Pastured-Raised Poultry Nutrition

By

Jeff Mattocks
Poultry and Livestock Nutritionist
The Fertrell Company
P.O. Box 265
Bainbridge, PA 17502
800-347-1566
jeff@fertrell.com

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FOREWARD:

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The Fertrell Company is a private company in Bainbridge, Pennsylvania specializing in natural agricultural products and services.

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INTRODUCTION

This publication explains the feed requirements of pasture-raised poultry and how to meet them. It also outlines the uses and nutritional values of different feed ingredients, both common as well as uncommon. It illustrates ration calculation methods for feed formulation and discusses applied feeding, including grain texture and milling practices.

FEED INGREDIENTS

Common Ingredients

Corn:
Corn is primarily used to supply energy to the diet. Other benefits of corn are the yellow/orange pigmentation with xanthophylls (5 ppm) and carotenes (0.5 ppm) for yellow skin and fat coloration. Corn has no feed inclusion limitations. Corn should be "medium ground" to uniform particle size, slightly smaller for chicks and larger for adult poultry. Corn is a staple ingredient in poultry diets. Corn has a higher potential, than other cereal grains, of aflatoxin formation as well as many other toxins. The formation of alflatoxin molds which lead to toxins are generally brought on by plant stress during the growing season. Try to buy high quality grains from areas without a difficult growing season.

Wheat:
Wheat is commonly used as a major source of energy in many countries. Wheat is higher in protein than corn or other small grains. However wheat is limited to 30% inclusion unless you add enzymes for digestion. Lysine should also be added as wheat is low in this amino acid. For proper digestion of wheat you should add Xylanase Enzyme, following manufacturer's directions.

Oats or Barley:
The primary purpose of oats and barley is to add fiber and to increase the bulk density of feed. The hull makes up 20% of the weight of oats and barley. High fiber from small grains keeps the digestive track clean and can also be used to limit feed intake. High-fiber small grains also add protein and energy, although most of this added nutrition is burned off digesting the excess fiber. Oats and barley have an inclusion limitation of 15% in any combination without added digestive enzymes. The result of excess oats or barley is wet litter and poor digestive viscosity.

Fishmeal:
Fishmeal provides a varied form of concentrated protein. Fishmeal also helps balance all of the essential amino acids, most importantly methionine and lysine. Fishmeal also stimulates appetite, as poultry have an instinctive craving for meat proteins.

Vitamin/Mineral Premix:
The primary purpose of the premix is to balance vitamins, macro and micro minerals to meet modern poultry hybrid health and performance needs.

Amino Acids:
Methionine and lysine are added to rations to balance amino acids, the building blocks of protein. Many amino acids will display a prefix (L- or D-). Amino acids occurring in animal tissues are always L isomers, while D isomers have no biological function in animal tissue. The only exception to this rule is methionine; poultry are able to use both D-methionine and L-methionine. Depending upon geographical location and grain availability, methionine or lysine may be required (Scott, 1982).

Salt:
Salt is required to support normal body functions and electrolyte balance.

Probiotic or Direct Fed Microbials (DFM's):
Beneficial bacteria added to the diet aids digestion and nutrient absorption for faster growth and better health. DFM's also replenish the bacteria flora, which directly compete with destructive or harmful pathogens (i.e. coccidiosis, E. coli and salmonella). Throughput or excess beneficial bacteria are excreted which aid to correct balance of bacteria in the litter.

Soybeans

Soybean Meal (Solvent-Extracted):

Soybean meal is the standard protein used by the poultry industry. The meal is a by-product of the vegetable and industrial oil industry, which removes the valuable oil, leaving a high-protein meal useful for livestock and poultry feed. The amino acid profile is very well suited to poultry nutrition when combined with corn or sorghum. The original bean has 18% oil. After oil removal, only 1.5% remains, thus decreasing the energy value. The oil extraction method includes de-hulling, cracking, conditioning to 158^{o} F, flaking to 0.25 mm, and then adding hexane to enhance oil extraction. Hexane must be removed from the meal because it is highly combustible and a potent carcinogen. There is no limitation for feed inclusion, except when extremely high levels are used in rations such as turkey pre-starter. The problem involves reduced carbohydrate digestibility, and the side affects may include wet litter and foot pad lesions in poults.

Raw Soybeans:

Raw soybeans should not be fed to poultry. When feeding soybeans to poultry, soybeans must be heat-treated to destroy a trypsin inhibitor that disrupts digestion. The presence of the trypsin inhibitors will also cause an enlarged pancreas (a 50%-100% increase). The side affects will occur at inclusion levels as low as 5%.

Roasted or Extruded Soybeans:

Roasted or extruded soybeans are an excellent source of both energy and protein. Roasted soybeans must be heated to 270^{o}-300^{o} degrees for 10 minutes to insure breakdown of trypsin inhibitor. Whole roasted soybeans should be “medium ground” to maintain uniform particle size with corn and other ingredients. Extruded soybeans will be in a meal form when purchased, no further grinding necessary. Extruded soybeans should not be stored for more than 30 days prior to use. The oil of the soybean has been exposed during this process. The oil may oxidize and turn rancid. This will smell similar to old motor oil. Neither of these forms of soybean has feeding limitations.

Roasted Soybeans vs. Soybean Meal:

Roasted soybeans’ natural oil is easy to digest and will also generate heat while digesting, which warms the bird. Roasted soybeans have a good smell and flavor, and poultry eat it well. On the other hand, solvent-extracted soybean meal has solvent residues. Also vegetable oils must be added to establish correct energy. These oils will not create similar heating when digested.

Expelled Soybean Meal:

Expelling is a grinding and a mechanical pressure extraction to remove the oil. This process uses a screw auger within a mesh casing that traps the meal and separates the oil. The entire operation is encased within a steam jacket to allow the oil to flow more freely and provides the heat required to breakdown the trypsin inhibitor. The extruded soybean meal is suitable for poultry and livestock feeds without feeding limitations other than excess protein. This process leaves approximately 7% of the original oil in the meal. This provides for an energy value midway between roasted soybeans and solvent-extracted soybean meal. Expelled soybean meal is a very suitable protein source for poultry raised in warmer climate due to lower energy values. However, expelled soybean meal is not available in all areas, mostly available in larger dairy production areas.

Water and Water Quality:

Water is understandably necessary to sustain life. Poultry will consume twice as much water as feed by weight. Therefore water quality is of great concern. Water should be tested for mineral content as in some cases minerals found in the water source have influenced the mineral requirements of the feed. Also of importance is the level of bacteria in the water as excessive levels will cause poor weight gains, decreased rate of lay and may lead to higher rates of mortality. Similar concern for water nitrate or nitrite levels; levels in excess of 50 ppm will affect the performance of poultry. If either condition is found (high bacteria or high nitrates and nitrites) these conditions can be corrected by chlorination, ultraviolet lights and filtration (Leeson and Summers, 1997).

Uncommon Ingredients

Sprouts:

Sprouted cereal grains may be used to increase vitamin content, especially carotenes. There are numerous studies regarding the feeding value of sprouted grains with very contradictory results. Sprouts may also used as a source of year round forage.

> For a time, sprouted oats were used to a considerable extent in the winter feeding of poultry to furnish a green and succulent feed. With the recent advances in knowledge concerning the importance of vitamins and other factors in poultry nutrition, efficient rations have been developed that have made the labor and expense of sprouting oats unnecessary. Therefore the practice has been largely discontinued. (Morrison, 1951, paragraph 1207)

The feed value of the grains changes significantly when sprouting occurs. Studies show decreased energy value, increased protein percentage and increased vitamin percentage. The reason for the change is as life begins, the energy from a seed is utilized very quickly to sustain the life of the new sprout.

Dairy Products or By-Products:

> Skim milk and buttermilk for poultry: Dairy by-products are especially valuable for poultry, and most commercial poultry men use rations including some milk by-product. Not only does milk furnish excellent protein, but also its high content of riboflavin is of particular value for poultry." (Morrison, 1951, paragraph 845)
>
> Whey has only about one-third as much calcium and phosphorus as skim milk…It is nearly as rich in riboflavin as is skim milk." (Morrison, 1951, paragraph 846)
>
> Whey is much more watery in composition than skim milk. When feeding whey it is very necessary to bear in mind the fact that most of the protein has been removed, and that the whey is not a protein-rich feed, like skim milk or buttermilk." (Morrison, 1951, paragraph 846)

The information above deals with feeding skim milk and buttermilk to laying hens. There are no limitations on the amount that can be fed. Generally 12-14 quarts per 100 hens is fed.

> Value of milk in poultry rations: A comprehensive three-year study at Pennsylvania State College in which additions of dried skim milk were added to a high grade all mash ration, showed that, when adjustments were made to keep the protein, calcium and phosphorus contents uniform, the rate of growth during the first two to four weeks of age, total feed intake, gain of weight during the growing period, and feed efficiency in the early part of the growing period all increased with increasing amounts of dry skim milk in the all mash rations. Most efficient and economical gains in up to four weeks were made with 2.5 and 5 percent milk. Greatest extra gains in weight per pound of dry skim milk consumed from 4 to 12 weeks occurred in the groups fed 1.25 to 2.5 percent dry skim milk…The University of Maryland reports that dried skim milk exerts a greater stimulating effect on a chick growth than can be explained on the basis of its riboflavin content. This is not true of dried whey. (Ewing, 1963)

Many more studies have been done and each shows benefits to the feeding of milk and milk by-products. Most studies recommend the feeding rates between 2-5% of the diet. I personally reserve the option of feeding milk products for treatment of coccidiosis and necrotic enteritis. The soothing affect of milk fed during these conditions will enable the affected poultry to resume eating and drinking normally. The feeding of milk during these times also enhances the growth and reproduction of beneficial bacteria in the digestive tract. This provides competition for harmful bacteria and organisms.

Pasture:

As this publication is written primarily for the benefit of pastured poultry producers, it is necessary to understand the importance of pasture to the diet. It is evident that poultry do consume green growing plants. Each type of poultry will consume different levels of forage as well as different varieties.

> Extensive experiments have been conducted to compare good pasture, or range with confinement or bare range for growing pullets or for laying hens. These experiments have shown that pullets which have been raised on fresh, uncontaminated pasture are usually more thrifty than those raised in confinement…Numerous experiments have shown clearly that the farm flocks of small or moderate size, it is more economical to provide clean, uncontaminated pasture during the growing season than to keep the layers in confinement. (Morrison, 1951, paragraph 1546)

Modern broiler breeds have very little desire to consume plant vegetation. However when provided with high quality forage, we have observed as much as 20% of the diet intake from forage. These observations are mostly noted on forage such as clover and alfalfa. It appears that they much prefer legumes. Forage consumption based on a mixed sward varies from 5-20% of the total diet. Upon gathering data from year to year and producer to producer, I have come to the conclusion that pastured poultry eat 5-20% pasture, depending on type and age of poultry and quality of forage growth.
Feed efficiency depends on feed concentrate intake, water intake, live weight, and average ambient temperatures. A typical industry broiler in a temperature-controlled environment will have a feed conversion rate (FCR) of approximately 2.09 lbs of feed to 1 lb live weight. It is difficult to estimate feed efficiency on pasture due to climate changes and temperature fluctuations.

Insects:

Personal observations have led me to the conclusion that insects are extremely high in protein and of great benefit in poultry diets. These proteins and amino acid profiles will be comparable to those of fish meal or meat meal. Unfortunately there is little data on nutrient content of insects. Below are some nutrient values:

Insect	Protein %	Fat%
Crickets	6.7	5.5
Termites	14.2	NA
Caterpillars	28.2	NA
Weevil	6.7	NA
Large Grasshopper	14.3	3.3
Silk Worm Pupae	9.6	5.6
Giant Water Bugs	19.8	8.3
Very Large Spider	63	10

Sources: http://www.planetscott.com/babes/nutrition.htm
http://ohioline.osu.edu/hyg-fact/2000/2160.html
http://www.riverdeep.net/current/2002/03/030402_eatingbugs.jhtml
http://www.eatbug.com/

> …a certain minimum amount of feeds of animal origin should be included in the ration. In the case of poultry that are confined, there is a greater benefit from including in the ration such supplements as meat scrap, fish meal, or dairy by-products, than there is for poultry which are on good pasture. This is due both the quality of protein in good pasture forage and to the worms and insects they secure on pasture. (Morrison, 1951, paragraph 1500)

Vegetarian Diet vs. Meat Products Diet

Both types of diets can be formulated to meet proper requirements. There are concerns as to health for the consumer concerning disease potential from the use of meat and bone meal or other animal by-products. These are valid concerns and I recommend the avoidance of re-feeding of domestic animals. The pitfall to the vegetarian diet is that in nature poultry eat non-plant foodstuffs. These foodstuffs include insects, small reptiles, and even small rodents. There is definitely a place in a poultry diet for meat-type protein whether we provide it or they catch it and it will more easily meet the bird's amino acid requirements. Vegetarian diets absent of meat-type proteins will require additional balancing of methionine which is not a prevalent amino acid in plant protein. I personally feel that diets including fishmeal (in place of domestic meat meal), reduces the possibility of cannibalization and overall satisfies the appetite of poultry better.

FEED PREPARATION

Milling

Several milling options are available for poultry producers.

- Large scale feed mills: These mills only deal with larger customers capable of receiving bulk feed in larger quantities. They require minimums of 8-10 ton deliveries.
- Small scale feed mills: These mills generally cater to the small farm units that are willing to receive 1-2 tons per delivery. These mills have minimum mixing requirements for special orders ranging anywhere from 500 lb to 2000 lb. The minimum mixing requirements may be partly due to machinery size or it may also be they do not wish to be bothered with orders less than 1 ton.
- Farm scale milling: This is the optimum for feed quality because you can make feed as needed to maintain freshness. Farm milling is generally done with grinder/mixer combinations. There are several manufacturers listed in the Reference Issue of *Feedstuffs* magazine. I find in our region at the local farm auctions, used grinder mixers of various sizes and brands will sell in the range of $400 to $4000. These values of course depend on condition.

New grist mills, both manual and powered models, are available from:

The C.S. Bell Co.
170 West Davis Street
P.O. Box 291
Tiffin, OH 44885
419-448-0791

www.csbellco.com
Also available through local dealers representing their products.

Soybean Roasting
Soybeans are roasted to breakdown the trypsin inhibitor. A urease test is done afterwards to determine if breakdown is sufficient. There are many different opinions on the methods and temperatures required for this process. The most common recommendation is heating to 270^{o} for 20 minutes when roasting whole soybeans.

The list of companies that offer small-scale roasters is short:

Gem Roaster
Third St.
Winona, MN 55987
507-454-1092 or 507-454-3755
Contact: Alice Goede

Schnupp's Grain Roasting, Inc.
R.D. 6, Box 840
Lebanon, PA 17042
800-452-4004
717-865-7334 fax
Sells the Roast-A-Matic

The other method of heating commonly used is extruding. In this process the beans are ground to a meal consistency then forced through a small die or orifice which generates the required heat by friction.

Commercial Feeds

Commercially produced feeds are available from all of the major manufacturers (i.e. Purina, Master Mix, Agway, and others). Commercially produced feeds will contain ingredients such as corn, soybean meal, meat and bone meal, feather meal, porcine meal, wheat midds, bakery meal (by product of the bakery industry), vitamins, minerals, and preservatives. They will all utilize a preservative (usually ethoxyquin) so the feeds will have a longer shelf life. Feeds may require a 6-month shelf life if they are manufactured at one central location, then warehoused and then distributed throughout a large area to smaller retail outlets. At the retail outlet they may be warehoused an additional 30-60 days prior to sale to the consumer.

Least Cost Rationing:
Commercially produced feeds are always produced under least cost guidelines. Every day commodities change value on the trade market. A change in protein could cost a large producer thousand of dollars. So they change the feed ingredients to compensate for the commodity changes. This is least cost rationing. This means that tomorrow's ration may be significantly different than today's ration. Since the feed is made in unrecognizable forms (pellets and crumbles), the feed will still look the same each time you purchase it even though ingredients may differ.

Crumbles vs. Mash Feed:
Crumbles are a crumbled pellet. Since small mills that do custom rations for small growers usually do not have pellet or crumbles capability, the rations are usually in mash form. Crumbles or mash can be

made as a suitable diet for poultry, but many people feel that poultry get a more complete diet from crumbles because they can't sort out certain ingredients. Other people feel that a mash diet is better because the grower can see the ingredients and have control over them.

Bagged vs. Bulk Feed:

The differences between bagged feed and bulk feed are:

- Price: Bagged feed is more expensive than bulk due to added cost of production and packaging. If this is not true at your mill you should be wary of the ingredients of the bagged feed. The ingredients may not be of the highest quality.
- Convenience: For growers with over 500 birds, bulk delivered feed will be much easier if it's available. You can get a custom ration. Growers under 500 generally opt for bagged feeds, usually the feedmill's formulation. Bagged feed allows the grower to buy small quantities at any time and helps guarantee freshness.
- Freshness: Freshness of feed impacts the appetite and therefore the production of poultry. When the feed is fresh, poultry will eat more frequently. However it is nearly impossible to make feed daily. Feeds are at the optimum levels for up to 14 days, and are satisfactory up to 45 days after grinding or milling. After 45 day the feed is generally so stale or oxidized that poultry appetite will be severely depressed. Oxidation starts immediately after the grinding or cracking of the grain. This oxidation occurs because of newly exposed moisture and starches within the grains. The oxidation of the starches will cause some energy losses of the feed value. However in most cases these losses are negligible when fed within 30-45 days after processing. Typical losses will include 10% of energy, 1-2% of the protein, 10% most vitamins, 30% vitamin K, and 15% riboflavin under normal storage conditions for 60 days.

Pastured poultry ration compared to Commercial ration

- There are not many significant differences between the commercially available diets and pastured poultry rations. The most significant differences would be ingredient controls, higher vitamin levels, and freshness. The rations cannot be balanced around the pasture as they change with each season and with each region. Therefore a ration is balance without including pasture and when pasture is available it is a bonus nutritional input.
- Storage: If you know you'll have to store feed for a long time, you can slow oxidation by improving the storage method. When ground feed is stored in limited air or air tight containers then minimal oxidation can occur. Generally unprocessed grains will store very well and hold their nutrition for up to two or even three years. These situations require water proof, bug proof containers or bins preferably in cooler conditions. For optimum storage, the use of air tight containers is best but not necessary. To enable storage of most grains for extended periods of time the grain will be treated with an insecticide or a dust added to repel insects during storage. Grains should be dried to 12-15% moisture content prior to storage to avoid condensation and molding.

FEEDING ISSUES

Feeding for Different Rates of Gain:

- Fast rate of gain: These are diets typically fed to meat production poultry to maximize growth potential. This type of commercial diet is included in the Appendices of this publication. These diets may be used in a commercial environment with climate control devices, lighting control and automated feeding equipment. These feeding methods may be used by pastured poultry producer with the understanding they may experience higher mortality rates due to the uncontrolled environment.
- Slow rate of gain: These feeding programs are used for egg production for both common layers and breeder stock poultry. Heritage breed poultry also require slower rate of gain feeding system as their

metabolism has not been bred for rapid development. This feeding style is intentionally designed to allow the poultry to develop a stronger metabolism and immune system. These feeding programs are also intended to control the fat production of the poultry. Excess fat will cause long-term problems with decreased rate of lay and increased egg size because of internal fat build ups on organs, primarily the reproductive system.

- Broilers and Roasters: Broilers are meat chickens raised for 42-45 days with a desired weight of 2.75-3.5 lb dressed. Broilers are typically fed diets categorized as Fast Rate of Gain. Roasters on the other hand are meat chickens raised for 49-56 days with a desired weight of 4-6 lb dressed. Roasters are typically fed diets categorized as Slow Rate of Gain.

Restricted vs. Full Feeding:

Restricted feeding methods are commonly used in commercial broiler and breeder operations. Broiler feed is restricted to reduce late-term mortality and ascites (water belly). When feed is restricted or withheld from broilers from day 7 through day 28 allowing feed for 8 hours, experiments have found a significant reduction of ascites and late term mortality (heart attacks) rates. The incidence of ascites can be controlled by diet, adjusting for lower energy values to allow internal organs to develop commensurate with body growth rate. This type of feeding program is generally accomplished with mash type diets.

Full feed methods of feeding can be used for the development of broilers, pullets and layers when diets are balanced for this type of feeding. This feeding method is not suitable for breeder flocks. Breeder layers will continue to over eat and over develop if allowed full feed. Feed restriction for broiler breeders is for weight and development control.

Self Selection and Whole Grain Feeding:

Poultry are capable of diet self selection.

> As with most other classes of poultry, the turkey seems able to balance its own nutrient intake when offered a selection of different diets on a range of individual ingredients. However, results from studies with turkeys are encouraging in that leaner carcasses are produced with this type of system. (Leeson and Summers, 1997)
>
> Chickens that are given the opportunity to simultaneously consume two or more feeds that differ significantly in protein content will tend to consume a mix of feeds that is close to the optimum protein content for their stage of growth. (Dudley-Cash, 1994)

In personal observations working with several growers throughout North America, I have seen these aspects to be true. In conjunction with these growers we have done field trials with turkey production starting at week 8 through finish. Starting at week 8 we offer whole wheat along with the regularly prepared feed. In week 8 the consumption of wheat is approximately 10% of the diet. Each progressing week, the ratio of wheat and prepared feed gets closer and actually inverts. The last week, the turkeys will consume approximately 80% whole wheat to 20% prepared feed.

Whole grain feeding concepts have been around since we have been interested in poultry. This is nothing new as we can watch the bird in the wild eat whole seeds at our bird feeders. The concept of feeding whole grains to production birds has been swept to the wayside with technology. However in recent years the concept of whole grain feeding has resurfaced.

> Feeding whole grains along with pellet-processed feed could result in considerable feed cost savings, depending upon the production system and market conditions. Moreover, some health benefits could be realized if a proper portion of the bird's diet contained whole grains. (Ferket, 2000)

> The feeding of whole grain to poultry was a common practice at one time…In addition to reduced feed cost, there are other good reasons for feeding whole grain. Whole grain frequently has considerable microbial activity on its surface…The feeding of whole grain usually results in a reduction in water consumption and improved litter quality. With improved litter quality comes reduced leg problems and lower coccidial load." (Dudley-Cash, 1998)

Keep in mind that the poultry should have an adequate supply of good quality grit at all times to digest whole grains. This is important not only with the feeding of whole grains but mash feeds as well. Most of the trials performed were using wheat as the whole grain. Other grains may be used. For instance ducks and geese prefer cracked or whole corn. Turkeys tend to ignore corn and prefer whole wheat. Chickens will generally prefer whole corn. Feeding whole corn to chickens or any other form of poultry should only be done when they are adult or nearing adult stage of life.

Omega-3 Fatty Acids:

Feeding for higher omega-3 fatty acids can be achieved by feeding feed ingredients such as the ones listed below. Of these are fish oil, linseed oil, flax seed, whole canola, and fish meal.

Ingredient	Omega-3 fatty acid content
Fish oil (menhaden)	34.7%
Linseed oil	56.4%
Flax seed	5.3%
Canola	4%
Fishmeal (menhaden)	1.75% (Robinette, 2002).

These are all acceptable feed ingredients, but each of these can create unfavorable side effects when overfed or mixed with others on the list. Too much fish oil or fishmeal will pass on the fishy flavor and smell. Canola will also pass on fishy flavors and aromas. This can occur in combination with each other or as lone ingredients added to a ration. Fishmeal can be added up to 5% without side affects. Fish oil can only be added up to 0.5% without side affects. Canola can be added up to 10% without noticeable smell or flavor changes. The flax products including the seed or the oil also will create off smells and flavors. These products generate paint-like smell to the eggs or meats produced. The upper limit for flax seeds included into a poultry diet is 10%. Flax seed oil should not be used above 0.5% and should approach this value slowly.

> Feeding flax seeds to poultry results in direct incorporation of linolenic acid into poultry meat and also into eggs. Feeding laying hens 10% flax results in a 10 fold increase in egg linolenic acid content, while feeding 20 and 30% results in 23 and 39 fold increase respectively…Linolenic acid is essentially responsible for the characteristic smell of fish oils and undoubtedly flax oil does have a paint-type smell. There is some concern about the taste and smell of linolenic acid-enriched eggs, and this area needs more careful study with controlled taste panel work. (Leeson and Summers, 1997)

Commercial egg producers have locked on to this concept and are now adding flax seed to there commercial layer diets. The buzz word in the egg industry is "Designer Eggs".

The pastured poultry producers raise chickens on grass to achieve higher levels of omega 3 fatty acids. I believe this synthesis does occur. I am not aware of omega 3 content of grass, however it is my feelings that the precursors or required nutrients are in the green forages and that the animal that ingest the forages manufactures Omega 3's through digestion and enzyme activity. We need to keep in mind that chickens are not ruminant therefore this information is a theory.

Organic Poultry Feeding:

There is quite a stir in the market place for "certified organic." The consumer is trying to find a product one step up from conventional food. This has created a growing niche market for certified organic poultry—both meat and eggs. In this rapidly growing market, the organic grain supply has decreased

while its price has increased—an average of 50% higher. There is a perceived benefit to certified organic poultry product in the market place. This is primarily due to the fact that antibiotics and other additives are not routinely fed. Poultry are fed certified organic grains, or grain raised without the use of chemical fertilizers, herbicides, pesticides, fungicides and genetically modified organisms (GMO). There are other feed restrictions along with these regulating feed supplements. All feed ingredients, supplements and additives must be reviewed before they can be used in a certified organic production system. Organic producers undergo very thorough screening and must adhere to guidelines to maintain this certification. Fishmeal that is preserved with ethoxyquin is prohibited. Synthetic amino acids are being phased out. Organic certification requirements are tightly enforced and the additional paperwork can be burdensome.

Organic certification is now under the control of the USDA National Organic Program. Additional information may be found at www.ams.usda.gov/nop. The national rules are being governed and enforced through local organizations which have applied to the USDA to perform certification review.

FUNDAMENTAL FORMULATION BASICS

Feed Nutrient Values:
Appendix A: Feed Ingredient Values and Spreadsheet Ration Calculator. The traditional feed nutrient values used for ration formulation. These ingredient values are the same as I use in the formulation of poultry feed rations. They are accepted throughout the nutritional community as acceptable averages. Appendix A contains protein, fat, fiber, and energy values, as well as macro mineral and vitamin values. I do not use most vitamin values for grains as they deplete during storage. Many grains today bought commercially may be more than a year old. The last pages of Appendix A include the micro mineral and amino acid values. Usually 22 amino acid values are listed; I have listed only the 4 most critical. Whenever using a fairly conventional type diet these 4 amino acids requirements will be met. Whenever one or more of these are deficient, I find that one or more of the other 22 will also be deficient. Therefore I have concluded that once these four amino acid values have been met that the other will be adequate.

Nutritional Requirements:
The following appendices identify the commercial industry nutritional requirements for selected categories of poultry (Leeson and Summers, 1997).

- Appendix B: Commercial Broiler-Roaster Nutritional Requirements
- Appendix C: Commercial Layer Nutritional Requirements
- Appendix D: Commercial Turkey Nutritional Requirements
- Appendix E: Commercial Meat Duck Nutritional Requirements

These requirements are all based on commercial feeding recommendations. I have converted the values into U.S. measurements for better interpretation. These pages will identify the protein, energy, vitamin, and mineral requirements for each type of poultry.

Sample Rations:

- Appendix F: Commercial Broiler Sample Rations
- Appendix G: Commercial Roaster Sample Rations
- Appendix H: Commercial Layer Sample Rations
- Appendix I: Commercial Turkey Sample Rations (Leeson and Summers, 1997)

The above information is based on confinement poultry with climate controls. This information may or may not be suitable for pastured or ranged poultry operations. Pastured or range poultry do not have climate control. Therefore the nutritional requirements will be different based on geographical location.

Sample Rations for Pasture Poultry:

- Appendix J: Pasture Broiler Sample Ration (Starter/Grower)
- Appendix K: Pasture Roaster Sample Ration
- Appendix L: Pasture Layer Sample Rations First and Second Laying Cycles
- Appendix M: Pasture Turkey Sample Starter, Grower 1, Grower 2, Finisher Rations

Formulating Your Own Ration:

Ration-Balancing By Hand:

- Appendix N: Formulating Rations with the Pearson Square.

Ration-Balancing on a Computer Spreadsheet:

- Appendix A: Spreadsheet Ration Calculator.

Jeff Mattocks of The Fertrell Company designed the spreadsheet above. Directions for use:

1. There are columns provided between each nutritional component for calculations.
2. Multiply the desired pounds of each feedstuff with corresponding component value. Place value in the right side column.
3. When all of the feedstuffs have been calculated, add each column of calculated values vertically downward to arrive with a total at the bottom of each column in the totals row.
4. Divide each total value by the total weight of the mix to determine the component level of proposed ration.
5. Compare total values with required or desired values and make adjustments as needed.
6. Please make copies of spreadsheets prior to making calculations and markings on the original spreadsheet.

Additional Resources:

My most often used references for feed ingredient nutritional values are:

- Feedstuffs, Reference Issue & Buyers Guide, Circulation Manager Feedstuffs
  191 S. Gary Ave., Carol Stream, IL 60188 Copies of the Reference Issues will cost approximately $40.00
- Commercial Poultry Nutrition (Leeson and Summers, 1997).
- National Research Council of Canada Building M-58, 1200 Montreal Road, Ottawa, Ontario K1A 0R6, Phone:1-877-672-2672 (in Ottawa, please call 1-613-993-9101) www.nrc.ca

There are many different reference books available. Some of which are recent publications and some that are quite old. Each of these may make good contributions to education and understanding of poultry nutrition. Keep in mind that each reference is written for poultry raised under controlled circumstances or for that period of time and that all of the data will not apply to pasture-raised poultry. I find myself reading old data and new data for comparisons. When I find the two time periods to agree on a subject I feel it is safe to assume this data to be constant and true. When I find conflicting data between the two time periods I use the data cautiously. Also most of the data available must be interpreted and revised to fit the pasture production model.

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APPENDICES

Appendix A1:
Feed Ingredient Values and Spreadsheet Ration Calculator

		%/Lb	Lb/Mix	%/Lb	Lbs/Mix	%/Lb	Lbs/Mix	Kcal/Lb	Kcal/Mix
Ingredients:	LBS	%CP	Protein	Fat	Fat	Fiber	Fiber	Energy	Energy
Alfalfa Meal		17%		3.0%		24.0%		640	
Aragonite		0.00%		0.0%		0.0%			
Barley		12%		2.0%		5.0%		1250	
Corn Gluten Meal		60.0%		2.0%		5.0%		1700	
Corn Grain Shell		8%		3.5%		2.9%		1520	
Crab Meal		32.0%		2.0%		6.0%		675	
Dicalcium Phosphate		0.00%		0.0%		0.0%			
DL Methionine		99.00%		0.0%		0.0%			
Fish Meal,60%		60%		7.7%		3.5%		1300	
Fish meal, Sea-Lac		63%		10.0%		1.0%		1300	
Hulless Oats		13.0%		4.0%		10.0%		1100	
Hulless Oats		16.0%		6.0%		10.0%		1100	
Lysine		99.00%		0.0%		0.0%			
Oats		10.0%		4.0%		3.0%		1100	
Oil, Canola		2%		99.0%		5.0%		3900	
Oil, Coconut		2%		99.0%		5.0%		3900	
Oil, Soy Bean		0.0%		4.0%		10.5%		3950	
Peas		22.4%		4.0%		6.3%		1300	
Poultry Nutri-Balancer		0.00%		0.4%		1.2%		115	
Shell Corn Grain		8%		3.5%		2.9%		1500	
Soy Bean Meal,48%		47.0%		3.5%		5.0%		1020	
Soybean Meal, Exp.		44.0%		7.0%		5.0%		1300	
Soybeans, Roasted		38%		18.0%		5.0%		1500	
Sunflower, Black Oil		18%		27.7%		31.0%		1200	
Triticale		11%		1.5%		2.9%		1430	
Wheat		12.0%		6.0%		5.0%		1380	
Wheat		9%		3.5%		5.0%		1400	
Wheat		14%		1.9%		2.9%		1440	
Whole Canola		22%		40.0%		5.0%		2150	
Total									

Appendix A2:
Feed Ingredient Values and Spreadsheet Ration Calculator (cont.)

	%/Lb	Lbs/Mix	%/Lb	Lbs/Mix	%/Lb	Lbs/Mix	%/Lb	Lbs/Mix
Ingredients:	Calcium	Calcium	Phos	Phos	Salt	Salt	Sodium	Sodium
Alfalfa Meal	3.0%		0.25%					
Aragonite	37.0%		1.0%		0%		0.10%	
Barley	0.1%		0.40%		0%		0.02%	
Corn Gluten Meal	0.2%		0.58%		0%		0.02%	
Corn Grain Shell	0.0%		0.25%		0%		0.02%	
Crab Meal	15.0%		1.70%		2%		0.85%	
Dicalcium Phosphate	22.0%		18.5%				0.10%	
DL Methionine	0.0%		0.0%					
Fish Meal,60%	3.0%		2.00%		1%		0.40%	
Fish meal, Sea-Lac	5.0%		3.00%		1%		0.34%	
Hulless Oats	0.1%		0.35%				0.02%	
Hulless Oats	0.1%		0.35%				0.02%	
Lysine	0.0%		0.0%					
Oats	0.1%		0.36%		0%		0.06%	
Oil, Canola	0.0%		0.42%		0%		0.03%	
Oil, Coconut	0.0%		0.42%		0%		0.03%	
Oil, Soy Bean	0.1%		0.30%		0%		0.06%	
Peas	0.1%		0.45%				0.01%	
Poultry Nutri-Balancer	13.9%		10.7%		10.00%		4.60%	
Shell Corn Grain	0.0%		0.25%		0%		0.02%	
Soy Bean Meal,48%	0.2%		0.58%		0%		0.02%	
Soybean Meal, Exp.	0.2%		0.60%		0%		0.02%	
Soybeans, Roasted	0.3%		0.60%				0.02%	
Sunflower, Black Oil	0.2%		0.56%				0.09%	
Triticale	0.5%		0.30%		0%		0.20%	
Wheat	0.1%		0.40%		0%		0.06%	
Wheat	0.3%		0.58%		0%		0.02%	
Wheat	0.5%		0.41%		0%		0.02%	
Whole Canola	0.4%		0.64%		0%		0.02%	
Total								

Appendix A3:
Feed Ingredient Values and Spreadsheet Ration Calculator (cont.)

	UI/Lb	UI/Mix	UI/Lb	UI/Mix	UI/Lb	UI/Lb	MG/LB	MG/Mix
Ingredients:	Vit A	Vit A	Vit D	Vit D	VitE	Vit E	Choline	CHO
Alfalfa Meal							486	
Aragonite					0			
Barley	0							
Corn Gluten Meal							6069	
Corn Grain Shell	750						1100	
Crab Meal							200	
Dicalcium Phosphate								
DL Methionine	0		0					
Fish Meal,60%								
Fish meal, Sea-Lac					0		18955	
Hulless Oats								
Hulless Oats							1400	
Lysine	0		0					
Oats	0							
Oil, Canola	0							
Oil, Coconut	0						486	
Oil, Soy Bean							467	
Peas							467	
Poultry Nutri-Balancer	148400		53600		1667		920	
Shell Corn Grain	750							
Soy Bean Meal,48%							6069	
Soybean Meal, Exp.	0						200	
Soybeans, Roasted							1311	
Sunflower, Black Oil							1364	
Triticale	0						1182	
Wheat	123				0		227	
Wheat							209	
Wheat	0						689	
Whole Canola	0						1311	
Total							200	

Appendix A4:
Feed Ingredient Values and Spreadsheet Ration Calculator (cont.)

	ppm/Lb	MG/Mix	ppm/Lb	MG/Mix	ppm/Lb	MCG/Mix	PPM	PPM/Mix
Ingredients:	Manganese	Manganese	Zinc	Zinc	Copper	Copper	Selenium	Selenium
Alfalfa Meal	38.2		38		14.08			
Aragonite	286							
Barley								
Corn Gluten Meal	30		11.36		15			
Corn Grain Shell	6		15		3			
Crab Meal								
Di-Calcium Phosphate	700		130		7			
DL Methionine								
Fish Meal,60%	286							
Fish meal, Sea-Lac	35.6		151		11.4			
Hulless Oats								
Hulless Oats								
Lysine								
Oats	38.2		38		14.08			
Oil, Canola	16		30		8			
Oil, Coconut	16		30		8			
Oil, Soy Bean	128.7		102		0.3			
Peas	15		25		6			
Poultry Nutri-Balancer	3295.6		2413.4		201		10	
Shell Corn Grain	6		15		3			
Soy Bean Meal,48%	32.3		60		28			
Soybean Meal, Exp.	40		92		8			
Soybeans, Roasted								
Sunflower, Black Oil	16.00		25.00		5.0			
Triticale	0		32		10			
Wheat	28		17		8.2		0	
Wheat	32.3		60		28			
Wheat	40		34		10			
Whole Canola	30.0		11.4		15.0			
Total								

Appendix A5:
Feed Ingredient Values and Spreadsheet Ration Calculator (cont.)

	%/Lb	Lb/Mix	%/Lb	Lb/Mix	%/Lb	Lb/Mix	%/Lb	Lb/Mix
Ingredients:	LYSINE	LYSINE	METH	METH	Meth/ Cystine	Meth /Cystine	Arginine	Arginine
Alfalfa Meal	0.80%		0.40%		0.18%		0.38%	
Aragonite								
Barley	0.39%		0.18%		0.40%		0.45%	
Canada Poultry VTM			2.47%		2.47%			
Corn Gluten Meal	1.90%		0.88%		1.90%		3.00%	
Corn Grain Shell	0.52%		0.22%		0.20%		0.39%	
Crab Meal	1.70%		1.18%		0.73%		0.93%	
Dicalcium Phosphate								
DL Methionine			99.00%					
Fish Meal,60%	4.60%		1.70%		2.20%		3.10%	
Fish meal, Sea-Lac	4.70%		1.80%		2.40%		3.23%	
Hulless Oats	0.40%		0.20%		0.42%		0.80%	
Hulless Oats	0.40%		0.20%		0.42%		0.80%	
Lysine	56.00%							
Oats	0.64%		0.21%		0.52%		0.80%	
Oil, Canola	0.00%		0.14%		0.34%		0.42%	
Oil, Coconut	0.00%		0.14%		0.34%		0.42%	
Oil, Soy Bean	4.10%		5.20%		2.20%		2.90%	
Peas	1.32%		0.13%		0.37%		1.49%	
Poultry Nutri-Balancer			2.48%		2.48%			
Shell Corn Grain	0.52%		0.22%		0.20%		0.39%	
Soy Bean Meal,48%	2.70%		0.65%		1.50%		3.20%	
Soybean Meal, Exp.	4.20%		0.60%		1.80%		3.50%	
Soybeans, Roasted	2.40%		0.54%		1.10%		2.80%	
Sunflower, Black Oil	0.54%		0.27%		0.50%		1.20%	
Triticale	0.32%		0.26%		0.26%		0.52%	
Wheat	0.30%		0.25%		0.50%		0.75%	
Wheat	0.32%		0.27%		0.14%		0.16%	
Wheat	0.32%		0.22%		0.48%		0.52%	
Whole Canola	2.40%		0.63%		1.00%		2.80%	
Total								

Appendix B: Commercial Broiler-Roaster Nutritional Requirements

	Both Pre-Starter	Broiler Starter #1	Roaster Starter #2	Broiler Grower #1	Roaster Grower #2	Broiler Finisher #1	Roaster Finisher #2
Approximate Protein	23	22	20	20	18	18	16
Metabolizable Energy (Kcal/Lb)	1386	1386	1318	1432	1364	1455	1386
Calcium (%)	1	0.95	0.95	0.92	0.92	0.9	0.9
Available Phosphorus (%)	0.45	0.42	0.42	0.4	0.4	0.38	0.38
Sodium (%)	0.19	0.18	0.18	0.18	0.18	0.18	0.18
Amino Acids (% of Diet)							
Argine	1.4	1.2	1.1	1.05	0.95	0.9	0.85
Lysine	1.35	1.2	1.05	1.1	0.9	0.9	0.8
Methionine	0.52	0.48	0.42	0.44	0.38	0.37	0.36
Methionine/Cystine	0.95	0.82	0.75	0.73	0.65	0.64	0.61
Tryptophan	0.22	0.2	0.18	0.17	0.15	0.14	0.13
Histidine	0.42	0.4	0.35	0.32	0.3	0.28	0.27
Leucine	1.5	1.4	1.2	1.1	1.0	1.0	0.9
Isoleucine	0.85	0.75	0.6	0.55	0.5	0.47	0.45
Phenylalanine	0.8	0.75	0.65	0.6	0.55	0.53	0.5
Phenylalanine+Tyrosine	1.5	1.4	1.2	1.1	1.0	1.0	0.9
Threonine	0.75	0.7	0.62	0.6	0.55	0.55	0.5
Valine	0.9	0.8	0.7	0.65	0.6	0.58	0.55

Vitamins (per Lb)		
Vitamin A (I.U.)	2955	2659
Vitamin D (I.U.)	1364	1227
Choline (mg)	364	327
Riboflavin (mg)	2.5	2.3
Pantothenic Acid (mg)	6.4	5.7
Vitamin B_{12} (mg)	0.006	0.005
Folic Acid (mg)	0.45	0.41
Biotin (mg)	0.09	0.08
Niacin (mg)	18.2	16.4
Vitamin K (mg)	0.9	0.8
Vitamin E (I.U.)	13.6	12.3
Thiamin (mg)	1.8	1.6
Pyridoxine (mg)	1.8	1.6

Trace Minerals (PPM)	**PPM**
Manganese	70
Iron	80
Copper	10
Zinc	80
Selenium	0.3
Iodine	0.4

Note: Trace mineral requirements remain the same for all rations.

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix C: Commercial Layer Nutritional Requirements							
Feed Intake	**0.28**	**0.26**	**0.24**	**0.22**	**0.2**	**0.18**	**0.16**
Approximate Protein (%)	13	14	15.5	17	19	20.5	22.1
Metabolizable Energy (Kcal/Lb)	1227	1227	1275	1295	1295	1295	1318
Calcium (%)	3	3.25	3.5	3.6	3.8	4	4.25
Available Phosphorus (%)	0.35	0.4	0.4	0.42	0.45	0.45	0.47
Sodium (%)	0.17	0.18	0.18	0.19	0.2	0.2	0.22
Amino Acids (% of Diet)							
Argine	0.55	0.6	0.68	0.75	0.82	0.9	0.98
Lysine	0.49	0.56	0.63	0.7	0.77	0.84	0.91
Methionine	0.28	0.31	0.34	0.37	0.41	0.47	0.56
Methionine/Cystine	0.48	0.53	0.58	0.64	0.71	0.8	0.91
Tryptophan	0.1	0.12	0.14	0.15	0.17	0.18	0.2
Histidine	0.13	0.14	0.15	0.17	0.19	0.25	0.25
Leucine	0.64	0.73	0.82	0.91	1	1.09	1.18
Isoleucine	0.43	0.5	0.57	0.63	0.69	0.73	0.82
Phenylalanine	0.34	0.38	0.42	0.47	0.52	0.57	0.61
Phenylalanine+Tyrosine	0.55	0.65	0.75	0.83	0.91	0.99	1.08
Threonine	0.43	0.5	0.57	0.63	0.69	0.73	0.82
Valine	0.49	0.56	0.63	0.7	0.77	0.82	0.91
Vitamins (per Lb)							
Vitamin A (I.U.)				3410			
Vitamin D (I.U.)				1150			
Choline (mg)				550			
Riboflavin (mg)				2			
Pantothenic Acid (mg)				4.5			
Vitamin B_{12} (mg)				0.005			
Folic Acid (mg)				0.35			
Biotin (mg)				0.07			
Niacin (mg)				18			
Vitamin K (mg)				1			
Vitamin E (I.U.)				12			
Thiamin (mg)				1			
Pyridoxine (mg)				1.5			
Trace Minerals (PPM)				**PPM**			
Manganese				70			
Iron				80			
Copper				8			
Zinc				60			
Selenium				0.3			
Iodine				0.4			

Note: Trace mineral requirements remain the same for all rations.

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix D: Turkey Nutritional Requirements

	Starter #1	Starter #2	Grower #1	Grower #2	Developer	Finisher
Approximate Protein (%)	28	26	23	21.5	18	16
Metabolizable Energy (Kcal/Lb)	1320	1365	1385	1410	1455	1500
Calcium (%)	1.4	1.3	1.2	1.3	1	0.9
Available Phosphorus (%)	0.7	0.6	0.5	0.6	0.5	0.4
Sodium (%)	0.18	0.18	0.17	0.17	0.17	0.17

Amino Acids (% of Diet)						
Argine	1.6	1.55	1.4	1.25	1.02	0.95
Lysine	1.7	1.6	1.5	1.3	1.15	1
Methionine	0.62	0.55	0.5	0.47	0.42	0.34
Methionine/Cystine	1	0.9	0.8	0.76	0.67	0.58
Tryptophan	0.28	0.26	0.22	0.21	0.18	0.16
Histidine	0.57	0.55	0.48	0.45	0.37	0.32
Leucine	1.95	1.9	1.6	1.45	1.25	1.15
Isoleucine	1.13	1.05	0.9	0.85	0.72	0.65
Phenylalanine	1.03	0.95	0.82	0.79	0.67	0.6
Phenylalanine+Tyrosine	1.8	1.7	1.5	1.4	1.2	1
Threonine	1	0.95	0.85	0.78	0.67	0.61
Valine	1.2	1.15	1	0.9	0.75	0.65

Vitamins (per Lb)					
Vitamin A (I.U.)	4320	3865	7000	3182	
Vitamin D (I.U.)	1230	1100	2200	1000	
Choline (mg)	865	775	1500	682	
Riboflavin (mg)	2.8	2.5	5	2.27	
Pantothenic Acid (mg)	7.8	6.8	15	6.82	
Vitamin B_{12} (mg)	0.006	0.006	0.012	0.01	
Folic Acid (mg)	0.50	0.35	0.5	0.23	
Biotin (mg)	0.12	1	0.15	0.07	
Niacin (mg)	36.5	32	60	27.3	
Vitamin K (mg)	1.0	1	1.5	0.7	
Vitamin E (I.U.)	20.0	14	20	9.1	
Thiamin (mg)	1.5	1.4	2.5	1.1	
Pyridoxine (mg)	2.75	2.3	3	1.4	

Trace Minerals (PPM)	**PPM**	**PPM**		**PPM**
Manganese	80	80		80
Iron	110	110		110
Copper	10	10		10
Zinc	80	80		80
Selenium	0.3	0.25		0.0015
Iodine	0.45	0.45		0.45

- The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix E: Meat Duck Nutritional Requirements

	Starter #1	Starter #2	Grower #1	Grower #2
Approximate Protein	22	20	18	16
Metabolizable Energy (Kcal/Lb)	1295	1320	1400	1420
Calcium (%)	0.8	0.83	0.76	0.75
Available Phosphorus (%)	0.4	0.42	0.38	0.35
Sodium (%)	0.18	0.18	0.18	0.18
Amino Acids (% of Diet)				
Argine	1.2	1.05	0.94	0.85
Lysine	1.1	0.96	0.86	0.78
Methionine	0.48	0.43	0.39	0.35
Methionine/Cystine	0.82	0.72	0.66	0.6
Tryptophan	0.22	0.18	0.16	0.15
Histidine	0.44	0.37	0.33	0.29
Leucine	1.56	1.28	1.16	1.04
Isoleucine	0.84	0.69	0.63	0.56
Phenylalanine	0.78	0.64	0.58	0.52
Phenylalanine+Tyrosine	1.52	1.24	1.12	1.01
Threonine	0.76	0.62	0.56	0.5
Valine	0.93	0.77	0.69	0.62

Vitamins (per Lb)	
Vitamin A (I.U.)	3650
Vitamin D (I.U.)	1140
Choline (mg)	365
Riboflavin (mg)	1.8
Pantothenic Acid (mg)	5.5
Vitamin B_{12} (mg)	0.005
Folic Acid (mg)	0.23
Biotin (mg)	0.1
Niacin (mg)	28
Vitamin K (mg)	0.7
Vitamin E (I.U.)	10
Thiamin (mg)	1
Pyridoxine (mg)	1.4

Trace Minerals (PPM)	**PPM**
Manganese	60
Iron	80
Copper	8
Zinc	60
Selenium	0.2
Iodine	0.4

Note: Trace mineral requirements remain the same for all rations.

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix F: Commercial Broiler Sample Rations

	Starter		Grower			Finisher	
Ingredients:	1	2	1	2	3	1	2
Corn	1137.5	541	1151.4	1212.8	1082.4	1302.8	1012
Wheat	0	400	0	0	350	0	540
Barley	0	400	0	0	0	0	0
Soybean Meal, 48%	700	535	625	610	460	516	340
Meat Meal, 50%	0	0	20	0	0	0	0
Fish Meal, 60%	0	0	40	0	0	0	0
Fat	70	34	90	90	20	94	20
Ground Limestone	34	32	26	30	30	30	30
Calcium Phosphate, 20% P	30	30	20	30	30	30	30
Iodized Salt	6	6	6	6	6	6	6
Vitamin: Mineral Premix[1]	20	20	20	20	20	20	20
Methionine	2.5	2	1.6	1.2	1.6	1.2	2
	2000	2000	2000	2000	2000	2000	2000
Calculated Analysis:							
Crude Protein (%)	22.0	22.0	21.8	20	18	18	16.1
Digestible Protein (%)	17.7	17.7	17.7	16.2	14.4	14.2	12.9
Crude Fat (%)	5.9	5.9	7	7	3.4	7.3	3.4
Metabolized Energy (kcal/kg)	1391	1390	1429	1430	1374	1455	1386
Calcium (%)	1.00	1.00	0.98	0.95	0.95	0.94	0.96
Av. Phosphorus (%)	0.42	0.42	0.42	0.42	0.41	0.41	0.41
Sodium (%)	0.17	0.17	0.17	0.17	0.17	0.17	0.18
Methionine (%)	0.48	0.48	0.4	0.4	0.38	0.37	0.37
Methionine & Cystine (%)	0.82	0.82	0.71	0.71	0.65	0.64	0.61
Tryptophan (%)	0.31	0.31	0.28	0.28	0.25	0.25	0.22
Lysine (%)	1.25	1.25	1.1	1.1	0.93	0.96	0.78
Threonine (%)	0.94	0.94	0.86	0.86	0.75	0.78	0.65

[1]Use of additional Choline Chloride if vitamin premix does not contain this vitamin.

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix G: Commercial Roaster Sample Rations

	Grower		Finisher	
Ingredients:	1	2	1	2
Corn	1200	1296	1058	1286
Wheat	198	280	280	280
Barley	0	0	100	0
Soybean Meal, 48%	440	320	380	320
Fat	80	20	100	30
Ground Limestone	30	30	30	30
Calcium Phosphate, 20% P	26	26	26	28
Iodized Salt	6	6	6	6
Vitamin: Mineral Premix[1]	20	20	20	20
Methionine	1.6	1.4	1.2	1
	2001.6	1999.4	2001.2	2001
Calculated Analysis:				
Crude Protein (%)	17	15.1	16.1	15.1
Digestible Protein (%)	13.8	12	12.9	11.9
Crude Fat (%)	6.5	3.8	7.4	4.2
Crude Fiber (%)	2.4	2.5	2.7	2.5
Metabolized Energy (kcal/kg)	1443	1400	1457	1410
Calcium (%)	0.9	0.91	0.91	0.92
Av. Phosphorus (%)	0.38	0.38	0.38	0.39
Sodium (%)	0.17	0.17	0.17	0.17
Methionine (%)	0.37	0.34	0.34	0.32
Methionine & Cystine (%)	0.63	0.56	0.56	0.54
Tryptophan (%)	0.87	0.72	0.8	0.71
Lysine (%)	0.23	0.2	0.22	0.2
Threonine (%)	0.72	0.63	0.67	0.63

[1]Use of additional Choline Chloride if vitamin premix does not contain this vitamin

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix H: Commercial Layer Sample Rations

Ingredients:	1-17 weeks	17-35 weeks	35-50 weeks
Corn	1192	1305	1313
Wheat	0	0	240
Soybean Meal, 48%	560	468	220
Fat	40	20	20
Ground Limestone	156	156	156
Calcium Phosphate, 20% P	23	23	23
Iodized Salt	7	7	7
Vitamin: Mineral Premix1	20	20	20
Methionine	2	1	1
	2000	2000	2000
Calculated Analysis:			
Crude Protein (%)	18.6	16.9	13
Digestible Protein (%)	17	15.4	11.7
Crude Fat (%)	4.4	3.6	4.2
Crude Fiber (%)	2.3	2.3	2.8
Metabolized Energy (kcal/kg)	1300	1295	1260
Calcium (%)	3.3	3.26	3.25
Av. Phosphorus (%)	0.41	0.4	0.4
Sodium (%)	0.19	0.19	0.18
Methionine (%)	0.42	0.34	0.28
Methionine & Cystine (%)	0.7	0.59	0.46
Lysine (%)	1.02	0.88	0.56

[1]Use of additional Choline Chloride if vitamin premix does not contain this vitamin

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix I: Commercial Turkey Sample Rations

	Starter		Grower		Finisher	
Ingredients:	1	2	1	2	1	2
Corn	900	1000	1154	1234	1358	1482
Soybean Meal, 48%	772	672	530	444	360	292
Meat Meal, 50%	100	100	200	200	100	60
Fish Meal, 60%	100	100	0	0	0	0
Fat	42	60	58	58	110	92
Ground Limestone	20	16	12	14	20	18
Calcium Phosphate, 20% P	40	25	20	24	26	28
Iodized Salt	4	4	4	4	4	4
Vitamin: Mineral Premix1	20	20	20	20	20	20
Methionine	2.6	2	1.4	1.4	0	1.6
	2000.6	1999	1999.4	1999.4	1998	1997.6
Calculated Analysis:						
Crude Protein (%)	27.9	26.0	23.2	21.5	17	15
Digestible Protein (%)	25.5	23.7	21.2	19.6	15.5	13.7
Crude Fat (%)	4.4	5.5	5.6	5.8	8.5	6.4
Crude Fiber (%)	3.5	3.4	3.4	3.4	3.4	3.4
Metabolized Energy (kcal/lb)	1315	1364	1394	1405	1477	1489
Calcium (%)	1.58	1.34	1.2	1.27	1.07	0.9
Av. Phosphorus (%)	0.85	0.69	0.63	0.66	0.5	0.46
Sodium (%)	0.18	0.18	0.18	0.18	0.17	0.16
Methionine (%)	0.61	0.56	0.5	0.47	0.78	0.69
Methionine & Cystine (%)	1.05	0.96	0.85	0.79	0.64	0.56
Lysine (%)	1.77	1.62	1.41	1.28	0.89	0.75
Tryptophan (%)	0.37	0.34	0.3	0.27	0.22	0.19
Threonine (%)	1.18	1.1	0.99	0.92	0.87	0.64

[1]Use of additional Choline Chloride if vitamin premix does not contain this vitamin

* The information contained in this table has been obtained from Commercial Poultry Nutrition, by S. Leeson and J.D. Summers

Appendix J: Pasture Broiler Sample Ration

Starter/Grower

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	25
Corn Grain Shell	1015
Fish meal	75
Oats	100
Vitamin Mineral Premix	60
Soybeans, Roasted	625
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	19.4%
Crude Fat	%	8.1%
Crude Fiber	%	4.5%
Calcium	%	1.30%
Phosphorus	%	0.79%
Salt added	%	0.34%
Sodium	%	0.17%
Energy	Kcal/LB	1,379
Vitamin A	IU/LB	4833
Vitamin D	IU/LB	1608
Vitamin E	IU/LB	50
Choline	IU/LB	476
Biotin	MCG/LB	50.7
Manganese	IU/LB	58.9
Zinc	IU/LB	47.9
Copper	IU/LB	4.03
Selenium (added)	IU/LB	0.30
Lysine	%	1.26%
Methionine	%	0.45%
Methionine/Cystine	%	0.64%
Arginine	%	1.25%

* These tables have been created by Jeff Mattocks, the Fertrell Company.

Appendix K: Pasture Roaster Sample Ration

Finisher

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	25
Corn Grain Shell	1215
Fish meal	50
Oats	100
Vitamin Mineral Premix	60
Soybeans, Roasted	450
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	16.1%
Crude Fat	%	6.8%
Crude Fiber	%	4.3%
Calcium	%	1.22%
Phosphorus	%	0.73%
Salt added	%	0.33%
Sodium	%	0.17%
Energy	Kcal/LB	1,384
Vitamin A	IU/LB	4908
Vitamin D	IU/LB	1608
Vitamin E	IU/LB	50
Choline	IU/LB	479
Biotin	MCG/LB	54.0
Manganese	IU/LB	58.9
Zinc	IU/LB	47.7
Copper	IU/LB	4.10
Selenium (added)	IU/LB	0.30
Lysine	%	1.05%
Methionine	%	0.40%
Methionine/Cystine	%	0.54%
Arginine	%	1.01%

Appendix L:

Pasture Layer Sample Rations
First Laying Cycle

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	175
Corn Grain Shell	965
Oats	100
Vitamin Mineral Premix	60
Soybeans, Roasted	600
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	16.5%
Crude Fat	%	7.5%
Crude Fiber	%	4.3%
Calcium	%	3.89%
Phosphorus	%	0.74%
Salt added	%	0.30%
Sodium	%	0.17%
Energy	Kcal/LB	1,274
Vitamin A	IU/LB	4814
Vitamin D	IU/LB	1608
Vitamin E	IU/LB	50
Choline	IU/LB	455
Biotin	MCG/LB	48.7
Manganese	IU/LB	69.3
Zinc	IU/LB	46.4
Copper	IU/LB	4.28
Selenium (added)	IU/LB	0.30
Lysine	%	1.04%
Methionine	%	0.37%
Methionine/Cystine	%	0.54%
Arginine	%	1.09%

Pasture Layer Sample Rations
Second Laying Cycle

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	200
Corn Grain Shell	1040
Oats	50
Vitamin Mineral Premix	60
Soybeans, Roasted	550
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	15.6%
Crude Fat	%	7.0%
Crude Fiber	%	4.2%
Calcium	%	4.34%
Phosphorus	%	0.74%
Salt added	%	0.30%
Sodium	%	0.17%
Energy	Kcal/LB	1,266
Vitamin A	IU/LB	4842
Vitamin D	IU/LB	1608
Vitamin E	IU/LB	50
Choline	IU/LB	457
Biotin	MCG/LB	49.5
Manganese	IU/LB	70.8
Zinc	IU/LB	46.5
Copper	IU/LB	4.25
Selenium (added)	IU/LB	0.30
Lysine	%	0.99%
Methionine	%	0.36%
Methionine/Cystine	%	0.50%
Arginine	%	1.01%

* These tables have been created by Jeff Mattocks, the Fertrell Company.

Appendix M:
Pasture Turkey Sample Starter Ration

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	15
Corn Grain Shell	295
Dicalcium Phosphate	10
Fish Meal,63%	100
Oats	250
Vitamin Mineral Premix	80
Soybeans, Roasted	950
Wheat	200
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	25.7%
Crude Fat	%	10.7%
Crude Fiber	%	5.1%
Calcium	%	1.38%
Phosphorus	%	1.05%
Salt added	%	0.45%
Sodium	%	0.23%
Energy	Kcal/LB	1,314
Vitamin A	IU/LB	6059
Vitamin D	IU/LB	2144
Vitamin E	IU/LB	67
Choline	IU/LB	516
Biotin	MCG/LB	49.7
Manganese	IU/LB	74.1
Zinc	IU/LB	55.8
Copper	IU/LB	5.08
Selenium (added)	IU/LB	0.40
Lysine	%	1.60%
Methionine	%	0.54%
Methionine/Cystine	%	0.89%
Arginine	%	1.74%

Pasture Turkey Sample Rations Grower #1

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	20
Corn Grain Shell	650
Dicalcium Phosphate	10
Fish Meal,63%	50
Vitamin Mineral Premix	70
Soybeans, Roasted	900
Wheat	200
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	23.3%
Crude Fat	%	10.2%
Crude Fiber	%	5.0%
Calcium	%	1.31%
Phosphorus	%	0.93%
Salt added	%	0.38%
Sodium	%	0.19%
Energy	Kcal/LB	1,376
Vitamin A	IU/LB	5450
Vitamin D	IU/LB	1876
Vitamin E	IU/LB	58
Choline	IU/LB	461
Biotin	MCG/LB	47.6
Manganese	IU/LB	65.3
Zinc	IU/LB	49.4
Copper	IU/LB	4.08
Selenium (added)	IU/LB	0.35
Lysine	%	1.43%
Methionine	%	0.49%
Methionine/Cystine	%	0.76%
Arginine	%	1.56%

* These tables have been created by Jeff Mattocks, the Fertrell Company.

Pastured Turkey Sample Rations
Grower #2

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	20
Corn Grain Shell	750
Dicalcium Phosphate	10
Fish Meal,63%	50
Vitamin Mineral Premix	70
Soybeans, Roasted	700
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	20.5%
Crude Fat	%	8.9%
Crude Fiber	%	4.9%
Calcium	%	1.29%
Phosphorus	%	0.90%
Salt added	%	0.38%
Sodium	%	0.20%
Energy	Kcal/LB	1,371
Vitamin A	IU/LB	5494
Vitamin D	IU/LB	1876
Vitamin E	IU/LB	58
Choline	IU/LB	506
Biotin	MCG/LB	49.4
Manganese	IU/LB	66.1
Zinc	IU/LB	50.1
Copper	IU/LB	4.33
Selenium (added)	IU/LB	0.35
Lysine	%	1.24%
Methionine	%	0.46%
Methionine/Cystine	%	0.69%
Arginine	%	1.34%

Pastured Turkey Sample Rations
Finisher

Ingredients:	LBS
Alfalfa Meal	100
Aragonite	20
Corn Grain Shell	920
Dicalcium Phosphate	0
Fish Meal,63%	50
Vitamin Mineral Premix	60
Soybeans, Roasted	450
Total	2000

Nutrient Name:	Units	Amount
Crude Protein	%	17.0%
Crude Fat	%	7.2%
Crude Fiber	%	4.8%
Calcium	%	1.08%
Phosphorus	%	0.72%
Salt added	%	0.33%
Sodium	%	0.17%
Energy	Kcal/LB	1,381
Vitamin A	IU/LB	4822
Vitamin D	IU/LB	1608
Vitamin E	IU/LB	50
Choline	IU/LB	527
Biotin	MCG/LB	47.5
Manganese	IU/LB	59.4
Zinc	IU/LB	45.6
Copper	IU/LB	4.18
Selenium (added)	IU/LB	0.30
Lysine	%	0.99%
Methionine	%	0.41%
Methionine/Cystine	%	0.58%
Arginine	%	1.06%

- These tables have been created by Jeff Mattocks, the Fertrell Company.

A. Appendix N:

B. Formulating Rations with the Pearson Square

by T.L. Stanton[1]

1. Quick Facts...

The Pearson square ration formulation procedure is designed for simple rations. In order for the square to work, follow specific directions for its use. Nutrient contents of ingredients and nutrient requirements must be expressed on the same basis (i.e., dry-matter or "as-fed").

The Pearson square or box method of balancing rations is a simple procedure that has been used for many years. It is of greatest value when only two ingredients are to be mixed. In taking a close look at the square, several numbers are in and around the square. Probably one of the more important numbers is the number that appears in the middle of the square. This number represents the nutritional requirement of an animal for a specific nutrient. It may be crude protein or TDN, amino acids, minerals or vitamins.

In order to make the square work consistently, there are three very important considerations:

1. The value in the middle of the square must be intermediate between the two values that are used on the left side of the square. For example, the 14 percent crude protein requirement has to be intermediate between the soybean meal that has 45 percent crude protein or the corn that has 10 percent crude protein. If barley is used that has 12 percent crude protein and corn that has 10 percent crude protein, the square calculation method will not work because the 14 percent is outside the range of the values on the left side of the square.

2. Disregard any negative numbers that are generated on the right side of the square. Be concerned only with the numerical differences between the nutrient requirement and the ingredient nutrient values.

3. Subtract the nutrient value from the nutritional requirement on the diagonal and arrive at a numerical value entitled parts. By summing those parts and dividing by the total, you can determine the percent of the ration that each ingredient should represent in order to provide a specific nutrient level. Always subtract on the diagonal within the square in order to determine parts. Always double check calculations to make sure that you did not have a mathematical error. It also is very important to work on a uniform basis. Use a 100-percent dry-matter basis for nutrient composition of ingredients and requirements and then convert to an as-fed basis after the formulation is calculated. Corn represents (31.0 / 35.00) x 100 of the ration, or 88.57 percent. Soybean meal represents (4.0 / 35.00) x 100 of the ration, or .43 percent.

Check of the calculation:

88.57 lb corn at 10.0% CP	= 8.86
11.43 lb SBM at 45.0% CP	= 5.14
100.00 lb mixture contains	= 14.00 lb CP, or 14 percent.

2.

3.

4.

5. Using More Than Two Ingredients

It is possible to mix more than two ingredients using the Pearson square. For example, to prepare a 15 percent crude protein mixture that consists of a supplement of 60 percent soybean meal (45 percent crude protein) and 40 percent meat and bone scrap (50 percent crude protein), and a grain mixture of 65 percent corn (9 percent crude protein) and 35 percent oats (12 percent crude protein), take the following steps. Since only two components can be used in the Pearson square method, the ingredients are combined first as follows:

60% SBM x 45% crude protein	= 27.0
40% MBS x 50%	= 20.0
Protein in supplement mixture	47.0%
65% corn x 9.0%	= 5.85
35% oats x 12.0%	= 4.20
Protein in grain mix	10.05%
5.0 parts x 60%	= 3.0 parts SBM
5.0 parts x 40%	= 2.0 parts MBS
32.0 parts x 65%	= 20.8 parts corn
32.0 parts x 35%	= 11.2 parts oats
	37.0
(3.0 / 37.0)	= 8.11% SBM
(2.0 / 37.0)	= 5.41% MBS
(20.8 / 37.0)	= 56.21% corn
(11.2 / 37.0)	= 30.27% corn
Check:	
8.11 lb SBM at 45% CP	= 3.65 lb
5.41 lb MBS at 50% CP	= 2.70 lb
56.21 lb corn at 9% CP	= 5.06 lb
30.27 lb oats at 12% CP	= 3.64 lb
100.00 lb contains	15.05 lb or 15% CP

6. Expressing Feed Composition

The crude-protein value of a feed or the percentage of any other component (e.g., calcium or phosphorus) can be expressed several ways. The two most common methods of expression are on an as-fed basis or dry-matter basis. Use the following procedure to calculate composition on a dry-matter basis.

Crude protein value on an as-fed basis divided by dry-matter content of the feed times 100 equals the crude-protein content on a dry-matter basis. If alfalfa hay is used as an example, the crude protein value is 17 percent on an as-fed basis. On a dry-matter basis, the crude protein value of the hay is calculated as follows: 17 / 0.91 (moisture content of 9 percent) times 100 equals 18.7 percent crude protein.

To determine the total digestible nutrient (TDN) content of the above alfalfa on a dry-matter basis, follow the same procedure: 50 percent (TDN value on an as-fed basis) divided by 0.91 (dry-matter content of the feed) times 100 equals 54.9 percent TDN on a dry-matter basis. Likewise, the crude-protein content or the TDN value also can be expressed on the basis of any given dry-matter level. For example, if you use a 90-percent dry-matter basis, use the following calculation. Given a TDN value of 76 percent and a dry-matter content of 86 percent (14 percent moisture), what would be the TDN value of this feed on a 90 percent dry-matter basis?

(76 x .90) / .86 = 79.5 percent TDN on a 90 percent dry-matter basis.

7. Ration Composition Calculations

If you know the dry-matter composition of a specific ration and want to determine what that composition will be on an as-fed basis for mixing, make the calculations shown in Table 1.

Conversely, if you know the "as-fed" composition of the ration and the dry matter of each ingredient, determine the ration dry-matter composition as shown in Table 2.

Table 1: Converting from dry matter to as-fed.

Feed	Ration dry-matter composition	Ingredient % dry matter	Calculations		Ration as-fed composition
Corn silage	70	35	70/.35 = 200	(200/233) x 100 =	84.84
Alfalfa	30	90	30/.30 = 33/233	(33/233) x 100 =	14.16

Table 2: Converting from as-fed to dry matter.

Feed	Ration dry-matter composition	Ingredient % dry matter	Calculations		Ration as-fed composition
Corn silage	65	35	65/.35 = 22.75	(22.75/54.25) x 100 =	41.94
Alfalfa	35	90	35/.90 = 31.50/54.25	(31.50/54.25) x 100 =	58.06

Colorado State University Cooperative Extension feedlot specialist and professor, animal sciences.
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