

Feeds and Feeding for Small-scale Egg-production Enterprises

Jacquie Jacob and Tony Pescatore, Animal and Food Sciences

Introduction

Animals eat in order to get the energy and nutrients they need to live, grow and reproduce. Animals use energy to perform normal body functions such as breathing, walking, eating, digesting, and maintaining body temperature. Different types of nutrients provide energy as well as the building blocks needed for the development of bone, flesh, feathers, and eggs. These nutrients include: water, carbohydrates, fats, proteins, minerals, and vitamins. Each of these components is important and a deficit of even one can have serious health consequences for poultry.

Water

Water is often overlooked, but is one of the most important nutrients. An animal can live longer without food than it can live without water. Water is also important for egg production. A whole egg has 78 percent water. In a laying flock, a shortage of water for just a few hours can result in reduced egg production.

Water is important in the body of a chicken. Water softens feeds and carries it through the digestive tract. Blood is 90 percent water and carries nutrients from the digestive tract to cells and carries away waste products. Water is also important in body temperature control. Chickens do not have sweat glands so their heat loss occurs in the air sacs and lungs through respiration. Excess heat is lost by the evaporation of water from the respiratory system.

Clean water must be available at all times. A chicken drinks twice as much as it eats. A laying hen eats about a quarter of a pound of feed every day, so she would drink a half a pound of water daily. One gallon (16 cups) of water weighs about

8 pounds so one hen would drink a full cup of water daily. A laying hen drinks about 25 percent of her daily water intake during the last two hours of daylight. Excessive salt in the diet will increase water consumption and result in wet manure, thereby increasing the risk of elevated ammonia levels.

Carbohydrates

Carbohydrates, often referred to as “carbs,” are an important energy source for chickens and make up the largest portion of the poultry diet, typically in the form of corn, wheat, barley or other grains. Not all carbohydrates can be digested by chickens because of the way the parts of the compounds are held together. For example, chickens cannot digest cellulose and many other types of fiber. This is why grass and other forages are not well digested by poultry.

Fats

Fats are another source of energy. For equal weights, fats have more than twice the number of calories of carbohydrates. Fats provide nine calories of energy per gram while carbohydrates provide only four. At room temperature, some fats are solid and others are liquid. This depends on the number of double-bonds between the carbon atoms in the compound. If there are no double-bonds, the fats are referred to as saturated. Saturated fats are typically solid at room temperature. Examples are tallow, lard, poultry fat, and choice white grease. If there are double-bonds, the fats are referred to as unsaturated fatty acids. Unsaturated fats are typically liquid at room temperature. Examples are corn oil, soy oil, and canola oil. Common sources of supplemental fat in commer-

cial poultry diets include animal fat, poultry fat, and yellow grease. The current high cost of vegetable oils makes including these fats in poultry diets uneconomical.

Fats are composed of building blocks called fatty acids. Although there are many different fatty acids, poultry have a specific requirement for one – linoleic acid. Linoleic acid is considered an essential fatty acid because poultry are not able to produce it from other nutrients. It is essential, therefore, that linoleic acid be supplied in poultry diets. When diets are maize-based, there is typically sufficient linoleic acid in the diet.

There are some ingredients that can be added to the diet to increase the level of polyunsaturated fatty acids, especially the omega-3 fatty acids which are important in human health. They include flax seed and algae meal.

Fat must be in poultry diets so that the fat-soluble vitamins A, D, E, and K can be absorbed from the diet. Fat is required for the absorption of these vitamins, so a shortage of fat may result in a vitamin deficiency.

In addition to its role in nutrition, fat is added to feed to reduce grain dust. Fat addition also makes the feed more appetizing to chickens. One problem with fats, however, is that they can go rancid. While this is a year-round problem, the risk is even greater in the summer. To prevent feed spoilage, antioxidants are added to poultry diets which contain added fat. A common antioxidant used in the United States is ethoxyquin. For organic diets, however, ethoxyquin cannot be included in the feed. Although ‘natural’ antioxidants are added to organic poultry feeds, organic feeds have a higher tendency to spoil.

Proteins

Proteins are an important nutrient. They are made up of smaller units called amino acids. After chickens eat feed, the activities of the digestive tract break down the protein into its amino acid components. These amino acids are then absorbed by the blood and transported to the cells in the body that convert the individual amino acids into the specific proteins required by the animal. These proteins are then used in the construction of body tissues such as muscles, nerves,

cartilage, skin, feathers, beak, etc. Protein also is needed for egg production. Egg white is high in protein.

There are two general types of amino acids – essential and nonessential. Both are required by the animal, but essential amino acids are those that cannot be made by the animal in quantities fast enough to meet the needs of the chicken. The nonessential amino acids are those that the body can produce as long as there is sufficient starting material. There are 22 amino acids commonly found in feed ingredients used in chicken diets. Of these, 11 are considered essential and must be supplied in the feed in the right amounts. Poultry diets typically contain a variety of feedstuffs because no single ingredient is able to supply all the needed amino acids in the right amounts.

Most tags on poultry feed only tell you the percentage of the protein in the feed. This information does not really tell you about the quality of the protein. Protein quality is based on the number of essential amino acids it contains. For poultry, the two most important amino acids are methionine and lysine. If there is not enough of either of these two amino acids, there will be a major drop in egg production and poor health of the flock. Commercial poultry diets typically contain methionine and lysine supplements. When such supplements are used, feed can contain less total protein than would be needed if the feed was created without them. If you are feeding organic diets, however, the use of supplemental amino acids is restricted.

The main sources of protein in poultry diets are plant proteins such as soybean meal, canola meal, corn gluten meal, and others. Animal proteins used for poultry diets include fishmeal and meat and bone meal. Fishmeal can only be used in low levels (less than 5 percent of the diet) or it will give the eggs produced a fishy taste.

Minerals

Minerals play many important roles in the body. The most obvious is bone formation, but minerals are also needed for several other important functions including formation of blood cells, blood clotting, enzyme activation, energy metabolism, and proper muscle function.

Minerals are typically classified as macro- or micro-minerals. Macro-minerals are those required in relatively larger amounts than micro-minerals. Micro-minerals are only required in trace amounts. The macro-minerals include calcium, phosphorus, chlorine, magnesium, potassium and sodium. Many people are familiar with calcium's role in proper bone formation and eggshell quality, but calcium's important role in blood-clot formation and muscle contraction is less well known. Phosphorus is also important in bone development. In addition, phosphorus is part of cell membranes and is required for many metabolic functions. Chlorine is important in the formation of hydrochloric acid in the stomach and thus plays a role in digestion. Sodium and potassium are electrolytes important for metabolic, muscle, and nerve functions. Magnesium also assists with metabolic and muscle functions.

The micro-minerals include copper, iodine, iron, manganese, selenium and zinc. Although poultry have lower requirements for micro-minerals, these minerals play essential roles in the body's metabolism. Iodine, for example, is required to produce thyroid hormones that regulate energy metabolism. Similarly, zinc is involved in many enzyme-based reactions in the body, and iron aids oxygen transportation within the body.

Grains are low in minerals, and many of the minerals they do contain are not biologically available. As a result, mineral supplements are added to commercial poultry feeds. Limestone or oyster shell are common sources of calcium. Steamed bone meal is another calcium source. Dicalcium phosphate is a common source of phosphorus and calcium. The micro-minerals are usually supplied in a mineral premix.

Vitamins

Vitamins are a group of organic compounds that poultry require in small amounts. Despite the low requirement levels, however, vitamins are essential for normal body functions, growth, and reproduction. A deficiency of one or more vitamins can lead to a number of diseases or syndromes.

Vitamins are divided into two categories: fat-soluble and water soluble. The fat-soluble vitamins

are A, D, E, and K. Vitamin A is required for normal growth and development of the skin and linings of the digestive, reproductive, and respiratory tracts as well as reproduction. Vitamin D3 is required for normal growth, bone development, and eggshell formation. Vitamin K is essential for blood-clot formation. Vitamin E is a natural antioxidant.

The water-soluble vitamins include vitamin C and the B vitamins. The B vitamins include vitamin B12, biotin, folacin, niacin, pantothenic acid, pyridoxine, riboflavin and thiamin. The B-vitamins are involved in many metabolic functions, including energy metabolism. Poultry can make vitamin C, so there is no dietary requirement for this vitamin. Vitamin C supplementation, however, has been shown to be useful when birds are stressed.

Some vitamins are produced by microorganisms in the digestive tract. Vitamin D can be produced when sunlight hits the bird's skin. This will not occur, of course, if the chickens are kept inside. Other vitamins must be supplied because they are not formed by the birds. Many essential vitamins are partially supplied by feed ingredients such as alfalfa meal and distillers' dried solubles. A vitamin premix is typically used to compensate for the fluctuating levels of vitamins found naturally in food to assure adequate levels of all vitamins. Individual vitamins vary in cost. A quality vitamin mix has the correct vitamins in the correct amounts. Cheap vitamin sources will include many of the less expensive vitamins.

Nutrient Requirements

Examples of nutritional requirements for the different age groups are shown in Table 1. The nutrient requirements for growing chicks and laying hens will vary depending on the breed or strain. Most of the commercial strains have diet specifications recommended by the breeders. In a commercial operation, diets are typically adjusted based on environmental temperature and feed consumption. At high temperatures chickens will eat less feed. As a result, the feed will need to be higher in nutrient density in order for the chickens to get all the nutrients needed in the amount of feed they are eating.

The requirement for individual nutrients vary depending on the energy content in the feed. With feeds high in energy, the hens will consume less and will, therefore, require higher nutrient levels in the feed. Detailed nutrient guidelines are available from the breeders and should be followed for the strain of layer being raised. Large commercial operations often use phase feeding to reduce feed costs. This means feeding different nutrient levels as required at each stage of development. For example, 17 percent crude protein (CP) for starter, 15 percent CP for grower, 14 percent CP for developing, 16 percent for a pre-lay diet, and 15 percent for layer.

For most small-scale producers, the use of several diets may not be practical. Aside from the fact that they may not be available, the increased cost with the amounts of each feed needed may not be cost effective. A 16 percent CP starter/grower may suffice with a 16 percent to 18 percent CP layer feed.

The diets fed should be specific for the type and age of chickens being raised. It is important to not feed chick feed to layers, or layer feed to growing chicks. Growing chicks need higher protein levels than adults. The protein can be reduced for the adults, but the calcium and phosphorus levels need to be increased to allow for egg production. The high level of calcium in layer diets would provide too much calcium for growing chicks and cause kidney damage and visceral gout.

Tables 2, 3, 4, 5, and 6 give examples of starter, grower, developer, pre-lay, and layer diets respectively. Options looked at corn versus sorghum and soybean meal versus whole soybeans. These are just examples. Formulations will vary depending on the nutrient content of the feed ingredients.

Table 1. Nutritional requirements for egg-type chickens.

NUTRIENT	Chick starter	Chick grower	Pullet developer	Prelay	Layers
Metabolizable energy, kcal/kg	2800	2800	2850	2850	2900
Crude protein %	17.00	15.00	14.00	16.00	15.00
Lysine, %	0.80	0.56	0.42	0.49	0.69
Methionine, %	0.28	0.23	0.19	0.21	0.30
Methionine + Cystine, %	0.59	0.49	0.39	0.44	0.58
Arginine, %	0.94	0.78	0.62	0.72	0.70
Histidine, %	0.25	0.21	0.16	0.18	0.17
Isoleucine, %	0.57	0.47	0.37	0.42	0.65
Leucine, %	1.00	0.80	0.65	0.75	0.82
Phenylalanine, %	0.51	0.42	0.34	0.38	0.47
Threonine, %	0.64	0.53	0.35	0.44	0.47
Tryptophan, %	0.16	0.13	0.10	0.11	0.16
Valine, %	0.59	0.49	0.38	0.43	0.70
Calcium, %	0.90	0.80	0.80	1.80	3.25
Avail Phosphorus, %	0.40	0.35	0.30	0.35	0.25
Sodium, %	0.15	0.15	0.15	0.15	0.15
Chloride, %	0.12	0.11	0.11	0.11	0.13

Table 2. Examples of chick starter diets, as percent of diet.

INGREDIENT	1	2	3
Corn	68.80		56.80
Wheat			
Sorghum		73.80	
Oats			5.00
Flax seed			0.20
Soybean meal, solvent extracted	26.90	21.20	
Whole soybeans, roasted			28.10
Sunflower seed meal, expeller			3.10
Dried distillers' grains with solubles			1.60
Yellow grease		0.50	
Alfalfa meal		0.10	1.00
D,L-Methionine		0.10	
Salt	0.35	0.40	0.30
Limestone	1.20	1.15	1.15
Dicalcium phosphate	1.75	1.75	1.75
Vitamin-mineral premix	1.00	1.00	1.00
TOTAL	100	100	100

Table 3. Examples of chick grower diets, as percent of diet.

INGREDIENT	1	2	3
Corn	72.70		56.00
Sorghum		79.00	
Oats			11.50
Flax seed			
Soybean meal, solvent extracted	21.35	12.00	
Whole soybeans, roasted			19.05
Sunflower seed meal, expeller			
Dried distillers' grains with solubles	2.00	3.75	8.70
Yellow grease		0.65	
Alfalfa meal		0.50	1.00
D,L-Methionine		0.10	
Salt	0.35	0.30	0.25
Limestone	1.10	1.20	1.10
Dicalcium phosphate	1.50	1.50	1.40
Vitamin-mineral premix	1.00	1.00	1.00
<i>TOTAL</i>	<i>100</i>	<i>100</i>	<i>100</i>

Table 4. Examples of pullet developer diets, as percent of diet.

INGREDIENT	1	2	3
Corn	75.00		57.00
Sorghum		70.50	
Oats		6.45	11.50
Flax seed			
Soybean meal, solvent extracted	17.00	8.00	
Whole soybeans, roasted			16.50
Sunflower seed meal, expeller			
Dried distillers' grains with solubles	4.15	10.00	10.25
Yellow grease		0.65	
Alfalfa meal		0.50	1.00
D,L-Methionine		0.10	
Salt	0.35	0.30	0.25
Limestone	1.30	1.25	1.30
Dicalcium phosphate	1.20	1.25	1.20
Vitamin-mineral premix	1.00	1.00	1.00
<i>TOTAL</i>	<i>100</i>	<i>100</i>	<i>100</i>

Table 5. Examples of pre-lay diets, as percent of diet.

INGREDIENT	1	2	3
Corn	68.00		55.75
Sorghum		73.80	
Oats			5.00
Flax seed			
Soybean meal, solvent extracted	23.35	17.00	
Whole soybeans, roasted			25.00
Sunflower seed meal, expeller			5.10
Dried distillers' grains with solubles	2.10	2.20	1.85
Yellow grease		0.50	
Alfalfa meal		0.10	1.00
D,L-Methionine		0.10	
Salt	0.30	0.30	0.30
Limestone	3.75	3.75	3.75
Dicalcium phosphate	1.50	1.25	1.25
Vitamin-mineral premix	1.00	1.00	1.00
<i>TOTAL</i>	<i>100</i>	<i>100</i>	<i>100</i>

Table 6. Examples of layer diets, as percent of diet.

INGREDIENT	1	2	3
Corn	64.46		57.75
Sorghum		72.50	
Oats			2.46
Flax seed			
Soybean meal, solvent extracted	23.00	15.43	
Whole soybeans, roasted			24.46
Sunflower seed meal, expeller			5.00
Dried distillers' grains with solubles			
Yellow grease	2.50	1.75	
Alfalfa meal		0.12	0.45
D,L-Methionine		0.20	
Salt	0.29	0.25	0.28
Limestone	7.95	7.90	7.90
Dicalcium phosphate	0.80	0.85	0.70
Vitamin-mineral premix	1.00	1.00	1.00
<i>TOTAL</i>	<i>100</i>	<i>100</i>	<i>100</i>

Sourcing Feed

It is important to buy the feed mixed specifically for the type of flock you are raising. That is, different diets for meat production, growing replacement flocks, and laying hens. You can get a lot of information by reading the feed tag. For information on feed tags, see ASC-216: “Reading a Feed Tag.”

Feed can be purchased as mash, pellets or crumbles. Crumbles are simply broken down pellets and are primarily used for chicks too small to eat pellets. Pellets are formed from mash to provide a feed in bite-sized morsels. In addition to reducing feed wastage, pellets improve palatability, destroy pathogens (since heat is involved in making pellets), reduce separation of ingredients, and improve flow-ability. The production of pellets requires the use of a binding agent which acts as a glue to hold the various ingredients together. For production of organic feed pellets, it is im-

portant to make sure that the binding agent is an approved feed additive. Pelletting has been shown to increase growth performance of meat chickens (broilers), but has limited performance improvement with laying hens. Pelletting feeds increases the cost of the feed and since they have not been shown to have major improvement in layer performance, mash is more economical.

Mixing Your Own Feed

If you have surplus grain, or can purchase it at a low cost, you might consider mixing your own feed. Such a decision should be made only after considerable consideration. You will need grain, which supplies energy; a protein source; calcium/phosphorus source, and a vitamin/trace mineral premix. If you are not able to source all of these feed ingredients, it is best to purchase a complete feed.



The majority of the poultry diets in the United States are corn-based. **Corn** is highly digestible and is often used as the standard to which other grains are compared. Yellow corn will also provide pigments to give yolks their yellow color. Corn will also function as a source of the essential fatty acid linoleic acid.



Some other countries where corn does not grow well, like parts of Canada and Europe, use **wheat** in their poultry diets instead of corn. It is important to know which variety you are using to be able to estimate its nutrient content. Some varieties contain what are known as anti-nutritional factors because they interfere with the digestion and absorption of the nutrients in the grain. There are enzymes which can be added to the feed to counter the effects of these anti-nutritional factors. If you are into organics, there are non-GMO feed enzymes available.



The same situation can occur with **barley** varieties. Several European countries use barley in their poultry diets. As with wheat, some varieties contain anti-nutritional factors which affect how well the chicken can use the nutrients in the grain. As with wheat, there are feed enzymes that can be added to barley-based diets which improve the nutritional value of the grain.



Sorghum is also a grain option for poultry diets. Several varieties of sorghum are high in tannins, another anti-nutritional factor. Sorghum is grown in some parts of the southeastern United States. These American varieties are typically low in tannins, or tannin-free, so you do not encounter the same nutritional problems as with high tannin varieties. Such varieties are a good alternative to corn.



Oats are a potential grain for poultry diets, but only the hull-less or naked oat varieties are used because of the high fiber in the hulls. The fatty acid composition of oats is different from that of other grains and the inclusion of too much oats in the diet can cause a change in the texture of the fat. As with wheat and barley, the use of feed enzymes is recommended when using oats in poultry diets.



The main protein source used in poultry diets is soybeans. If **whole soybeans** are used in poultry diets the soybeans must be roasted first. Soybeans contain an anti-nutritional factor, a trypsin inhibitor, that is destroyed during heating. The roasted soybeans are then ground and included in the poultry diets.



More common with commercial poultry diets, however, soybeans are included in poultry diets as **soybean meal** (SBM). SBM is a by-product of the vegetable oil industry after the oil has been removed from the soybeans. The processes involved in the extraction of the oil de-activates the anti-nutritional factor in soybeans making the soybean meal by-product safe for inclusion in poultry feed. Soybean oil can be extracted using solvent-extraction or mechanical extraction. While solvent-extraction is more efficient at oil removal, organic soybean meal must be produced using mechanical extraction.



Soybeans, while common in the United States, do not grow in all parts of the world. **Field peas** are commonly grown and used in poultry feeds in Canada and other countries. They do not need to be roasted.



Soybeans do not grow well in much of Canada and Europe, so canola is more popular. Canola is a type of rapeseed specifically bred to be free of the anti-nutritional factors commonly found in rapeseed. Canola itself is not commonly added to poultry feeds. Instead, it is the by-product of the canola oil industry, **canola meal**. As with soybean meal, organic canola meal must be produced using mechanical extraction.



Another byproduct of the vegetable oil industry is **sunflower seed meal**. The quality of sunflower seed meal will vary among processing facilities, based primarily on the number of hulls in the final product. Typically, the seeds are de-hulled and then some of the hulls are returned to help with the oil removal process. This will affect the fiber level in the sunflower seed meal. Again, with organic diets, the sunflower seed meal must be mechanically extracted.



A corn by-product, **corn gluten meal**, can also be used in poultry feeds, although it is typically too expensive to make its use economical. It is a good protein source.

The harvesting of livestock and poultry for food production in North America results in the production of nearly 50 billion pounds of byproduct material not used in human foods. These materials are used by the rendering industry to produce an important protein byproduct for poultry. The rendering process breaks down tissues into protein-rich products that have no resemblance to the original material. The cooking process controls bacteria while preserving the nutrients and results in a safe, nutritious animal feedstuff.



Meat meal is produced by rendering meat trimmings, inedible parts and organs, and fetuses. The materials are rendered (cooked) to produce a nutritional and economical feed ingredient which recycles these 'waste' materials. Blood, hair, hoofs, horns, manure, stomach contents and hide trimmings are NOT included in meat meal. When bones are added to the meat it becomes meat and bone meal. Beef and pork by-products account for more than 80 percent of all products produced. If these by-products were not recycled into animal feeds they would have to be disposed of in landfills, causing environmental problems.



Poultry byproduct meal is an animal by-product of poultry processing. It is made from grinding rendered parts of poultry carcasses and can contain bones, offal, and possibly undeveloped eggs. The only feathers that would be present would be those that are unavoidable in the processing of the birds. The feathers are used in a specific feedstuff, *feather meal*.



Fishmeal is another animal protein product included in poultry diets. Several species of fish can be processed into fishmeal, with Menhaden accounting for 90 percent of fishmeal production in the United States. Antioxidants must be added to fishmeal to stabilize the fat it contains and prevent it from spoiling during transportation and storage. Fishmeal is an excellent source of the essential amino acids lysine, methionine and tryptophan. The typical antioxidant added to fishmeal is ethoxyquin. This product cannot be used in organic fishmeal. Instead, a less efficient but natural antioxidant must be used.



Dried distillers' grains with solubles (DDGS) are a byproduct of the growing corn-based ethanol production and is a low cost feed alternative. It is higher in protein than corn, but is deficient in the amino acids lysine and tryptophan. DDGS is being used to replace some of the corn and soybean meal in poultry diets. It is important to know what type of DDGS you are using, since there are high, medium, and low oil types available depending on the processing method used.



Alfalfa (*Medicago sativa*) is grown as an important forage crop in the United States and other countries. The crop is known as alfalfa in the United States, but is referred to as lucerne in other countries. Alfalfa is a legume, meaning that it is able to fix nitrogen from the air. This capability helps improve soil quality and results in a high-protein crop. Alfalfa is widely grown as a forage crop for cattle and other ruminants. The use of **dehydrated alfalfa meal** in diets for monogastric animals typically is limited by its high fiber content. Enzyme supplementation of alfalfa has not been shown to be effective in improving performance of broiler chickens fed alfalfa-containing diets. Alfalfa is, however, a natural source of xanthophylls, which are the pigments that give the yellow color to chicken skin and egg yolks.



Flax seed is a special ingredient added to some poultry diets. It provides a source of omega-3 fatty acids and is often used to produce specialty eggs that can increase the level of the omega-3 fatty acids in eggs. Premiums can be received for omega-3 enriched eggs, but eggs cannot be labeled as such unless there is research using your eggs to justify the claim.



The term "algae" refers to a variety of different plants. There are two main groups of algae – macroalgae (often referred to as seaweed) and microalgae. There are 10,000 species of seaweeds, but only a few of them are of interest in animal feeding. Among these is kelp. **Kelp meal** has been used in organic poultry feeds and is a valuable source of micro-minerals, pigments and polyunsaturated fatty acids.



There are different types of microalgae. Autotrophic species are photosynthetic-like plants. These are harder to mass produce because of the need for light. Heterotrophic algae, however, get their energy from organic carbon in much the same way as yeast, bacteria and animals. For this type of algae, the carbon source is sugar or acetate. Because they do not use photosynthesis, the resulting algae meal product does not appear green. **Algae meal** is an excellent source of polyunsaturated fatty acids.

Mycotoxins

Mycotoxins can be present in animal feed. Mycotoxins are produced by molds, which are filamentous fungi that frequently contaminate grains and improperly stored feed. Mold growth is typically associated with extremes in weather conditions, and mold spores are found almost everywhere, including in soil and plant debris. Crops can be contaminated with mold in the field, during harvest, storage, processing or feeding. The effects of mycotoxins in poultry feed depend on the specific mycotoxin or mycotoxins that may be present, the level of contamination, the length of time the animal has been consuming the contaminated feed, and the animal's age, sex, and level of stress.

Hundreds of different mycotoxins exist. They vary in their chemistry and the way they affect animals. The molds that are most common in animal feed are *aspergillus*, *fusarium*, and *penicillium*. As a result, the mycotoxins of greatest concern are produced by these molds and include aflatoxin from *aspergillus*; deoxynivalenol, zearalenone, T-2 toxin and fumonisin produced by *fusarium*; and ochratoxin and PR toxin produced by *penicillium*. Ergot is another mycotoxin commonly present in animal feed.

Even with excellent management, low levels of mycotoxins may exist in poultry feed. Several mycotoxin binders have been developed that prevent the toxic effects of mycotoxins on animals consuming the feed. These materials bind with the mycotoxins and prevent the negative effects on the animals consuming them. Potential mycotoxin binders include activated carbon; aluminosilicates (e.g., clay, bentonite, montmorillonite, zeolite, phyllosilicates); and complex indigestible carbohydrates (e.g., cellulose, polysaccharides in the cell walls of yeast and bacteria) as well as some synthetic polymers. The diversity in chemistry of mycotoxins influences the effectiveness of mycotoxin binders. Mycotoxin control measures may require multiple approaches to solve the problems associated with mycotoxin consumption. More recent approaches include the use of a combination of binders, microbial enzymes, yeast cell walls, and natural antioxidants.

Speciality Feeding

There has been some research to show improvement in growth performance for chicken meat production with the use of **whole grains**. Some researchers demonstrated reduced levels of intestinal pathogens. There was also increased gizzard size, and higher gizzard function may play a positive role in the control of bacterial populations. Other researchers, however, have shown increased coccidian problems with whole versus ground grain in the diet. The main advantage of feeding whole grains is the cost-savings in not having to grind the grains. For those growing their own grains, combining whole grains with a complementary protein pellet is a viable option.

Some producers have used **sprouting grains** in poultry production. This has not been shown to improve performance. Sprouting barley grain, for example, has been shown to decrease the metabolizable energy of the grain and decrease digestibility. Drying and grinding the sprouts improved their digestibility. This is a lot of work for minimal return. In addition, the use of sprouted grains increases the possibility of mold production.

Some backyard flocks use **fermented feed**, a process where a complete feed is soaked in water for up to 72 hours. The use of fermented feed is popular in commercial pig production, but has never been adopted by commercial poultry producers. There has been some research showing that fermented feed improved body weight gain and feed efficiency. This appears to be a result of a reduction in the pH of the wet mash (pH < 4) and an increase in short-chain fatty acids. This reduced the likelihood of food-borne pathogens becoming colonized in the digestive tract. There is also a release of phytate-bound phosphorus which is not available to the birds. This latter effect can be achieved by the use of the feed enzyme phytase, a commercially available product used by most commercial operations to improve the availability of phosphorus in the diet. With laying hens, some have seen increased egg weight and improved feed efficiency. Such studies, however, have involved less than 500 hens and only for a period of 20 weeks of production. The increased labor costs, higher risk of mold formation with the production

of mycotoxins, and the increased costs of feeders, do not justify the use of fermented feeds.

Pasture poultry has become more popular. In such production systems, chickens have access to large areas of various grasses or other forage plants. Although chickens will range, it must be remembered that the digestive tract of chickens is very different from that of cattle and sheep. The avian digestive system (see ASC-203: "Avian Digestive System") has very limited ability to digest grass. While pasturing chickens can be seen eating grass, they are not able to get a lot of nutrition from the grass. Foraging chickens are looking for seeds and insects that can be found in some pastures. During the spring and early summer insects are plentiful and can provide some nutrients to the chickens. However, in late summer the amounts of seed and insects available will decline. By winter they are nearly non-existent. Therefore, it is important for pasture poultry producers, especially those using improved chicken genetics, to provide a balanced feed year round. The feed should be available at all times. When insects and seeds are available, then chickens will eat less of the prepared feed. It is also important that the prepared feed not be diluted with the addition of scratch grains or cracked corn. For information on how much feed is required, refer to ASC-191: "How Much Will My Chickens Eat?"

Summary

Poultry requires a balanced source of protein, an energy source, and the correct amount of vitamins and minerals. When manufacturers are preparing feeds there are several steps in the process. First, the nutritionist defines the animals that will receive the formulated feed. They next select the right nutrient specifications for the animals and set the maximum/minimum allowances. They will then list the available ingredients with their characteristics, nutrient content, and prices. Finally, they use feed formulation software to prepare the recipe for the feed. The formulae are reviewed periodically and adjusted as required. This process enables feed companies to provide complete feeds that meet the needs of the bird.

Mixing your own feed is difficult, especially when these resources are not available. If you have your own grains, however, you can work with a nutritionist for the development of a protein plus vitamin/mineral supplement to combine with your grains. This may reduce your overall feed costs however, the cost of a supplement may be very expensive and proper mixing equipment must be available. With any grain source, mycotoxins can be a problem, so it is important to get your grains tested for mycotoxins and to properly store your grains. You can use the grains ground or whole, depending on the equipment you have available. Sprouting grains or fermenting feed is a possibility, however it is not recommended because of the complexity of the system and the potential for problems.

Meeting the nutritional needs of the bird throughout the stages of its development and production cycle is essential for the health of the flock and to have a profitable poultry operation.