

POULTRY NUTRITION

INTRODUCTION

Poultry nutrition is more than just giving any available feed to your birds. Market poultry – broilers and turkeys - require proper nutrition to grow and finish out. Breeding poultry require correct nutrition to reproduce. Laying flocks require correct nutrition to be productive. As humans, we need the right balance of nutrients supplied by the food pyramid (meats, vegetables, dairy products, and fruits) on a daily basis. Similarly, poultry require the correct balance of five classes of nutrients (proteins, carbohydrates, fats and oils, vitamins, minerals, and water) for optimum growth, maintenance, finishing, work, reproduction, and production.

The poultry producer must know the nutritional requirements of the bird's function; either egg production or meat production. After determining the nutritional requirements, the poultry producer should look into the availability and cost of appropriate feedstuffs. It is also critical that the poultry nutritionist know the limitations associated with each ingredient. Some ingredients may have anti-nutritional properties which limit their usage in poultry diets.



Poultry Research Feed Mill

All foods that sustain life contain nutrients. Poultry convert the nutrients into useful forms via the digestive system. Blood then carries the nutrients throughout the body. Nutrients pass through capillary walls and enter body cells to provide nourishment and energy for life processes.

Nutrients can be either dietary essential or non-dietary essential. Poultry feeds must supply the dietary essential nutrients because the body cannot produce them on its own. The body can synthesize the non-dietary essential nutrients for growth and maintenance. Poultry diets must supply daily nutrient requirements from the five classes of nutrients.

CLASSES OF NUTRIENTS

Protein

Proteins are complex organic macromolecules containing carbon, hydrogen, oxygen, nitrogen, and usually sulfur. They consist of one or more chains of amino acids. Proteins are fundamental components of all body cells and include many biochemicals (such as enzymes, hormones, and antibodies) necessary for proper body functions. They are essential in the animal's diet for growth and repair of tissue and can be obtained from many feedstuffs such as meat and fish meals, cereal grains and legume byproducts such as soybean meal.

Proteins consist of one or more chains of amino acids that are required by the body. The breakdown of protein during digestion releases the amino acids. Blood carries the amino acids to all body parts. Single stomach, or monogastric, animals require 22 amino acids in their body. Those animals can manufacture 12 of the 22 non-dietary essential amino acids, but cannot store the amino acids in their bodies. As a result, they must get a daily dose of protein containing the other 10 dietary essential amino acids. Proteins can come from both plant and animal feedstuffs.

Plant proteins come directly, such as corn, or indirectly from plants as byproducts. Examples of byproducts include soybean meal, cottonseed meal, peanut meal and canola meal. Note these high protein meals are byproducts of edible oil extraction from the “oil seeds”. Perhaps you have seen canola and peanut oils in the grocery store. Animal protein sources are usually byproducts of meat processing and include blood meal, feather meal, fishmeal, meat and bone meal, and poultry by-product meal.

Protein or amino acid digestibility can vary depending on the specific ingredient. In general, animal byproduct proteins are easier to digest than plant proteins. For example, poultry digestibility of cottonseed meal can be as low as 60% for certain amino acids or as high as 90% for other ingredients such as dehulled soybean meal and meat products like poultry byproduct meal. The protein content of an ingredient or complete diet is usually described as “Crude Protein”. Crude protein is based on the nitrogen content of the feedstuffs; proteins contain an average of 16% nitrogen. Crude protein thus can contain not only “pure protein” but other non-protein substances such as nucleic acids (from DNA) or urea which is a nitrogenous waste product excreted by the kidneys. National Research Council (NRC) nutrient requirements for poultry assume an average of approximately 85% ingredient bioavailability.

Carbohydrates

Carbohydrates are organic compounds that include sugars, starches, celluloses, and gums. Carbohydrates are produced by photosynthetic plants and contain only carbon, hydrogen, and oxygen, usually in the ratio 1:2:1. For example let’s consider glucose; there are essentially two atoms of hydrogen for each atom of carbon [$C_6H_{12}O_6$ or $C_6(H_2O)_6$]. Note that unlike proteins, carbohydrates do not contain any nitrogen atoms. Feed grains are high in carbohydrates and serve as the major energy source for animals. Breakfast cereal grains are good examples of high carbohydrate feed grains; think of Kellogg’s Corn Flakes™, Wheaties™, Rice Krispies™, etc. Sugars and starches are highly digestible and make up almost 75% of an animal’s diet. Starch and sugar carbohydrates contain 4 kilocalories per gram. Excess carbohydrates produce fat in an animal.

Not all carbohydrates can be digested by simple stomached animals such as chickens, pigs or even human beings. Based on digestibility, the two groups of carbohydrates are nitrogen-free extract and crude fiber. As you might expect nitrogen-free extract does not contain any nitrogen but rather consist of non-nitrogen sugars and starches, such as those found in the cereal grains. Nitrogen-free extract is highly digestible and considered the more soluble form of carbohydrates. On the other hand, crude fiber contains carbohydrates like cellulose and gums that cannot be easily digested by poultry. Grazing animals like cattle are able to digest crude fibers like cellulose which is rich in pasture grasses.

Fats and Oils

In terms of providing energy, fats and oils serve the same function as do digestible carbohydrates. Fats and oils are the densest forms of energy and derived from plants and animals. At room temperature, fats are solids and oils are liquids. They both provide 2.25 times more energy than do carbohydrates (9 kilocalories per gram versus 4 kilocalories per gram for digestible carbohydrates and protein). Poultry require only small amounts of fats and oils. They are very important nutrients in the diet.

Minerals

Minerals are naturally occurring inorganic solids, with a definite chemical composition, and an ordered atomic arrangement which are important for life and good health. Many are essential components of bodily substances, such as the calcium and phosphorus in bones and the iron in hemoglobin. Others help regulate many metabolic activities. Based on availability and needs, minerals are divided into three groups - macro minerals, electrolytes and trace (micro) minerals. Minerals provide the inorganic elements critical to life. For example, calcium carbonate (limestone) is a mineral form of calcium.

Macro Minerals include:

- Calcium (Ca)
- Phosphorus (P)
- Magnesium (Mg)

Electrolytes include:

- Sodium (Na)
- Chlorine (Cl)
- Potassium (K)

Macro minerals are required in fairly high concentrations compared with the trace minerals. These macro minerals are critical to skeletal formation but can serve other non-structural functions as well. For example, calcium is necessary for heartbeat regulation, blood clotting, and muscle contractions in addition to bone and teeth maintenance. Magnesium (Mg) is necessary for utilizing energy in the body and for bone growth. Almost all biochemical reactions require phosphorus. The calcium to phosphorus ratio is very important in poultry diets; 2 to 1 with respect of dietary calcium to available phosphorus.

Electrolytes are elements that have either a positive (sodium and potassium) or negative (chloride) electrical charge in solution.

Sodium (Na) and chlorine (Cl) are usually found together as the mineral sodium chloride (NaCl, or common salt). Salt serves to maintain acidity levels in body fluids and proper osmotic pressure in body cells. The hydrochloric acid produced in the stomach contains the element chlorine.

Potassium (K) also serves to maintain proper acid levels in body fluids and osmotic pressure in body cells. It is also required in some enzymatic reactions in carbohydrate metabolism and protein synthesis.

Trace Minerals include:

- | | |
|------------------|-----------------|
| • Copper (Cu) | Selenium (Se) |
| • Zinc (Zn) | Cobalt (Co) |
| • Manganese (Mn) | Iron (Fe) |
| • Iodine (I) | Molybdenum (Mo) |

Animals need very small amounts of trace minerals, usually ranging from 0.05% to 0.25%. However, this small percentage is critical for performing essential body functions associated with life, such as:

Growth of bones and soft tissues	Digestion
Blood and body fluid processes	Body tissue repair
Vitamin utilization	Release of body heat for energy needs
Regulation of chemical processes	Muscle activity
Reproduction	Internal organ functioning

Vitamins

Vitamins are essential organic (carbon based) compounds needed in small amounts by the body. They are absolutely critical to all life processes such as growth, maintenance, reproduction. Vitamins do not directly build body tissue as do macro minerals like calcium and phosphorus. They assist many of the enzymes controlling the metabolic processes of life and are often referred to as co-enzymes.

As to solubility and storage in the body, vitamins are either fat-soluble or water-soluble. They are obtained naturally from plant and animal feedstuffs. Vitamin B12 originates from bacteria. The body stores fat-soluble vitamins. Large amounts of fat-soluble vitamins can be deadly to an animal. This is not true for water-soluble vitamins, which cannot be stored in the body. Regular intake of adequate amounts of water-soluble vitamins is important.

Fat-soluble vitamins include:

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

The water-soluble vitamins include:

- Thiamine (Vitamin B₁)
- Riboflavin (Vitamin B₂)
- Pyridoxine (Vitamin B₆)
- Vitamin B₁₂
- Folic Acid
- Biotin
- Niacin or Nicotinic Acid
- Pantothenic Acid
- Choline

Water

All animals require water for body functions. Water is necessary for digestion and absorption of nutrients, removal of waste, production of milk, shaping of cells, and regulation of body temperature. Water is perhaps the single most important factor for life and is why NASA is so interested in finding evidence of surface water on the planet Mars.

Water is the largest component of bodies and constitutes approximately 50% of body mass. The animal's feeding habits directly affect the amount of water consumed. Chickens usually consume approximately two times (2X) as much water as they consume feed.

CLASSES OF FEEDSTUFFS

A number of classes of feedstuffs are available for use by the poultry industry. Modern poultry diets are formulated based on the Metabolizable Energy (ME) content of the diet which represents the energy available from the diet to fuel metabolism within the birds.

The vast majority of all poultry diets fed in the United States are based on corn and soybean meal, with small amounts of fat, calcium, phosphorus, salt, vitamins and trace minerals.

Cereal grains like corn are added primarily as a source of metabolizable energy although they also contribute some protein as well. Grains may represent as much as 60 to 70 percent of a poultry diet. Protein requirements are provided primarily by soybean meal with the optional addition of animal feedstuffs such as meat and bone meal. By-product ingredients such as wheat middlings are used to reduce overall diet cost and improve pellet quality with respect to wheat by-products. Think of making a peanut butter sandwich with corn bread rather than wheat bread. The wheat bread holds together a lot better. Poultry nutritionists often add wheat to the diet to help the pellets remain strong and bind together.

Grains

- Barley
- Corn
- Grain Sorghum
- Wheat

Plant Proteins

- Linseed Meal
- Canola Meal
- Peanut Meal
- Soybean Meal

Processing By-Products

- Animal Fat (Feed Grade)
- Distillers Dried Grain w/solubles (DDG)
- Rice Bran
- Wheat Bran
- Wheat Middlings and Shorts

Animal Proteins

- Fish Meal
- Meat & Bone Meal
- Poultry By-product Meal

Grains

BARLEY – Barley ranks fourth in world production of cereal grain crops, both in acreage harvested and production. It is more suited to production in northern regions, and is a principal feed grain in the northern US. Half of the barley produced in the US is used for livestock and poultry feed. Barley does contain gluten, and seems to have some positive glycemic properties.

CORN - Corn, the most commonly used grain in the United States, is widely available, and is high in energy. No limitations are placed on its use for human and livestock consumption and for industrial products, such as starches, sweeteners, corn oil, beverage and industrial alcohol, and fuel ethanol. Thousands of foods and other everyday items, from toothpaste to cosmetics to adhesives to shoe polish, contain corn components. Corn is non-toxic and highly palatable. Corn has to be ground to increase digestibility before feeding to commercial poultry.



GRAIN SORGHUM - Grain sorghum is the third most important cereal crop grown in the United States behind corn and wheat. This grain is comparable to corn with a feeding value roughly 90 to 95% of corn. When compared to corn, it contains more protein but less fat. Grain sorghum ranks second to corn in the amount used for feed. Grinding grain sorghum increases digestibility and maximizes benefits.

WHEAT - Wheat is primarily used for human consumption (bread and cereal foods). When used in an animal feed, wheat should be limited to only 50% of the total grain content. The high gluten content in wheat makes it an excellent ingredient to use for improving pellet quality in poultry diets. Wheat is coarsely ground or cracked for feeding. Feed mills avoid grinding wheat to a fine meal because of dust hazards during processing. Any grain dust can be highly explosive.

Processing By-Products

ANIMAL FAT (Feed Grade) – Feed-grade animal fats are usually rendered from beef, pork, and poultry raw materials. Feeding these fats provides a concentrated source of energy, and also reduces dustiness of the feed, increases palatability, and provide a source of linoleic acid, an essential fatty acid (EFA).

DISTILLERS DRIED GRAINS w/solubles – Distillers dried grains with solubles (DDG or DDGS) are a by-product of the distillation process; either from brewing or ethanol production. These grain residues have been dried to 10 – 12% moisture, and are stable enough to be shipped for a considerable distance without spoilage. This by-product is packaged and traded as a commodity.

RICE BRAN – When the chaff, or seed coat, is removed from rough rice, the remaining cereal grain is called brown rice. Removing the *bran*, or residual husk and germ, from brown rice, results in the familiar white rice. Rice bran is high in protein, dietary fiber, and essential fatty acids. Rice bran can be as high as 16% protein, but adding excessive amounts of rice bran in poultry diets may increase rancidity.

WHEAT BRAN - Wheat bran is the seed coat remaining after wheat is manufactured into flour. It is added to poultry feeds to lower overall diet cost when available at a reasonable price. It is recommended to add no more than 10% wheat bran to the diet because of the high bulk, the laxative effect and possible rancidity concerns.

WHEAT MIDLINGS AND SHORTS - These by-products are generally screenings, bran, germ, and flour remnants from wheat milling. They are higher in fiber, protein, and minerals than are the whole wheat grains. Wheat middlings and shorts are used to improve pellet quality in poultry feeds and lower the caloric content of certain poultry diets such as those used for broiler breeder flocks.

Plant Proteins

LINSEED MEAL – Linseed meal is a by-product of flaxseed when the fat is extracted. It contains 35% protein. Linseed meal is sometimes used in laying hen diets to increase the omega-3 fatty acid content of eggs.

CANOLA MEAL - Canola was developed through conventional plant breeding from rapeseed, an oilseed plant already used in ancient civilization as a fuel. Rapeseed was once considered a specialty crop in Canada; canola has since become a major American cash crop. Canola meal contains approximately 40 percent crude protein. It is an oilseed meal used to supplement and sometimes replace soybean meal in poultry feeds, particularly in the northern latitudes of the United States and Canada.

PEANUT MEAL - Ground peanut kernels with the fat extracted is peanut meal. The protein content is approximately 35% but varies depending on the amount of hulls and the method used to extract the fat. Peanut meal is a fair source of protein for poultry.

SOYBEAN MEAL – Soybean meal is the most commonly used plant protein source. Most commercial diets contain large amounts of soybean meal. It is a very palatable supplement, and contains either 44% or 48.5% protein, depending on whether or not the hulls have been removed during the oil extraction process. It is usually the most economical protein source for animal diets produced in the US.



Animal Proteins

Compared to plant proteins, animal proteins are higher in quality because of a better balance of essential amino acids.

FISH MEAL - Fish meal is made from dried and ground fish and fish by-products. It contains approximately 60% protein. Fish meal is occasionally used in poultry feeds but high cost tends to limit its usage. Too much fish meal in a poultry diet will result in the eggs and meat having a “fishy” flavor. Most of the fish meal available in the United States goes either into the aquaculture or pet food industries.

MEAT AND BONE MEAL - produced by cooking animal tissues and bones under steam pressure and then grinding them. This meal has a protein content of 50% to 60%, and is a common source of protein in poultry rations.

POULTRY BY-PRODUCT MEAL – This poultry by-product is very high in protein. The meal is made by rendering clean poultry carcass parts and grinding the product into a meal.

FEED ADDITIVES

Feed additives are important to the business of food in the country and world. With the help of feed additives, producers can grow more economically the food-producing animals that represent a large percentage of the protein consumed in this country.

Feed additives are compounds that producers add to a diet for reasons other than to supply nutrients to the animal. Different additives affect different parts of the body. In general, the purposes of feed additives are to enhance production efficiency, to improve health, and to reduce morbidity.

Feed additives are typically mixed into the feed in very small amounts. Concerns with toxicity and end-product residues make regulation of most additives strict and subject to change as new information becomes available. Proper mixing, delivery, and consumption of feed additives is critical.

Because feed additives are regulated, no one can authorize the use of one in a manner inconsistent with the label. To find detailed information on the regulation and use of feed additives, refer to the *Feed Additive Compendium*. The *Feed Additive Compendium* provides the following information:

- Amount of each additive that can be added to a feed
- Combination of additives that are legal
- Purpose or “claim” for each level of addition
- Withdrawal period for each additive

Official information about the approval of antibiotics and other animal drugs is found in the *Code of Federal Regulations (CFR)*, updated annually by the Food and Drug Administration (FDA).

PUBLIC HEALTH

Many people are concerned with the effects of feed additive use on human health. No solid evidence of problems with human or animal health has arisen since the use of additives began 50 years ago. The FDA tests all additives and confirms by research if an additive is suitable and safe for use.

TYPES OF FEED ADDITIVES USED IN POULTRY DIETS

Antibiotics

A feed additive is classified as an antibacterial agent (or antibiotic) if it limits the growth of certain bacteria. Bacteria that cause clinical sickness or subclinical reductions in health reduce poultry performance.

Antibiotics are approved in the United States for use as low-level continuous or periodic additions to a diet to enhance production efficiency. They are also approved for the treatment of clinical disease. Several production responses can be achieved through appropriate use of antibiotics. Using antibiotics in a diet for the FDA approved time span can enhance gain and feed efficiency. Examples of antibiotics used in the poultry industry are chlortetracycline, oxytetracycline, bacitracin, and tylosin.

Antibiotics can also reduce the occurrence and severity of respiratory diseases and diarrhea. Antibiotic use occurs in almost all livestock species. Antibiotics are produced in organisms found naturally in the environment. People and animals have been exposed to antibiotics for centuries. Their use in the poultry industry results in healthier animals. In recent years the use of low level or sub-clinical concentrations of antibiotic growth promoters has been discouraged because scientist have developed evidence that certain strains of bacteria can develop antibiotic resistance. This is important for certain antibiotics used both in the animal feeding industry and human medicine because as human beings we want our

antibiotics to work well when needed to cure a disease condition. Use of antibiotics at therapeutic concentrations to cure disease rather than promote growth is not controversial. Antibiotic growth promoters used at non-therapeutic concentrations were banned in Europe in 2006 and United States poultry producers no longer use most antibiotic growth promoters because they are obviously aware of this controversy and want to be good stewards of the environment. The use of non-antibiotic growth promoters such as prebiotics and probiotics are now widely practiced in the US poultry industry.

Other Additives

Coccidiostats

Coccidiosis is a parasitic disease of the intestinal tract of animals, caused by coccidian protozoa. Young poultry raised in floor pens will typically have a coccidiostat in their diet or they will be vaccinated against the disease. Some common coccidiostats include BioCox™, Coban™, and Nicarbazine™.

Dewormers

Dewormers can be placed in the feed or water to control stomach and intestinal worms. Using anthelmintics (wormers) properly increases performance by eliminating the intestinal worms that reduce feed efficiency. Anthelmintics should not be used if the birds do not need worming. Examples of common anthelmintic additives for poultry are hygromycin, piperazine tartrate, phenothiazine, and Tramisol™. Fenbendazole™ is currently approved for use in turkey feeds.

Pellet Binders

Pellet quality is a major factor for efficient broiler and turkey production. Wheat-based diets tend to pellet better than corn-based diets. A number of other pellet binders are also available to poultry nutritionist, including colloidal clays like sodium bentonite and sugar-rich binders like lignosulfonates.

Pigments

Yellow dietary pigments are very important in poultry feeds, particularly with respect to laying hens. Egg yolks are yellow because of the yellow xanthophyll pigments in corn. If poultry nutritionists use other ingredients like grain sorghum (milo) or wheat there are not enough pigments present to color the eggs. The most common pigment concentrates are often made from golden marigold flowers. Alfalfa meal can also be used to pigment eggs.

Non-Antibiotic Growth Promoters

Prebiotics - A prebiotic is “a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microflora that confers benefits upon host well-being and health.” Examples include yeast cell wall products rich in mannan oligosaccharides (MOS). Many non-starch oligosaccharides (NSPs) can function as a prebiotic.

Probiotics – Unlike antibiotics, probiotics imply the use of live microorganisms such as *Lactobacillus* and *Bacillus subtilis* species. These are the so called “good bacteria” that normally reside in the lower digestive tract of most animals. They can prevent pathogenic bacteria such as

E. coli from establishing populations high enough to cause disease through a process called “competitive exclusion.”

Exogenous Enzymes – There are several enzymes available for use in poultry feeds to improve nutrient utilization. These include phytase enzymes to improve the absorption of phosphorus from corn and soybean meal, beta glucanase enzymes to reduce digesta viscosity caused by certain fibers and NSPs and lipases to improve the bioavailability of dietary lipids or fats.

Note: Hormones and steroids are NOT utilized in the production of poultry; their use in poultry production is not approved by the FDA.

FORMULATING DIETS FOR POULTRY

A feed’s nutritive value and digestibility vary within the different classes of poultry. However, producers can access dependable guides to assist them in matching feeds to animal needs. Nutritionists have developed feeding standards for determining daily nutritive requirements of poultry. Proper feeds are formulated using those feeding standards. Poultry producers sometimes use the terms ration and balanced diet synonymously. The two terms have different meanings. A bird may be provided a certain amount of feed (ration), but that does not mean the bird receives the correct amount of daily nutrition (balanced diet). Poultry diets are based on the age and intended use of the bird. Poultry generally have continuous access to feed throughout the day. Broiler breeder and turkey breeder diets are restricted in the sense that feed is usually offered every other day during the growing period, referred to as “skip-a-day” feeding.

Laying Hen Diets

Poultry for egg production must be provided balanced diets meeting requirements for body maintenance and egg production. Most laying hens are of the white leghorn breed. These birds are bred to have a fairly small body size (small maintenance requirement) coupled with maximum egg production approaching 300 eggs per year. Eggs are rich in protein, minerals, and vitamins; therefore, laying hens are fed feeds high in these nutrients. Use the following table as a general guide for feeding leghorn poultry. Note it is critical to increase the calcium concentration as the hens begin producing eggs. The egg shells are made of calcium carbonate or limestone.

Appr. Age	Type of Diet	Energy	Protein	Calcium	Phosphorus¹
0 – 8 weeks	Pullet Starter	2850 kcal/kg	18%	1.0%	0.50%
9 – 17 weeks	Pullet Grower	2850 kcal/kg	16%	0.9%	0.45%
17 + weeks	Laying Hen	2850 kcal/kg	17%	3.5%	0.45%

¹Non-Phytate or available phosphorus

Diets formulated for market broilers and turkeys are relatively high in protein, minerals, and vitamins. These feeds generally contain more protein and energy than laying hen feeds and are fed free choice. Feeding free choice means that fresh feed is readily available to poultry, and they eat when their appetite demands. Maximum feed to gain ratios are very important when feeding these meat producing birds. Turkey diets begin with protein concentrations as high as 28% while broiler starter diets usually contain about 22% protein.

Broiler Diets

Appr. Age	Type of Diet	Energy	Protein	Calcium	Phosphorus ¹
0 – 3 weeks	Starter	3000 kcal/kg	22%	0.95%	0.47%
4 – 5 weeks	Grower	3100 kcal/kg	20%	0.9%	0.45%
6 - 7 weeks	Finisher	3200 kcal/kg	18%	0.85%	0.42%

¹Non-Phytate or available phosphorus

SIX ESSENTIALS OF A GOOD POULTRY FEED

- **BALANCED NUTRITION.** Increased weight gain and greater profit are realized with a balanced diet.
- **DIVERSIFIED IN FEEDSTUFFS.** Different feedstuffs allow for diet balancing.
- **SUCCULENT.** Poultry consume more feed if it is fresh and appealing.
- **PALATABLE.** Poultry consume more feed if it tastes good.
- **ECONOMICAL.** Low cost, high quality diets keep the producer in business.
- **SUITABLE FOR THE ANIMAL.** Livestock or ruminant animal feeds are NOT appropriate for poultry.

“RULES OF THUMB” FOR FEEDING POULTRY

Nutritional requirements for poultry are approximately the same as those for other domesticated animals in that all animals require the essential nutrients. However, poultry are unable to digest large amounts of crude fiber or roughage. High roughage cattle feeds would never work well for poultry and vice versa; a concentrated poultry feed could potentially kill a cow or horse that was not adapted to a low roughage highly concentrated feed. Swine actually can do pretty well on a poultry feed; they are non-ruminant animals.

FEED PREPARATION

Feed preparation can increase palatability and consumption, improve digestion, eliminate waste, and make the feed easier to handle. Conversely, improper feed preparation can decrease the value of a feed. Grinding grain for poultry feed is essential because it increases consumption and digestion. Very finely ground grain feels floury and is not palatable to poultry. After grains are ground and mixed into the final feed formula, the resulting mix is reconstituted into pellets for older birds or crumbles for baby chicks. Feeding crumbles and pellets to poultry increases consumption, reduces waste, and handles easier. Pelleting a finely ground mash feed can improve feed efficiency over 4% for broilers and turkeys.

NUTRITIVE REQUIREMENTS OF POULTRY

Feed nutritionists have developed feeding standards to serve as guides for producers to determine the nutritive requirements of animals. The feeding standards are only guidelines. Differences occur in the feeding values of any two lots of the same kind of feeds because are never identical depending when and where they were harvested. Also, the abilities of animals to digest and utilize feeds will vary. Remember, a diet may meet the nutritive requirements listed in the standards, but it may not be a good feed.

To determine the nutritive requirements of an animal, one must know the approximate age, or more appropriately, weight of the animal, or group of animals. Also, the class of the animal must be known. Some of the classes of poultry are replacement pullets, laying hens, growing and finishing broilers and turkeys. Each class has different nutritive requirements.

After the class of poultry is determined, refer to a feed analysis standard, such as those of the National Research Council (NRC), or Leeson and Summer's *Commercial Poultry Nutrition* to find the nutritive requirements for the class and age/weight of the poultry. A range is provided in the standards to allow for economic conditions. These will determine whether the producer will use the lower or higher figures in the standards. The higher figure usually is recommended for maximum performance but these are usually more expensive to feed as you might suspect. Sometimes it is more profitable to feed a little bit lower nutrient density with the understanding that the birds may have to stay in the rearing facility a few days longer.

COMPUTING DIETS USING THE PEARSON'S SQUARE

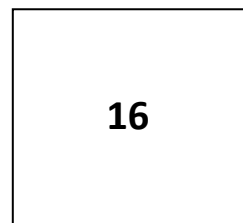
The Pearson's Square method is a simplified process for computing the proportions of feeds in poultry diets. Use the desired protein requirement to compute the ration. The following example determines the number of pounds of ground corn (9% protein) and concentrate (41% protein) needed to formulate a 16% protein feed. Presume this concentrate will contain all the additional minerals, vitamins and other feed additives necessary to produce a complete feed.

USING THE PEARSON'S SQUARE METHOD

Step 1.



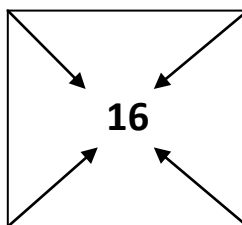
Step 2.



Steps 3, 4, and 5.

Corn 9.0

**25.0 Parts of Gr. corn
to use in mixture**



Concentrate 41.0

**7.0 Parts of Concentrate
to use in mixture**

Total Parts in Mixture = 32

Step 6. Ground Corn $25/32 = 78.12\%$
 Concentrate $7/32 = 21.87\%$

Explanation:

- Step 1. Draw a square.
- Step 2. In the center of the square, where diagonal lines would cross, enter the percentage of protein desired (16) in the feed.
- Step 3. To the left of the upper left-hand corner of the square, list the protein content of the grain (ground corn, 9% in the example).
- Step 4. To the left of the lower left-hand corner of the square, list the concentrate and its protein content (41%).
- Step 5. The smaller number along a diagonal of the box is subtracted from the larger number along the same diagonal of the box, and the calculated difference is listed at the far right (that is, $16 - 9 = 7$, and $41 - 16 = 25$). The differences are the parts of the two individual feedstuffs to use in the final mixture.
- Step 6. The percentage of each feed to use in the mixture is determined.

To produce a 16% protein ration using ground corn (9%) and concentrate, 78.12 lb. of ground corn is mixed with 21.87 lb. of concentrate.

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* *Dr. Chris Bailey, Poultry Nutritionist, Department of Poultry Science, Texas A&M University, and Dr. Austin Cantor, Associate professor, University of Kentucky, researched and revised this topic. This topic was reviewed extensively by members of the National FFA Poultry Evaluation CDE Committee. Kirk C. Edney, Ph.D., Instructional Materials Service, Texas A&M University, refined, edited and formatted this topic. The background materials in this topic were initially developed by Larry Ermis, Curriculum Specialist (retired), Instructional Materials Service, Texas A&M University.*