Organic Poultry Production: Providing Adequate Methionine

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Because synthetic amino acids are generally banned in organic livestock production, and animal slaughter by-products cannot be used in organic feed, nutrition can present challenges in organic poultry production. Providing the amino acid methionine (MET) is generally the most difficult one. Feed rations that are high in plant proteins, such as soybean meal, can be used instead of synthetic MET, but high-protein diets are not healthy for poultry or the environment. Diets containing fishmeal, milk products, and nonconventional sources of protein, such as earthworms or insects, can help provide MET, but the ingredients are expensive and, in most cases, not available in organic form. It is difficult to design diets with sufficient MET without oversupplying protein. For these reasons, development of a natural MET supplement is needed.

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Introduction

The ban on synthetic amino acids in organic livestock production is similar to the ban on synthetic nitrogen in crop production. In both cases, protein/nitrogen is closely related to the level of performance of the animal or crop (Sundrum, 2005), but synthetic sources are prohibited. Rather, organic production relies on natural cycles of nitrogen (i.e., nitrogen-fixing by plants and nutrient cycling via applications of animal manure on crops).

Under the USDA National Organic Program (NOP), poultry must be raised with outdoor access, fed certified organic feed and given no animal slaughter by-products, antibiotics, drugs or synthetic parasiticides. Interestingly, poultry are omnivorous in nature but are often fed as vegetarians in commercial production. Under the European Union organic legislation, a greater amount of outdoor access is required for organic poultry than in the US. In Europe, organic poultry production is not expected to be as high-yield as conventional confinement systems, and slower-growing meat birds are used. According to Sundrum (2006), organic poultry production focuses on animal health and welfare, good environmental practices, and product quality, and less on economic measures such as reducing costs and maximizing production (weight gain, feed efficiency, etc.). However, economic returns are a concern for any commercial operation. For more information on organic poultry requirements, see ATTRA's *Organic Poultry Production*.

In the U.S., synthetic methionine (MET) has been the only synthetic amino acid allowed in organic livestock production, and only in poultry. It is allowed temporarily but is being phased out. When the NOP organic rule was first published in 2002, the MET allowance was to end in 2005. An extension was granted until 2008 and then again until October 2010. In the same vein, Europe has allowed a small amount of nonorganic feed ingredients to be used. From 2010 until the end of 2011, 5% nonorganic ingredients can be used. This small amount of nonorganic ingredients (i.e., potato protein and corn gluten meal) has the potential to supply the MET requirement. In the U.S., a Methionine Task Force made up mainly of organic poultry producers has been in contact with the National Organic Standards Board about the MET problem. The Task Force first began meeting in 2003 and was reorganized in 2006.

Proteins are made up of amino acids, and MET is an essential amino acid that is not synthesized in sufficient quantity by the animal and must, therefore, be supplied in the diet. Cysteine (CYS) is another amino acid related to MET metabolism, and together they are called the sulfur amino acids (see box below). Methionine can be provided as part of an intact protein or as a pure amino acid. It is the most limiting amino acid (or the most difficult one to supply) in a typical corn and soybean diet and is generally added in a pure form. The CYS requirement can be provided by MET. Most of the total sulfur amino acid requirement is met by the feedstuffs (about 75%), but the rest is normally supplemented by synthetic MET (about 25%). Synthetic MET is used in virtually all commercial poultry diets in the U.S., both conventional and organic.

Related ATTRA publications

Arsenic in Poultry Litter: Organic Regulations

Organic Poultry Production in the United States

Parasite Management for Natural and Organic Poultry: Coccidiosis

Methionine and Cysteine metabolism (Sulfur Amino Acids)

Methionine (MET) and cysteine (CYS) are collectively referred to as sulfur amino acids (SAA) and are involved in complex metabolic processes. Methionine is involved in the synthesis of body proteins and is a constituent of many body parts, including muscles, organs, and feathers. It is also involved in functions unrelated to protein synthesis, such as the synthesis of polyamines. In addition, MET is a methyl-group donor, helping to form dozens of compounds including epinephrine, choline, and DNA. After donation of a methyl group, through an irreversible process called transsulfuration, MET can form CYS, another amino acid needed for protein synthesis. (Two cysteines bonded together form cystine.) Although not technically an essential amino acid, CYS synthesis is inadequate when poultry diets are deficient in MET. The requirement for MET can be satisfied only by MET, whereas that for CYS can also be met with MET. Betaine and choline are nutrients that are involved with MET metabolism and save or spare some MET. See the Appendix for more information on MET metabolic pathways and functions.

Synthetic methionine

Synthetic MET is manufactured as a pure amino acid. Common forms are DL-MET and 2-hydroxy-4(methylthio) butanoic acid (a.k.a. methionine hydroxyl analogue free acid). Raw materials for DL-Met include oil, natural gas, air, and water which are used to make propene, sulphuric acid (H2S), methanol (CH3OH), and ammonia (NH3) for manufacture of DL-MET (Binder, 2003). DL-Methionine (the "DL" refers to the racemic mixture), comes in a crystalline form and is 99% available MET. It is available from the companies Degussa and Adisseo. Methionine hydroxyl analogue comes in a liquid form and is 88% available MET. It is available from Novus International. Synthetic MET is inexpensive, but as the cost of oil goes up, other methods of manufacturing MET will be increasingly attractive. Synthetic MET is so pure that only about 5 lbs. of DL-MET are needed per U.S. ton of feed.

Products with zinc methionine available from Zinpro are listed by the Organic Material Review Institute (OMRI) as being permitted in organic livestock production. 4-Plex-E has 20% MET (directions for feeding poultry are 1.6 lbs. per U.S. ton). Zinpro-E has 40% MET (directions for feeding poultry are 0.4 lbs. per U.S. ton). Because feeding directions are just to satisfy zinc levels, only a small amount of MET is provided. Novus International has a zinc methionine product, Mintrex, that is not listed by OMRI but has 80% MET value and is fed at 0.25 to 0.50 lbs. per U.S. ton.

Natural methionine supplement

There is interest in developing a natural MET supplement by fermentation, extraction, or hydrolyzing protein.

Many amino acids are produced commercially by bacterial fermentation. Because genetically-modified organisms are not permitted in organic production, any MET-producing bacteria would need to be naturally selected. However, high levels of MET are toxic, so the yields from fermentation are very low and not cost effective. Therefore, production is limited, and it is possible that natural MET can not be produced this way.

MET can be extracted from intact proteins or proteins partially hydrolyzed to isolate it, but there are no such products on the market for livestock.

Methionine requirements of poultry

Poultry do not have specific requirements for crude protein levels, only amino acid levels. Amino acid requirements are usually presented as percentages of the diet. They may also be presented as a percentage of the protein requirement. The National Research Council's (NRC) Nutrient Requirements of Poultry is commonly used in the U.S. (available online at *http://www.nap.edu/openbook.php?isbn=0309048923)*. The requirements of broilers are given for starter, grower, and finisher phases, because the requirements change as the bird grows (less amino acids and more energy are required with age). Overall crude protein levels of 23, 20, and 18% are used for starter, grower, and finisher phases, respectively. The MET and CYS requirements are listed in Table 1.

The NRC lists the total amino acid requirement rather than digestible amino acid. Baker (1997) specifies digestible amino acid requirements for broilers. In the starter phase, they are 0.41% for MET and 0.41% for CYS.

Table 1: Sulfur amino acid requirements of broilers*
(fast-growing broilers raised in an environmentally controlled indoor environment)

	Starter	Grower	Finisher
	%	%	%
Methionine	0.50	0.38	0.32
Methionine + cystine	0.90	0.72	0.60
Source: NRC, 1994			

*"Broilers" are chickens that are young birds, tender enough to be prepared by fast cooking methods such as broiling.

Protein and amino acid requirements vary considerably according to the productive state of the bird, that is, the rate of growth or egg production. For example, a mature rooster is bigger than a hen; however, the laying hen has higher amino acid requirements due to egg production.

Factors affecting responses of poultry to amino acids include environmental temperature, dietary factors, immunological stress, age, species, genetics, and gender. These factors either influence feed intake or reduce the efficiency of use of an amino acid (D'Mello, 1994). For example, male meat birds need more essential amino acids as well as more feed than females.

Amino acid balance

Amino acids need an ideal balance in relation to each other. An undersupply of a single essential amino acid will inhibit the responses to those in adequate supply. In poultry, lysine is used as the reference amino acid, and amino acid requirements can be expressed as a percent of lysine (100%). For example, methionine plus cysteine should equal 77.5% of the lysine level for a chick at 0-3 weeks (Cole and Lunen, 1994). The ratio of MET to CYS should be about 60:40. Ideal proteins differ for broilers, layers, turkeys, and other types of birds.

Nutrient balance and feed intake

Energy-to-protein ratios are important. Energy is provided mainly by carbohydrates and fats in the diet. If the diet is well-balanced, the bird eats primarily to satisfy its energy requirements. If the diet is deficient in protein in relation to its energy content, the bird will overeat energy in an effort to obtain sufficient protein.

Dietary energy exerts its effect through variations in feed intake (Emmert, no date). As energy levels increase, feed intake decreases. A high-energy diet effectively limits feed intake, which also limits amino acid intake. Therefore, a high dietary concentration of amino acids (and other nutrients) is needed for high-energy diets. The NRC nutrient requirements are based on high-energy, high-protein (high amino acid level) diets. These high efficiency diets began to be fed in the 1950s, and genetic selection favored birds with voracious appetites.

According to U.S. research, the methionine requirement of slow-growing birds is similar to that of fast-growing birds.

In contrast, as energy decreases, feed intake increases, requiring a lower concentration of nutrients in the diet. If low concentrations of amino acids are used, diets should be low-energy so that feed intake will be increased.

Birds eat less when it is hot and more when it is cold (NRC, 1994). Therefore, diets usually need to be higher in amino acids during hot weather in order to make sure birds get enough.

Feeding diets deficient in essential amino acids can increase feed intake. Cherry & Siegel (1981) fed pullets diets that were equal in energy and contained 15% crude protein and only differed in levels of MET and SAA. The three diets contained 0.27, 0.32, and 0.37% MET, and 0.51, 0.56, and 0.61% SAA, respectively. Dietary effects on bodyweight, age at sexual maturity, egg production, egg size, and egg quality were not significant. They found that the pullets compensated for a marginal deficiency of SAA by increasing their feed consumption, and that the SAA requirement for maximum feed conversion efficiency was greater than the requirement for egg production.

Ewing (1963) noted that as energy in the diet increases, the requirement of MET increases in proportion. Forty years ago, at 1000 Cal/lb. of feed (2,222 kcal/kg), 0.50% MET was recommended in the diet. Ewing suggests formulating diets with amino acid requirements calculated as a percent of energy.

According to Larbier and Leclercq (1994), small birds such as leghorns are able to keep energy intake constant even with varying levels of dietary energy concentration, but heavy genotypes cannot (their feed intake is more constant).

Nutrient balance has an important impact on the carcass. In general, diets high in energy produce fat carcasses, and diets high in protein lead to lean carcasses. But again, the protein-to-energy balance is important. If a bird consumes excess energy compared to protein, a fatter bird develops (Leeson and Summers, 1991).

Methionine requirements of slow-growing meat chickens

In the U.S., the fast-growing Cornish Cross broiler is used in both conventional and organic production. In contrast, slow-growing meat chickens are used in the European Union organic program, as well as the French Label Rouge program, and have a growing period of about 12 weeks. Small growers in the U.S. often use standard-bred birds, such as Barred Rock or New Hampshire, which are very slow-growing.

In the U.S., maximum protein accretion is the goal both in conventional and most organic poultry production, and genotypes with a high growth capacity are raised with a high supply of amino acids in concentrated diets. In contrast, in Europe slower growth and lower protein accretion are expected in organic poultry production, and low-protein, low-energy diets are fed to maintain a slow growth curve.

According to Sundrum (2005), a slow growth curve is important in sensory qualities of the meat that consumers prefer. In the US, Fanatico et al. (2007) found that a trained sensory panel noted more intense flavors in the thigh meat of 12-week-old slow-growing birds compared to that of 8-week-old fast-growing birds; however, the consumer sensory panel could not distinguish a difference. U.S. consumers, accustomed to the sensory attributes of conventional poultry, may require additional experience and exposure to specialty poultry meats to recognize their qualities.

The nutrient requirements of high-yielding broilers raised in controlled indoor environments are well-known. In contrast, the nutrient requirements of lower-yielding meat chickens raised in less controlled housing with access to the outdoors and a high level of activity are not as well-known. Peter et al. (1997) found that a protein level of 20% is adequate as a starter for slow-growing birds. After six weeks, protein content can be reduced to 17.5%.

U.S. research was conducted to determine the MET requirements of slower-growing meat chickens. Fanatico et al. (2006) raised three genotypes with different growth rates (Fast, Medium, and Slow), using graded levels of MET, and found that, based on feed efficiency and weight gain responses, the MET and SAA requirements of the various genotypes are similar during the starter and grower phases. Breast yield response was not measured.

Fanatico et al. (2007) also compared these three genotypes when they were given a low-MET basal diet or diets containing intermediate or high MET levels that were formulated with or without synthetic MET. As expected, the Fast birds had higher weight gain, better feed efficiency, and greater carcass and parts yield than slower-growing birds. The level of MET had a significant impact on weight gain. There was no interaction between MET level and genotype, meaning that the slow- and medium-growing birds responded the same way that the fast-growing birds did (weight gain increased with increased level of MET). However, an interaction did occur when breast yield was measured. Breast yield of Fast birds increased with the level of MET; breast yield of Medium birds responded only to the Intermediate diet; and breast yield of Slow birds responded only to the High diet.


Photo courtesy Alisha Staggs

Han and Baker (1991) found that slow-growing meat chickens require the amino acid lysine at the same concentration as fast-growing broilers. However, the fast-growing broilers required more than twice as much daily lysine as the slow-growing meat birds; the increased need was supplied by greater daily feed intake.

The body composition of meat chickens may come into play when considering amino acid requirements. If the protein-to-fat ratio of the bird is greater in a fast-growing chick than in a slow-growing chick, then dietary amino acid requirements may be higher for the fast-growing chick.

Laying hens

The requirements for layers are given on the basis of feed intake. For example, 0.30% MET and 0.58% SAA are required for leghorn-type layers that consume 100 g (0.22 lb.) of feed per day. Brown-egg layers have 10% higher amino acid requirement values than white-egg layers because of their heavier weight. Laying hens have lower MET requirements than meat birds. But during weeks

22-34, layers are still growing and, at the same time, laying eggs. The amino acid requirements of low-yielding standard breed layers such as Rhode Island Reds or Brown Leghorns are not well-known.

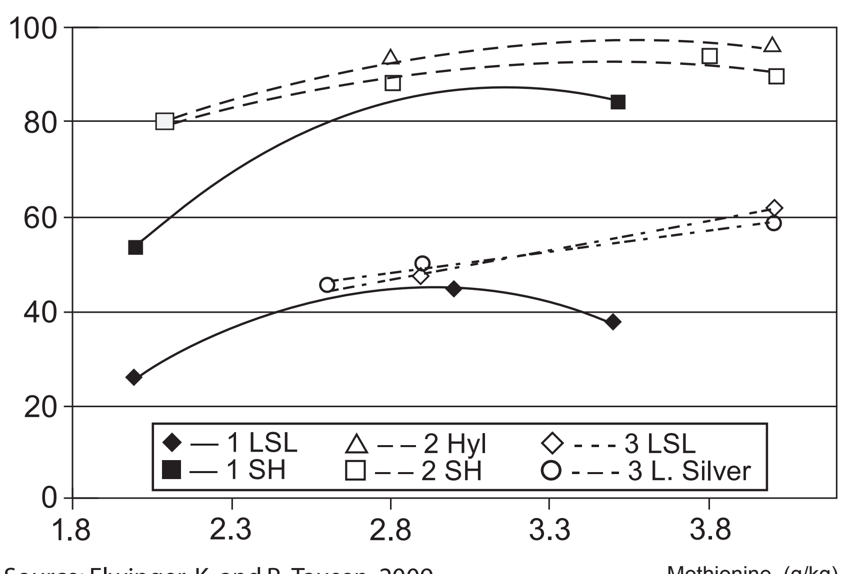
Turkeys

Turkey poults have very high amino acid requirements to meet the demands of their rapid growth. It can be hard to get sufficient amino acids into poults in the starter phase because feed intake is low, and the poults need to accrete a lot of protein. This is especially difficult to do without synthetic MET. From 0 to 4 weeks, 0.55% MET and 1.05% SAA are required. Amino acid needs of turkeys differ substantially by gender. In Europe, slow-growing turkeys are used in the same vein as slow-growing meat chickens as discussed above.

Methionine deficiency problems

The protein and amino acid concentrations presented as requirement in the NRC are to support maximum growth and production. Achieving maximum growth and production, however, may not always ensure maximum economic returns, particularly when prices of protein sources are high (NRC, 1994). And maximum economic returns may not be the only goal.

Figure 1. Feather cover (% of body size)



Source: Elwinger, K. and R. Tausen. 2009.

In the past: How did we raise poultry before synthetic methionine was available?

Synthetic MET was not used in diets until the 1950s. In the past, poultry ate many animal products such as meat and bone meal; high-protein diets were common.

According to Sundrum (2005), there are no effects on animal health from feeding a suboptimal diet or low-nutrient diet, but the birds may not be fully realizing their genetic potential. In fact, breeding companies that sell specialty birds usually show expected growth performance on a high-nutrient diet as well as a low-nutrient diet designed for conventional and specialty production, respectively. See Hubbard Breeders Website, *www.hubbardbreeders.com/product_leaflets/S757N.pdf*, for an example.

Low-nutrient diets or feed restrictions are often used in the starter phase to slow the growth of fast-growing birds in order to reduce metabolic disorders and lameness. Feed density can be increased later for compensatory gain (Sundrum, 2005). The ability to adapt to variations in feed supply as wild animals do still exists in domestic animals (Sundrum, 2005). However, high-yielding animals are more sensitive to suboptimal feed rations than low-yielding animals.

U.S. organic poultry companies are concerned that fast-growing birds with reduced MET levels in their diet will not only perform poorly, but will also suffer impaired immune function, resulting in poor feathering, feather pecking, cannibalism, and mortality.

The antioxidant mechanisms of sulphur amino acids and their compounds are important. Normally, cells are equipped with antioxidant mechanisms to deal with free radicals. If antioxidants are out of balance, problems can occur that cause decreased animal performance. Sulphur-containing compounds such as MET and CYS are powerful antioxidants that can prevent damage in cells (Anon, 2009).

Elwinger and Tausen (2009) found that reduced MET levels reduce feather cover and egg weight, although the production of eggs was not affected. See Figure 1. They also found that feed intake increased as feather cover deteriorated, thus reducing feed efficiency.

Ambrosen and Petersen (1997) studied the impact of protein levels in feed (11% vs 19% crude protein) on cannibalism and plumage quality. The plumage improved with increased protein. Chickens supplemented with MET had better plumage quality and reduced feather pecking compared to the MET-deficient birds. However, Biedermann et al. (1993) did not show poor feathering with low protein levels. There are many factors involved in feather pecking beside the nutrient level, and it is common for feather pecking to occur on farms with high levels of MET in the diet.

Methionine in feedstuffs

Methionine and cysteine are present as intact proteins in various feedstuffs. (Methionine is expressed as a percent of the feed ingredient or as a percent of the protein in the feed ingredient.) The Degussa (Evonik) company has a database that lists amino acids, including MET and CYS, present in feedstuffs. It is updated every five years and will be online in the future. Corn is low in MET (0.17%), and soybean meal is moderate (0.64%). See Chart 1 for MET and CYS contents of various feedstuffs.

As mentioned earlier, the amount of total sulfur amino acids (MET + CYS) in feedstuffs should be considered instead of only MET. If CYS is inadequate, some of the MET will be used to satisfy that requirement.

Amino acids are more digestible in some ingredients than others. The Ajinomoto company has a table of digestibility of amino acids in various feed ingredients (available on its Website, *http://www.lysine.com/new/tecpoul2.htm*). Methionine in most ingredients, such as in corn and soybean meal, is highly digestible (91%), but in flaxmeal, MET digestibility is only 82%, and in sesame meal only 42%.

Chart 1: Methionine and cysteine content of feedstuffs

	Met	Cys	Notes
Soybean, full-fat, extruded	0.48	0.56	
Soybean meal, expelled	0.54	0.59	
Fishmeal, menhaden	1.68	0.5	
Yeast, brewers dried	0.64	0.43	
Casein	2.56	0.4	ratio met to cys is not good; should be 60:40
Milk powder, skim	0.79	0.33	
Rice	0.22	0.19	
Meat and bone meal >50%CP	0.81	0.58	
Meat meal >50% CP	0.72	0.85	
Potato protein	1.64	1.06	
Black soldier larvae	0.9		
Algae	1.33	0.55	
Rapeseed, full-fat	0.38	0.46	
Soybean meal, 48% CP	0.64	0.7	
Sunflower meal expeller	0.67	0.49	
Sunflower, full-fat	0.38	0.3	
Sesamemeal	1.06	0.6	
Safflower meal	0.38	0.41	
flax meal			
Dried distiller grains abd soluble, corn	0.51	0.48	
Alfalfa meal	0.21	0.16	
Grass	0.27	0.16	
Corn gluten meal, 60% CP	1.46	1.06	
Corn	0.17	0.18	
Wheat	0.19	0.27	
Field peas	0.19	0.31	
Whey powder	0.17	0.24	
Source: AminoDat Degussa Amino Acid database			

Small- vs large-scale organic poultry production

Profit margins are usually thin in poultry production, including organic production. Therefore, feed efficiency and breast yield are important measurements for companies to determine profitability. These measurements may not be as important to small producers who may have wider profit margins or may manage their operations as hobbies rather than businesses. Small-scale producers generally use extensive free-range systems in which grassy areas provide additional nutrients, including live protein (insects, worms, etc.) and high-quality forages during warm months.

Plant protein

If only plant protein is used, more protein is required than when animal proteins are also used. However, high-protein diets are not good for the birds or the environment. Various types of plant protein are discussed below.

- Oilseed meals, such as soybean meal, are common poultry feeds after the oil has been extracted for the vegetable oil market, leaving a high-protein meal. However, the extraction process uses chemical solvents, and the remaining meal is not permitted in organic production. Organic soybeans are produced in full-fat (roasted or extruded) or meal (expelled) form.
- Many legumes and oil seeds such as field beans, field peas, lentils, etc. have antinutritional factors (ANF), including tannins and lectins; some ANF can be removed by processing or heat-treatment. For example, soybeans have a trypsin inhibitor and must be heat-treated to destroy it.
- Sesame meal has a high MET content (1.06%); however, the MET is not well-digested and is also low in lysine.
- Sunflower meal has a MET content similar to soybean meal. Chickens cannot remove the hull of whole sunflower seeds. A SARE producer project looked at providing MET through a combination of dehulled sunflowers, fishmeal, and crabmeal, in conjunction with small-scale methods of dehulling sunflowers, and found the approach questionable (FNE05-54).
- Canola (a cultivar of rapeseed) meal is lower than soybean meal in MET.
- Flaxseeds have a MET content of 0.62% and should be limited because of a fishy flavor left in the meat or eggs.
- While corn is relatively low in MET, corn gluten meal is high (1.46% MET). Unfortunately, there is none in organic form in the US.
- High-methionine corn has been naturally selected by the Michael Field Institute (*http://michaelfieldsaginst.org/work/crop/WorkPlan_Corn_Breeding.pdf*). Jacob et al. (2008) fed the variety 3 floury-2 MF hybrid, which averages 0.32% MET, compared to 0.18% in conventional corn. They found that synthetic MET was not needed when using high-MET corn for pullets. However, high-MET corn is also high in protein; therefore, the overall high protein content of the diet is still a problem. In addition, the high moisture and low yield of this corn variety make it unattractive to corn growers.
- Potato protein is high in MET (1.64%), and it is a conventional by-product that is currently used in Europe, where a small percentage of feed ingredients do not have to be organic in organic livestock production. There is very little if any organic potato protein in the U.S.

Animal protein

Animal protein is high quality and a good source of MET. In a natural setting, poultry consume many sources of animal protein, including insects and worms. In the past, animal slaughter by-products (i.e., meat and bone meal) were important ingredients in poultry diets (see box), but they are banned in organic livestock production. However, other animal products can be used, such as fishmeal and milk products, and are discussed below. Insects and worms on range provide high-quality protein.

- Fishmeal is a good source of MET (1.68%) in organic livestock production. However, there is little fishmeal available without the synthetic preservative ethoxyquine which is not permitted in organic production. Natural substances such as tocopherol can be used to prevent rancidity. Unfortunately, there is very little fishmeal available without ethoxyquinine. Fishmeal can be used only in small amounts because it taints the flavor of meat and eggs. Some companies market their products as "veg-fed," and, therefore, fishmeal is not an option for them.
- Dairy by-products can be high in MET and highly digestible. Because liquid milk products are not concentrated due to the presence of water, powdered or concentrated products are particularly useful. Casein is the solid residue that remains after the acid or rennet coagulation of milk. It has a very high level of MET (2.56 %) and is very high in crude protein (80%). Organic casein is not available commercially for livestock feed. Whey powder, a by-product of cheese-making after most of the protein and fat are removed, is not particularly high in MET unless the protein is concentrated.
- Dried brewer's yeast has a moderate level of MET (0.64%).

Additional proteins

Outdoor access is required in organic poultry production. Many operations only provide small areas (the NOP does not specify stocking density for outdoor areas); therefore, birds may not have significant access to grassy areas. Small poultry producers, however, usually provide extensive outdoor access by way of small portable houses moved regularly to fresh pasture. Forage is a source of MET. Although the MET level of forage is generally low to moderate, foraging should be encouraged. Birds can also obtain high-quality protein from insects and worms on pasture.

Moritz et al. (2005) found in the summer that forage (tall fescue, orchardgrass, red clover, and white clover) had higher MET levels than in the fall (0.31% vs. 0.17%, respectively). They compared broiler performance in diets with/without synthetic methionine and with/without feed restriction. They concluded that the ability of forage to meet the MET requirement depends on environmental conditions and subsequent feed intake. Horsted et al. (2006) found that chicory was an especially attractive forage to hens and had a moderate MET content (0.40%). The quality of forages needs to be maintained for good MET levels. In most parts of the country, forage growth slows or stops in the winter. Moritz found that the digestibility of forage varies over the seasons as well.

Fishmeal and dairy products can provide high-quality protein for organic poultry. Worms and insects on pasture are also a good protein source but may contribute to parasite problems in birds due to indirect life cycles.

Earthworms and insects are high-quality proteins, similar to fishmeal, and high in MET. While there are few commercial products, Neptune Industries developed Ento-Protein, an insect meal, and worms and insects can also be produced on-farm. Worms and insects can convert wastes such as food scraps or animal manure to high-quality protein. The remains, especially worm castings, can also be very useful soil amendments. See ATTRA's *Worms for Composting (Vermicomposting)* and *Baitworm Production*. Additional unconventional proteins are discussed below.

- Black soldier flies lay eggs in waste, and when the larvae hatch, they consume the waste and develop into a source of high-quality protein. The larvae can "self-harvest" because they crawl upwards and will fall into collection tubes.

- Algae is high in MET (1.33%). Chlorella has potential as a feed supplement; however, production in ponds, harvesting, and drying are challenging.
- Worms, algae, and aquatic plants accumulate heavy metals at concentrations greater than in the surrounding environment, and these heavy metals could transfer to meat and eggs (DEFRA, 2006). Unconventional proteins may be too expensive because of the labor and processing required.
- Although some of the feedstuffs discussed above are high in MET, large amounts are required to meet SAA requirements compared to the very small amounts of a pure MET supplement. For instance, one pound of DL-MET replaces 50 pounds of fishmeal.

If synthetic MET is removed from typical diets based on corn and soybean meal, the feed ingredients should be adjusted to provide more MET.

Formulating diets and feeding strategies

It is difficult to meet SAA requirements in organic poultry production without also providing excessive protein. Supplying sufficient MET to birds with plant proteins, such as soybeans or sunflower meal, may result in diets with excessive protein levels, which can be harmful to both the birds and the environment. Birds excrete the nitrogen in protein as uric acid, which is broken down into water and ammonia. Extra water is needed to excrete excess protein, making litter wetter and promoting microbial growth. High-moisture litter creates an optimal environment for pathogens and can cause breast blisters. Excess ammonia can also cause respiratory problems, which increases the susceptibility of birds to other diseases, and ammonia emissions from poultry houses are a concern for air quality. Metabolizing excess protein can also be detrimental to the bird, stressing the kidneys, depending on the extent of the excess (Fanatico, et al. 2009). Evidence that excess protein causes stress in birds is also seen in the increased size of adrenals (Leeson and Summers, 1991). Feeding high levels of protein, particularly fishmeal, can predispose birds to necrotic enteritis (Dahiya and Drew, 2007).

In addition, plant proteins usually have antinutritional factors that require heat treatment or other processing to remove.

Many feeds have maximum inclusion rates beyond which feeds can not be used without determintal effects. See Leeson and Summers (1991) for more information.

Broiler and layer diets without synthetic MET were formulated by the Methionine Task Force in 2003 and compared to a diet with synthetic MET (see Appendix). All the diets without synthetic MET are excessive in protein, with the exception of diets using potato protein and corn gluten meal, which are not available in organic form in the U.S. In addition, earthworm meal is not available. A chart accompanies the formulations and shows digestible or available MET in various feedstuffs.

There are strategies to conserve feedstuffs with high-quality protein. For example, the highest quality proteins (generally animal proteins) should be used in the starter phase when birds are young, their digestive systems are not developed, and their feed intake is low. Plant proteins can be used later during finishing (Sundrum, 2005). Multiple phase feeding (beyond the usual starter, grower, and finisher phases) can be useful to more closely match the diet with nutrient requirements. A broiler's nutrient requirements change daily rather than only three times.

In "choice feeding," a completely formulated feed is not provided but rather the separate ingredients. For example, corn may be offered separately from a protein concentrate mixed with vitamins and minerals. Choice feeding could help match nutrients even more closely to requirements that change daily according to temperature, stage of production, and gender. In choice feeding, homegrown organic feeds can be readily used. Many grains are provided in whole forms to reduce processing costs, improve gut health and maintain nutrient content.

Diet formulations

There are diet formulations available for feeding with synthetic MET, such as those at the Canadian Website *http://www.gov.mb.ca/agriculture/livestock/poultry/bba01s38.html*. However, neither the MET levels nor protein levels of the diets are listed, so it is not known whether the target MET level is met without excessive protein.

Sample diet formulations for broilers, layers, and turkeys are provided in Possibilities and Limitations of Protein Supply in Organic Poultry and Pig Production (Sundrum, 2005). However, many of the ingredients are nonorganic, such as potato protein and corn gluten meal, and these cannot be used in the U.S.

See Table 2 for starter and grower organic meat-chicken diets from Europe using organic sunflower, sesame, and rapeseed, which can be difficult to obtain in the U.S. Note that the MET and MET+CYS levels are lower than those recommended by the NRC.

See Table 3 for fishmeal-based organic broiler diets designed by West Virginia University for research using both slow- and fast-growing broilers. No synthetic MET is used, and all the ingredients are available in the U.S.

Trials

The Methionine Task Force and its members have conducted feeding trials to test various diets. For example, Organic Valley did trials with high-MET corn and presented a poster at the 1st IFOAM International Conference on Animals in Organic Production (see Appendix). Some trials included additional betaine in an attempt to spare or reduce the need for some MET.

The Methionine Task Force has also sponsored research to develop a natural methionine product. In addition, the Task Force commissioned an 80-page literature review of methionine by researchers at California State Polytechnic University (Burns-Whitmore, 2007).

See *Nutrition and Feeding of Organic Poultry* (Blair, 2008) for general information on organic feedstuffs and feeding.

Conclusions

It is likely that organic poultry will not have enough methionine in the diet after synthetic methionine has been banned or that the diets will contain excessive protein. Animal proteins (dairy products, fishmeal, or insects/worms) and nonconventional proteins such as algae have an important role to play, but a natural methionine supplement would greatly reduce the problem.

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Table 2. Organic starter and grower diets

	Starter 0-3 weeks	Grower 3 -11 weeks
	%	%
Corn	20	15
Wheat	37	43.5
Sunflower	7	7
Pea		4
Rapeseed	5	2
Soybean meal	24	22
Sesame	1	1
Soy oil	2.5	2.5
Minerals/vitamins	3	3
Organic acid	0.5	0
Calculated feed composition (%)		
Crude protein	20.5	19.7
MET	0.34	0.32
MET+CYS	0.71	0.675

Source: modified from Rodenburg, T.B., J. Van Harn, M.M. Van Krimpen, M.A.W. Ruis, I. Vermeij and H.A.M. Spoolder. 2008. Comparison of three different diets for organic broiler: effects on performance and body condition. British Poultry Science 49:74-80.

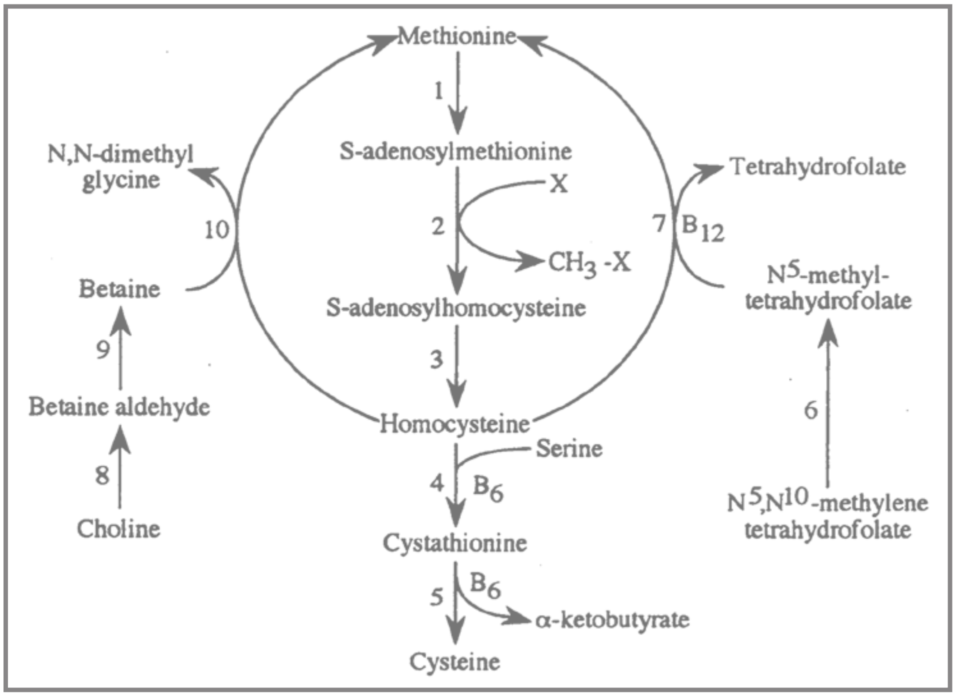
Table 3. Organic research diet formulations and descriptions of nutrient content						
	Starter formulation1		Grower formulation		Finisher formulation	
Item	Slow-growing broiler (0–28 d)	Fast-growing broiler (0–21 d)	Slow-growing broiler (28–56 d)	Fast-growing broiler (21–38 d)	Slow-growing broiler (56–83 d)	Fast-growing broiler (38–54 d)
Ingredient (%)						
Corn	38.33	38.33	54.90	54.90	65.55	65.55
Soybean meal (44%)	43.91	52.08	36.19	34.45	26.24	24.95
Sand2	6.22	—	—	—	—	—
Soybean oil	4.53	1.86	5.00	3.02	3.14	5.00
Fish meal (60.9%)	4.00	5.00	0.25	5.00	2.00	2.08
Limestone	1.18	1.16	1.33	1.05	1.17	1.00
Dicalcium phosphate	1.10	0.86	1.53	0.82	1.11	0.66
Salt	0.42	0.41	0.51	0.46	0.49	0.46
Vitamin-mineral premix3	0.20	0.20	0.20	0.20	0.20	0.20
Choline	0.10	0.10	0.10	0.10	0.10	0.10
Calculated nutrient						
ME (kcal/kg)	2,918	2,918	3,215	3,131	3,209	3,167
CP	25	29	20	22	18	19
Methionine	0.44	0.52	0.35	0.43	0.34	0.38
TSAA	0.82	0.95	0.68	0.77	0.63	0.68
Analyzed nutrient						
CP	24	27	22	24	21	23
Met	0.41	0.45	0.33	0.38	0.32	0.37

[1]All formulations were breed-specific to recommendations determined by the University of Arkansas.
[2]Washed builder's sand was used to dilute nutrients in the Slow-growing diets so that corn percentages could remain constant among Slow-growing and Fast-growing diets.
[3]Supplied per kilograms of diet: vitamin D3, 1,361 ICU; vitamin A, 3,629 IU; vitamin E, 9.07 IU; vitamin K, 0.679 mg; thiamine, 0.453 mg; riboflavin, 2.27 mg; niacin, 18.1 mg; pantothenic acid, 4.54 mg; pyridoxine, 0.907 mg; folacin, 0.227 mg; biotin, 0.011 mg; vitamin B12, 0.005 µg; calcium, 0.093 g; sodium, 0.025 mg; potassium, 1.4 mg; magnesium, 26.5 mg; sulfur, 61.7 mg; manganese, 9.82 mg; zinc, 20.58 mg; iron, 8.23 mg; copper, 2.06 mg; iodine, 0.411 mg; selenium, 0.039 mg.

Source: Adapted from Rack, A.L., K.G.S. Lilly, K.R. Beaman, C.K. Gehring, and J.S. Moritz. The effect of genotype, choice feeding, and season on organically reared broilers fed diets devoid of synthetic methionine. Journal of Applied Poultry Research 18:54-65.

Appendix A

Methionine Pathway



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Appendix B

Evaluation of Organic Broiler and Layer Ration Formulations

Introduction

A series of ration formulations was developed to evaluate the viability of using alternative ingredients to replace the available methionine currently supplied by synthetic sources in poultry rations. The ingredients' nutritional information came from several sources: Feedstuffs Reference Guide 2003-2004, National Research Council's Nutrient Requirements of Poultry (1994), Ajinomoto Heartland LLC, and information supplied by several ingredient producers. The nutritional profiles that served as the basis for the formulations were derived using several sources as well.

The basis for feed formulation is developing the nutritional matrix that is the backbone for each ingredient. For each ingredient, a complete nutritional profile must be established for each of the nutritional constraints of the ration. The values shown in the attached chart, "Available Methionine Content of Ingredients for Poultry," were developed using the previously identified sources of information. Typically, many evaluations have used *total* methionine levels rather than the *available* methionine values shown on this chart. This was done because many of the ingredients contain significant total methionine levels, but due to many factors, only a fraction of this methionine is available to poultry. Using the available methionine values for both the ingredients and the nutritional requirements results in the most valid ration formulations. It must be noted that both the nutritional content of ingredients and the nutritional requirements for ration formulations will vary among nutritionists and feed manufacturers. The values presented here are an attempt to establish acceptable averages for each bird type.

Available Methionine Content of Ingredients for Poultry

The range of available methionine values in ingredients that could possibly meet organic production standards (no animal by-products) is significant, from a low of 0.08% of the ingredient (as fed) for dried kelp meal to a high of 0.93% for Menhaden fishmeal. For the purposes of this evaluation, fishmeal will be considered an acceptable ingredient under the organic standards. The primary ingredients in current poultry rations are corn and soybean meal. Corn (0.16% available methionine) is extremely low in available methionine and soybean meal (0.61% available methionine) can be considered as moderate in its available methionine content. For these reasons, it is the standard in poultry rations that supplemental synthetic methionine is added. These synthetic sources typically are DL-methionine (99% available methionine) and HMB (Alimet, 88% available methionine). Due to the available methionine potencies of the supplements, the typical inclusion rate is three to six pounds per ton of the ration (0.15 to 0.3% of the ration). For the rations in this example, organic soybean oil was also used when necessary to allow more formulation freedom, even though many organic feed producers do not use soybean oil (the oil is usually supplied to the ration in the form of full-fat soybean meal).

Broiler Ration Formulation

The attached sheet summarizes a series of broiler rations that were formulated to meet a common nutrient profile. The nutrients of interest in this comparison are shown in the "Nutritional Comparison" section below each ration. The alternative ingredients chosen for these formulations were restricted to those with the greatest available methionine content. The "Other" portion of the diet is comprised of all other required ingredients: limestone, phosphate, salt, trace minerals, and vitamins.

Ration A represents what could be considered a current ration. Ration B is the resulting formulation after removing the DL methionine. In this case, several compromises had to be made to achieve a feasible solution. These compromises result in a ration that would be unsuitable for broiler production. The energy of Ration B had to be reduced by 100 kcals and the available methionine reduced by 0.04%. At the same time, the protein of the rations increased from 21 to 38% (a level which could be physiologically harmful to the birds) and the available lysine (the second essential amino acid after methionine) was increased by 102%. Ration C was formulated without DL methionine but with fishmeal allowed up to a limit of 2.5% of the ration. In this ration, the target available methionine level of 0.49% was achievable, but (as in Ration B) an energy level reduction was required, and the protein and available lysine were excessive. Therefore, Ration C should be considered unacceptable due to these surpluses. Rations D was formulated with fishmeal and corn gluten meal, while Ration E used fishmeal, corn gluten meal, potato protein, earthworm meal, and sesame meal. In Rations D and E, the target values were achievable for energy and available methionine, and the excesses in available lysine were at an acceptable level. The main concern with Rations D and E is the increase in protein of about 7 to 8%. Several nutritionists contacted were uncomfortable with protein levels that exceeded the requirements by more than 5%. It might be possible to reduce this protein excess if more alternative ingredients were available and used in the ration.

These formulations simulated a broiler ration. Turkey rations are more nutrient dense than broiler rations, but the amino acid balance is proportionally similar. It can be assumed that in attempting to formulate turkey rations with these same constraints and ingredients, there would be similar deficiencies and excesses, and most likely to a greater magnitude.

Layer Ration Formulation

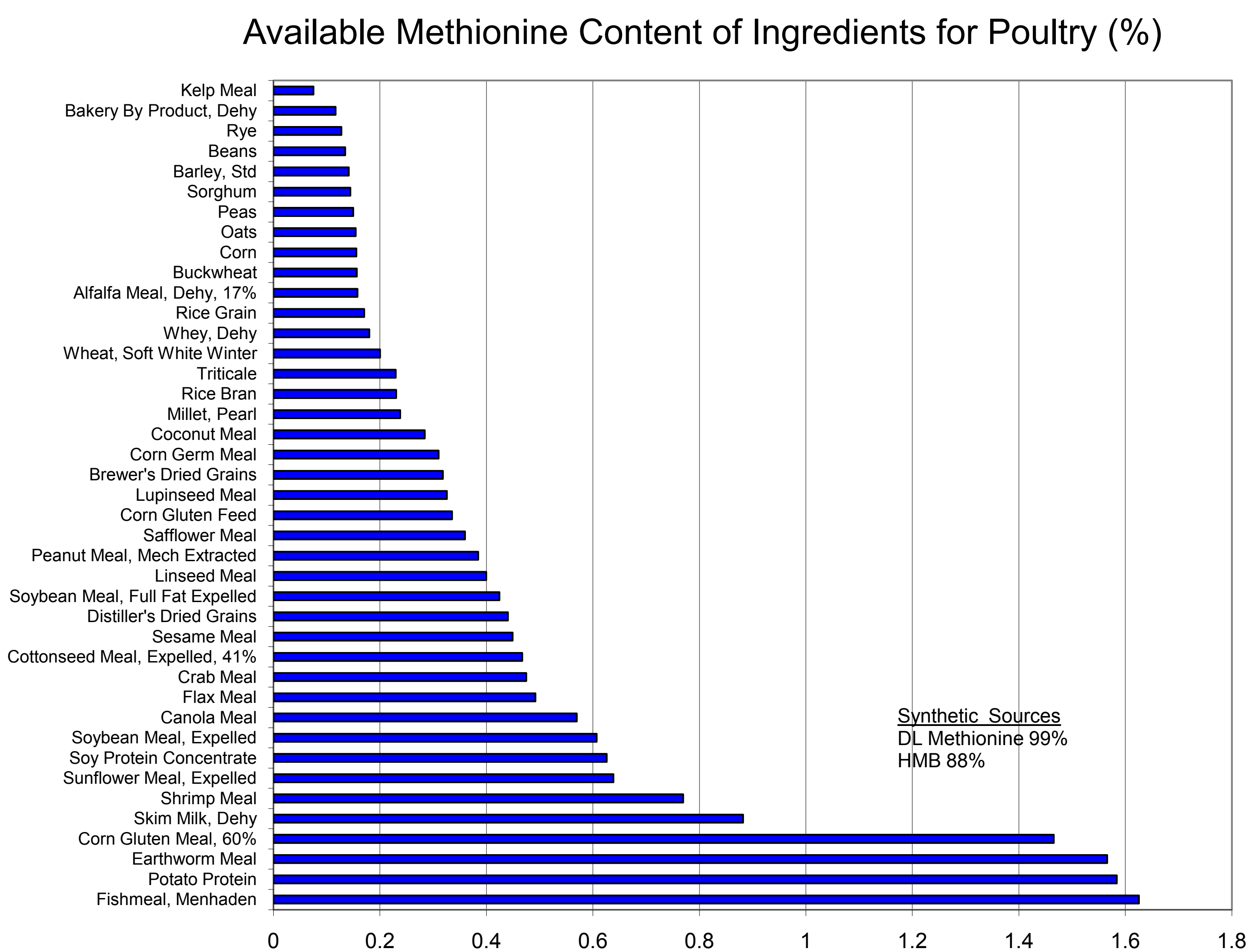
The same ingredient restrictions were used for both the layer rations and the broiler rations. As with the broiler rations, Rations B and C are unacceptable due to deficiencies in energy and excesses in protein and available lysine. For the layer rations, Rations D and E, with the expanded use of alternative ingredients, proved to be feasible solutions, without the energy deficiencies and the protein and available lysine excesses seen in the broiler rations. This can be explained by the fact that layer rations are less nutrient dense than rations for broilers or turkeys.

Conclusions

This series of formulations demonstrates that synthetic methionine supplements cannot simply be removed from the rations and the remaining ingredients reformulated. The resulting imbalances would be detrimental to the birds' health. It appears that the use of fishmeal alone as an alternative ingredient is not sufficient to replace the synthetic methionine. It did appear that potentially feasible rations could be developed with the use of alternative ingredients. The primary constraint of this last conclusion is that these ingredients are either non-existent or of extremely limited availability when they are forced to fully comply with the organic ingredients standards. And again it must be noted that these conclusion were reached using only two "average" rations. Other nutritionists will likely experience additional deficiencies/excesses when formulating specific rations.

Source: from the Methionine Alternative Task Force 2003

Appendix C



Source: from the Methionine Alternative Task Force 2003

Appendix D

Broiler Ration Formulation Evaluation					
	Ration				
	A	B	C	D	E
	(lbs. per ton)				
Corn	1065	170	160	874	950
Soybean Meal	855	1720	1690	800	582
Soybean Oil	21	66	60	0	0
DL Methionine	4	0	0	0	0
Other	55	44	40	56	58
Fishmeal	0	0	50	50	0
Corn Gluten Meal	0	0	0	220	245
Potato Protein	0	0	0	0	0
Earthworm Meal	0	0	0	0	65
Sesame Meal	0	0	0	0	100
Nutritional Comparison					
Metabolizable Energy (kcal/lb)	1350	*1250*	*1250*	1350	1350
Protein, %	21	*38*	*39*	*29*	*28*
Available Methionine, %	0.49	0.45	0.49	0.49	0.49
Excess Available Lysine, %	0	*102*	*108*	*25*	*11*
Italicized values indicate imbalances of nutritional concern					

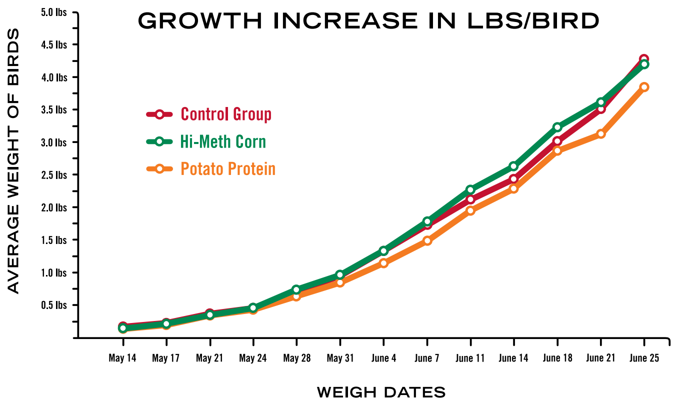
Appendix E

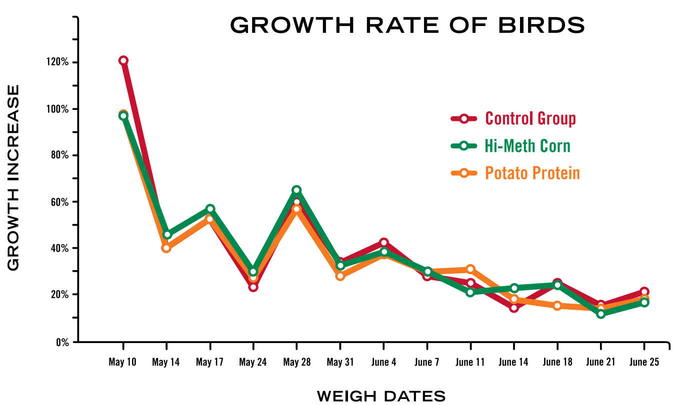
Layer Ration Formulation Evaluation					
	Ration				
	A	B	C	D	E
	(lbs. per ton)				
Corn	1090	245	455	1075	1310
Soybean Meal	645	1498	1245	465	40
Soybean Oil	58	56	57	0	0
DL Methionine	3	0	0	0	0
Other	204	201	193	215	210
Fishmeal	0	0	50	50	50
Corn Gluten Meal	0	0	0	195	125
Potato Protein	0	0	0	0	65
Earthworm Meal	0	0	0	0	100
Sesame Meal	0	0	0	0	100
Nutritional Comparison					
Metabolizable Energy (kcal/lb)	1325	*1165*	*1215*	1325	1325
Protein, %	18	*34*	*31*	22	20
Available Methionine, %	0.40	0.40	0.40	0.40	0.40
Excess Available Lysine, %	0	*107*	*88*	0	0
Italicized values indicate imbalances of nutritional concern					

Alternatives to Synthetic Methionine Feed Trial

Purpose

To find a natural alternative to synthetic DL-Methionine in organic poultry rations.





FEED RATIONS UNDER TESTING

Control Group (25 chicks)		Hi-Meth Corn (26 chicks)		Potato Protein (25 chicks)	
239 lbs	Organic Shell Corn	0 lbs	Organic Shell Corn	275 lbs	Organic Shell Corn
0 lbs	Organic Hi Methionine Corn	240 lbs	Organic Hi Methionine Corn	0 lbs	Organic Hi Methionine Corn
128 lbs	Organic Soymeal	140 lbs	Organic Soymeal	0 lbs	Organic Soymeal
13 lbs	Organic Flaxmeal	0 lbs	Organic Flaxmeal	0 lbs	Organic Flaxmeal
13 lbs	Organic Poultry Builder	12 lbs	Organic Poultry Builder	12 lbs	Organic Poultry Builder
50 lbs	Organic Oats	50 lbs	Organic Oats	50 lbs	Organic Oats
50 lbs	Organic Barley	50 lbs	Organic Barley	50 lbs	Organic Barley
6 lbs	Calcium	5 lbs	Calcium	5 lbs	Calcium
1 lbs	Dical Phos	3 lbs	Dical Phos	3 lbs	Dical Phos
0 lbs	Potato Starch	0 lbs	Potato Starch	105 lbs	Potato Starch

Background[1]

Three groups of cornish cross broiler cockerels are being given different rations.

Each group is receiving the same amount of feed each day.

Growing conditions are similar, all three groups are being raised on the same organic farm, in separate adjoining pens.

Each batch is being weighed twice/week to measure growth patterns.

Chicks arrived on 5/10 as day-olds from Sunny Hatchery in Beaver Dam, WI.

Changed/refilled waterers twice daily.

Feed was given twice a day (splitting the total grams/day) except for the week of June 9th through 17th, 1 X/day.

Control Group

Good energy level, but not as high as the Hi Meth Corn group.
Very good appetites—always rushed the feeder and waterer.
Initially, noticed a few birds with fecal matter covering vent as chicks.
(After we physically removed the matter it did not reappear.)
Abcesses in wings from banding problems developed.
(May have had something to do with some of the birds' eventual total growth?)
0% Mortality (no birds lost).
Feed Conversion Ratio: 2.77 lbs feed/1 lb gain.

High-Methionine Corn

Highest energy level.
(Initial feeding frenzies lessened when feed was increased above recommended levels.)
Initially, noticed a few birds with fecal matter covering vent as chicks.
(After we physically removed the matter it did not reappear.)
Gained weight fastest, but Control Group caught up towards the end and surpassed the High Methionine Group at the last weighing. Although they were so close, this might have been insignificant.
3.85% Mortality—lost one bird due to neck/leg problems at the end of the trial (week 6)
Feed Conversion Ratio: 2.78 lbs feed/1 lb gain.

Potato Protein

Grew the slowest and never caught up with the Control or Hi Meth Corn groups, leading one to believe that it would take longer to grow out a broiler, or raise a layer to begin laying eggs.
Feed seemed to cake up more both towards the bottom of the bags and in the feeder.
Birds initially seemed to take more water than the Control or Hi Meth Corn groups, but eventually it was the same as the others.
VERY calm, in comparison to the others groups.
12% Mortality: lost 3 birds due to leg/neck problems early on.
Feed Conversion Ratio: 3.28 lbs feed/1 lb gain.

Conclusion

High-Methionine Corn is a potential alternative to synthetic methionine in organic poultry rations.

[1] Test conducted at Appley Ever After Farm, Viroqua, WI

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Organic Poultry Production: Providing Adequate Methionine

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