants in heavy production (i.e., fattening or lactation) and almost all non-ruminants, the concentrate portion of the ration constitutes most of the DM intake.
4- The processing of grains and other concentrates can dramatically increase or decrease their digestibility.
5- The relative capacity of animals to digest and absorb such feeds as fats and molasses must be considered.
6- Amino acid composition of feeding stuffs and protein digestibility are especially critical for non-ruminants with nonfunctional cecums.
7- In non-ruminant rations, levels of non-protein nitrogen must be monitored to avoid ammonia toxicity.
8- Some forage, such as high –quality alfalfa hay, is frequently added to swine for its vitamin content or to reduce cost, and for poultry for its high vitamin content.
9- Ruminants and non-ruminants with functional cecums can be maintained relatively easily on high –roughage rations. In these cases minerals and vitamins may be all that is additionally required.
10- Roughage can be mixed with the concentrate along with any supplements, to make a complete feed.
11- Beef cattle have been successfully fed finishing rations with no roughage , but feeding all – concentrate and high concentrate rations has many limitations and needs high level of management . But high levels of performance can be better maintained by including 10-15 % roughage. Also the energy can be increased without eliminating much of the roughage by adding 4-5 % fat.
12- All animals are susceptible to health –related problems when radical changes are made in the composition of their feed. Therefore, it is imperative that any great changes in feed composition be done gradually over a period of time.
13- To reduce the incidence of bloat , grains should be processed more coarsely , grains mixed with roughage more uniformly , more fibrous roughage is fed , substituting corn for other grains, raising the roughage level temporarily , and providing a readily accessible supply of water.

How do you balance rations?

Ration formulation consists of combining feeds that will be eaten in the amount needed to supply the daily nutrient requirements of the animal. The following points are necessary:

1- More than simple arithmetic should be considered.
2- Formulating rations is both an art and a science.
3- Consideration of availability and cost of ingredients (based on delivery after processing).
4- Moisture content should be considered when comparing costs and balancing rations.
5- Well –balanced satisfactory ration should be palatable, digestible, economical, enhancing the quality of the product produced.
6- The cost per unit of production is the ultimate determinant of what constitutes the best ration.
7- Feed composition tables or average analyses should be considered only as guides, because of wide variations in composition. Such ingredients as oil meals and prepared

supplements, which meet specific standards, need not be analyzed so often, except as quality –control measures.

8- Formulation should be changed considering any changes in availability of feeds, prices, change of bird or animal weight and productivity.

The following four steps should be taken in an orderly fashion in order to formulate an economical ration

1- Find and list the nutrient requirements and / or allowances for the specific animal to be fed. Allowances take into consideration a margin of safety. Factors to be considered in determining the requirements are: a-Age b-Sex c-Body size d- Type of production e- Intensity of production.
2- Determine what feeds are available and list their respective nutrient compositions. In ruminants DM, protein, energy, calcium and Na are the generally considered in ration formulation. Additional minerals are generally supplied either as free-choice salt mix or as a premix incorporated in the ration. Animals in confinement may need some vitamin D supplementation. In rations for non-ruminants, one must also ensure adequate essential AAs, essential FAs, vitamins D and E, B complex vitamins and minerals.
3- Determine the cost of the feed ingredients, cost of mixing, transportation and storage.
4- Consider the limitations of the various feed ingredients and formulate the most economical ration.

Adjusting moisture content:

$$\textbf{\% nutrient in dry diet (total)} = \frac{\text{\% of nutrient in wet(total)}}{\text{\% of DM in diet (total)}} \times 100$$

$$\textbf{Amount of ingredient in dry diet} = \frac{\text{\% of ingredient in wet diet}}{\text{\% of DM wanted in diet}} \times \textbf{\% of DM of ingredient}$$

Calculating amount of rations given or supplement added

Amount of ration given for a lactating cow (Kg dry matter)

$$= \frac{\text{Needs of energy (NEl)for maintenance ,milk production and activity}}{\text{Density of energy in ration formulated (NEl Mcal/kg dry matter)}}$$

Amount of a supplement (in Ibs or Kgs) for a specific nutrient

$$= \frac{\text{Amount of nutrient needed in Ibs or kgs}}{\text{\% of nutrient in the supplement}}$$

Percentage of a supplement for a specific nutrient

$$= \frac{\text{\% of nutrient needed to be in the ration}}{\text{\% of nutrient in the supplement}}$$

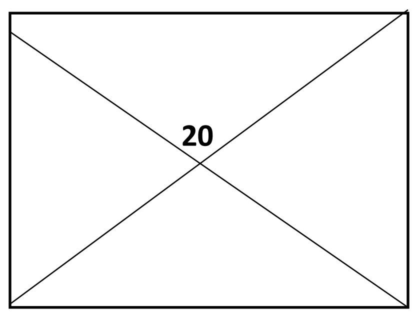
Mathematical methods used in ration formulation

Five different methods will be presented. Despite the sometimes confusing mechanics of each system, the end result of all the 5 methods is the same.

1-The square method (Pearson square)

In this method only one specific nutrient or energy receives major consideration. So only correctly speaking, it is a method of balancing the protein or energy requirement with no consideration to the other nutrients.

Corn, CP 9 %



24

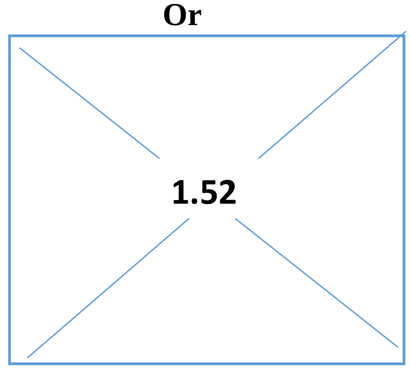
SBM, CP 44 %

11
35

Note that:
44-9 = 35 and 24 + 11 = 35
also
20 % is the needed protein level
Ration is composed of:
Corn%=24 ÷ 35 x 100=68.57
SBM%=11 ÷ 35 x 100=31.43

Or

Hay NEl 1.3



0.18

Hay % = 0.18 ÷ 0.4 x 100=45
Mixture % = 0.22 ÷ 0.4 x 100=55

Mixture NEl **1.7**
0.4

0.22
0.4

2-Trial and error method

Feeds are interchanged by using trial – and – error followed by correction if needed until the right combination is found.

3-Simultaneous equations method

a- To formulate rations involving two sources (X & Y) and one nutrient (for e.g. protein percentage).

Equations will be X+Y = 100 parts (dummy equation) and Xx its CP % + Yx its CP % = CP % of mixture needed (original equation).

b- To formulate rations involving two sources (X&Y) and two nutrients (a &b)

(a_1) X + (a_2) Y = amount of the nutrient needed **(a)** in a certain amount of mixture

(b_1) X + (b_2) Y = amount of the nutrient **(b)** in the same amount of mixture

The simultaneous equations can be solved by multiplying the free factor of one by the other in order to cancel one of the two unknowns (X&Y) in the two equations together:

4-The 2 × 2 matrix method

$$a_1 X + b_1 Y = C_1$$

$$a_2 X + b_2 Y = C_2$$

$$X = \frac{\begin{vmatrix} C1 & b1 \\ C2 & b2 \end{vmatrix}}{\begin{vmatrix} a1 & b1 \\ a2 & b2 \end{vmatrix}} \quad \text{or} \quad \frac{(C1\ b2 - C2\ b1)}{(a1\ b2 - a2\ b1)}$$

$$Y = \frac{\begin{vmatrix} a1 & c1 \\ a2 & c2 \end{vmatrix}}{\begin{vmatrix} a1 & b1 \\ a2 & b2 \end{vmatrix}} \quad \text{or} \quad \frac{(a1\ C2 - a2\ C1)}{(a1\ b2 - a2\ b1)}$$

In least –cost formulations, matrix algebra is used by the computer, but the matrices that are used are much larger than 2 × 2 and are far more complicated. The 2 × 2 matrix offers a rapid means of calculating a simple ration using two feeds to fulfill two nutrients.

5-The computer method

a- It is the electronic feed formulation and sophisticated but nothing magical or mysterious.
b- Computers can alleviate many human errors in calculations, but data come out are no better than those which go into it.
c- The people back of the computer – the producer – and the nutritionist who prepare the data and who evaluate and apply the results, become more important than ever.
d- The computer knows nothing about – palatability – bloat prevention, limitations imposed on certain feeds and others.
e- Is of most use where a wide selection of feed ingredients is available and / or prices shift, costs, and limitations.
f- Computer gives the least – cost rations and its efficiency depends upon how the information fed are so precise.
g- Computer gives formulation in a matter of minutes.
h- The rations formulated should be reviewed at frequent intervals for availability of feeds, prices or chemical composition, also restrictions should be validated.

- **The following steps should be taken in an orderly fashion in order to formulate an economical ration for poultry :-**

1- Find and list the nutrient requirements and / or allowances for the particular chickens going to be fed.
2- Choose the most nutritious and cheap protein concentrate available.
3- Calculate the amount of nutrients (ME, CP, Ca, and available P, salt, methionine and lysine) satisfied by the added percentage of the protein concentrate, or fish meal if it is going to be added.
4- Deduct the nutrients in the concentrate from that required to extract the amounts needed to be satisfied by any other feeds available.
5- Meet the needs for Ca &P by using limestone, bone meal or any other supplements. Meet the needs for the common salt.

6- Using for example yellow corn and soybean oil meal to meet the requirement for ME and CP, an algebraic method (the simultaneous equation) should be used to calculate the percentage mixed of each of the two feeds keeping the C/P ratio within the required range.
7- Calculate the amount of methionine and lysine the corn / SBM mixture will contain and the balance is supplemented using methionine and lysine amino acids available in kgs in the market.
8- Check the calculation and the end formula , using the formulation sheet , before mixing

Steps for ration formulation in animals

1- Take all the details and information about the animal given.
2- Estimate the amount of FCM produced if the animals are lactating, and to calculate at the end amount of ration which should be given.
3- Prepare the formulation sheet and fill in the requirements, ration specifications and feeds or mixtures available.
4- Calculate the percentages of roughage and concentrates and supplements if needed.
5- Calculate the % of protein and estimate the correction or fortification of the concentrate mixture.
6- If a commercial concentrate mixture is used, no supplements for Ca or P or salt are needed except when the mixture is diluted by other feeds.
7- Fill the sheet and compare the ration contents for energy, protein. Ca, P &salt with the requirements and decide about the amount of the daily ration.
8- Simultaneous equations are suitable to estimate the percentages of corn and SBM in the growing or fattening concentrate mixtures , while the square methods is satisfactory for the other kinds of rations.

Chemical Composition of Feedstuffs

Adapted by

Department of Nutrition and Clinical Nutrition

Chemical Composition for commonly used Animal and Poultry Feedstuffs – Part II
التركيب الكيميائي لمواد علف الحيوان والدواجن الشائعة الاستخدام – الجزء الثاني

TDN %	AMEn Kcal/Kg	Met+Cys %	Met %	Lys %	AV.P %	Total P%	Ca %	CF %	EE %	CP %	DM %	Feedstuffs
Animal proteins												
85	2700	1.90	1.00	8.00	0.18	0.20	0.30	1.0	1.5	85.6	93	**مسحوق دم مجفف بالرذاذ** **Blood meal, spray dried**
69	2890	1.32	0.77	2.85	3.15	3.50	7.00	1.5	12.0	55.0	93	**مسحوق لحم 55% بروتين عالي الدهن** **Meat meal, 55% protein, high fat**
62	2300	1.29	0.77	2.95	3.87	4.30	9.00	0.5	5.0	56.0	93	**مسحوق لحم 55% بروتين منخفض الدهن** **Meat meal, 55% protein, low fat**
69	3000	0.81	0.47	1.93	4.05	4.50	10.00	2.41	20.3	42.8	93	**م. لحم و عظم 45% بروتين عالي الدهن** **Meat and bone meal ,45% protein, high fat**
60	1820	0.91	0.53	2.11	5.49	6.10	12.90	1.0	7.4	42.7	93	**م. لحم و عظم 45% بروتين منخفض الدهن** **Meat and bone meal ,45% protein, low fat**
-	2300	1.37	0.95	2.43	4.86	5.40	12.50	2.0	10.0	45.0	90	**م. سمك 45% بروتين** **Fish meal, 45% protein**
76	3200	2.85	2.20	5.70	1.62	1.80	2.50	0.6	10.0	72.0	92	**م. سمك هيرنج 72% بروتين** **Fish meal Herring, 72% protein**
74	1920	2.10	1.10	3.00	1.62	1.80	3.50	2.0	14.0	58.0	93	**مخلفات مجازر الدواجن** **Poultry by-product meal**
64	2900	4.00	0.55	2.00	0.56	0.60	0.26	1.0	4.5	86.0	93	**م. الريش** **Feather meal**
45	1030	0.40	0.15	0.40	1.65	2.20	7.80	13.0	2.0	25.5	90	**زرق الطيور المجفف (اقفاص)** **Poultry manure (cages)**
82	2650	1.20	0.90	2.80	1.00	1.00	1.30	0.1	1.0	34.0	94	**لبن فرز مجفف** **Skimmedmilk powder**
78	1950	0.50	0.20	1.00	0.80	0.80	0.90	0.2	0.7	13.0	94	**شرش مجفف** **Whey powder**
Coarse fodders or roughages												
48	-	-	-	-	-	0.22	1.40	30.0	2.3	12.5	90	**دريس برسيم مسقاوي** **Berseem hay**
49	-	0.37	0.20	0.78	-	0.23	1.30	25.0	2.0	15.5	90	**دريس برسيم حجازي** **Alfalfa hay**
44	600	0.33	0.18	0.54	0.22	0.25	1.40	30.0	2.1	12.0	90	**برسيم حجازي مجفف صناعيا 12% بروتين** **Alfalfa, dehydrated meal 12% protein**
54	1000	0.43	0.22	0.59	0.22	0.22	1.20	26.6	2.2	15.6	90	**برسيم حجازي مجفف صناعيا 15% بروتين** **Alfalfa, dehydrated meal 15% protein**

TDN %	AMEn Kcal/Kg	Met+Cys %	Met %	Lys %	AV.P %	Total P%	Ca %	CF %	EE %	CP %	DM %	Feedstuffs
55	1250	0.56	0.27	0.85	0.22	0.23	1.40	24.0	2.7	17.3	92	برسيم حجازي مجفف صناعيا 17% بروتين **Alfalfa, dehydrated meal 17% protein**
55	-	-	-	-	-	-	-	13.0	1.0	17.3	90	عرش بنجر السكر مجفف **Sugar beet tops, dried**
35	-	-	-	-	-	0.28	0.60	46.0	0.5	1.5	92	مصاصة قصب سكر **Sugar cane pit**
44	-	-	-	-	-	0.05	0.16	42.1	1.5	3.2	90	تبن قمح **Wheat straw**
43	-	-	-	-	-	0.08	0.33	40.0	1.6	4.0	90	تبن شعير **Barley straw**
45	-	-	-	-	-	0.12	1.37	40.0	1.0	5.5	90	تبن فول **Broad bean straw**
40	-	-	-	-	-	-	-	39.0	0.8	6.0	90	تبن برسيم **Berseem straw**
40	-	-	-	-	-	-	-	40.0	1.0	4.0	90	قش ارز **Rice straw**
42	-	-	-	-	-	0.06	1.59	44.3	1.5	5.0	88	تبن عدس **Lentils straw**
45	-	-	-	-	-	-	-	37.0	0.5	6.0	90	حطب ذرة **Corn stalks**
45	-	-	-	-	-	0.20	0.52	29.2	1.0	4.0	90	قوالح ذرة **Corn cobs**
72	2730	-	-	-	0.08	0.27	0.08	8.0	3.5	8.3	87	كيزان ذرة **Corn ears**
56	-	-	-	-	-	0.14	0.58	33.0	1.05	6.0	90	قشور فول بلدي **Broad bean hulls**
20	-	-	-	-	-	0.04	0.18	60.0	1.3	6.6	92	قشور فول سوداني **Peanut hulls**
11	-	-	-	-	-	0.08	0.10	39.4	7.0	3.0	92	سرسة الارز **Rice husks**
Calcium and phosphorus supplements												
-	-	-	-	-	-	-	37.00	-	-	-	94	حجر جيري **Limestone**
-	-	-	-	-	-	-	38.00	-	-	-	96	كربونات كالسيوم **Calcium carbonate**
-	-	-	-	-	-	-	38.00	-	-	-	96	مسحوق صدف ناعم **Oyster shell, ground**
-	-	-	-	-	18.00	18.00	24.00	-	-	-	97	فوسفات كالسيوم ثنائية (انتاج محلي) **Calcium phosphate, dibasic**
-	-	-	-	-	21.00	21.00	16.00	-	-	-	98	فوسفات كالسيوم احادية **Calcium phosphate, mono**
-	-	-	-	-	20.00	20.00	-	-	-	-	97	فوسفات صوديوم ثنائية **Sodium phosphate, dibasic**
-	-	-	-	-	21.80	21.80	-	-	-	-	97	فوسفات صوديوم احادية **Sodium phosphate, mono**
-	400	-	-	-	13.00	13.00	27.50	-	1.5	7.0	93	مسحوق عظام **Bone meal**

NOTE: DM = Dry Matter, CP = Crude Protein, EE = Ether Extract, CF =Crude Fiber, Ca = Calcium, AV.P =Available Phosphorus, Lys =Lysine, Met = Methionine, Cys = Cystine, AMEn = Metabolizable Energy Poultry- nitrogen corrected, TDN = Total Digestible Nutrients.

- There are meat meals 50% and 60% protein low and high fat- also meat- and- bone meal 50, 55, 60% protein low fat. Fish meal may also contain 60, 65, 70% protein with high or low fat.

References

Central Lab for Food & Feed (CLFF), Ministry of Agriculture, Agricultural Research Center, Technical Bulletin Nr.1, 2001.

Cheeke, P.R. 1991. Applied Animal Nutrition. Feeds and Feeding. New York. Macmillan Publishing Company.

Crampton, E.W., L.E. Lioyd. 1959. Fundamentals of Animal Nutrition. United States of America. W.H. Freeman and Company.

Ensminger, M.E., and C.G. Olentine. 1978. Feeds & Nutrition – Complete, 1st ed. U.S.A. The Ensminger Publishing Company.

McDonald, P., R.A. Edwards, and J.F.D. Greenhalgh. 1979. Animal Nutrition, 2nd ed. London. Longman Group Limited.

Morrison, F.B. 1959. Feeds and Feeding, 22nd ed., Clinton, Iowa. Morrison Publishing Company.

Nahm, K.H. 1989. The complete Agricultural Lab Manual. Taegu University Press.

National Research Council (NRC). 1985. Nutrient Requirements of Sheep. 6th rev. ed. Washington, D.C.: National Academy Press.

National Research Council (NRC). 1988. Nutrient Requirements of Dairy Cattle. 6th rev. ed. Washington, D.C.: National Academy Press.

National Research Council (NRC). 1994. Nutrient Requirements of Poultry. Washington, D.C.: National Academy Press.

Wahby, M.H. 1964. Veterinary Hygiene and Dietetics, for veterinary students and practitioners, Faculty of Veterinary medicine, Cairo University.