Petition for Amending the National List of the USDA's National Organic Program

<u>DL- Methionine, ML-Methionine Hydroxy analog, and DL-Methionine-hydroxy analog calcium-for use only in organic poultry production</u>

A Synthesized Essential Amino Acid

Submitted July 31, 2009 by:
Dave Martinelli, on behalf of the Methionine Task Force
(Please refer to the first attachment to this petition for a list of Task Force representatives.)

Introduction:

The Methionine Task Force requests that 7 CFR §205.603(d)(1) be amended, as follows:

> DL–Methionine, DL–Methionine—hydroxy analog, and DL–Methionine—hydroxy analog calcium (CAS #–59–51–8; 63–68–3; 348–67–4)—for use only in organic poultry production until October 1, ~~**2010.**~~ **2015, provided that the total amount of synthetic methionine in the diet remain below the following levels, calculated as the <u>average pounds per ton</u> of 100% synthetic methionine (MET) in the diet over the life of the bird:**

Laying chickens	**4 pounds**
Broiler chickens	**5 pounds**
Turkeys and all other poultry	**6 pounds**

Further Clarification of the Proposed Amendment
Under this recommendation, producers would be able to exceed the above maximum levels on a particular formulation, provided that there was an offsetting formulation below the maximum level, such that the **<u>average</u>** inclusion rate of 100% synthetic methionine <u>over the entire life cycle of the bird</u> was below the recommended maximum level.

Reference is specifically made to 100% synthetic methionine as some forms of synthetic methionine (e.g. the liquid form Alimet) are not 100% methionine. The maximum pounds as shown above is based on the 100% synthetic methionine equivalent so that a consistent standard can be applied to all organic operations, irrespective of the form of MET they are using (e.g. wet vs. dry).

All of the above proposed maximum levels represent extremely small percentages of the overall diet. When expressed as percentages, the amounts are:

Laying chickens	0.20%
Broiler chickens	0.25%
Turkeys and all other poultry	0.30%

Petitioners are required to provide the following information as applicable:

Category for inclusion on the National List:

- *This request is to change the annotation date currently listed on synthetic methionine [MET] in Section 205.603 of the National List as a synthetic substance allowed for use in organic poultry production subject to the limitations on usage as defined above.*

Common name:

- *The three names in the title of this document are the most widely used common names. They are however the common names associated with specific manufacturers. Throughout this petition the term "Methionine" will be used to refer to the natural form of the amino acid and the term MET will be used to refer to any synthetic analog.*

Chemical Structure:

- *The formula for Methionine is $H_2NCH_3SCH_2CH_2COOH$.*
  Other Chemical Structures:
  DL-Methionine CH3-S-CH2-CH2-CH(NH2)-COOH
  Methionine Hydroxy Analog CH3-S-CH2-CH2-CH(OH)-COOH

Manufacturers name, address and telephone number

- *There are three major manufacturers of MET world wide:*

Adisseo
3480 Preston Ridge Road, Suite 375. Alpharetta, GA 30005 Phone 678-339-1513

Degussa Feed Additives
1701 Barrett Lakes Blvd., Suite 340 Kennesaw, GA 30144 Phone 800-955-3114

Novus International, Inc.
530 Maryville Centre Drive St. Louis, MO 63141 888-906-6887

List of uses, rates and applications for crops and livestock uses, mode of action for handling uses:

- *Typically added to poultry feed rations at the following rates:*
    - *Laying Hens: 0.20% (4 lbs per ton of feed)*
    - *Broilers: 0.25% (5 lbs per ton of feed)*
    - *Turkeys: 0. 30% (6 lbs per ton of feed)*

Sources and detailed description of manufacturing procedures:

The following text is taken from the May 21, 2001 Methionine Livestock TAP Review:

Methionine may be isolated from naturally occurring sources, produced from genetically engineered organisms, or entirely synthesized by a wide number of processes. While methionine has been produced by fermentation in laboratory conditions, racemic mixtures of D- and L- methionine (DL-Methionine) are usually produced entirely by chemical methods (Araki and Ozeki, 1991). Methionine can be produced from the reaction of acrolein with methyl mercaptan in the presence of a catalyst (Fong, et al., 1981). Another method uses propylene, hydrogen sulfide, methane, and ammonia to make the intermediates acrolein, methylthiol, and hydrocyanic acid (Degussa). The Strecker synthesis can be used with α-methylthiopropionaldehyde as the aldehyde (Fong, et al., 1981). A recently patented process reacts 3-methylmercaptopropionaldehyde, ammonia, hydrogen cyanide, and carbon dioxide in the presence of water in three reaction steps (Geiger et al., 1998). Other methods are discussed in the 1999 Crops Amino Acid TAP review. DL-methionine hydroxy analog calcium and DL-methionine hydroxy analog forms are considered to be alpha-keto acid analogues in which the amine group has been replaced by a hydroxy (OH) group. These forms are converted to the amino form in the bird by transamination in the liver, using non-essential amino acids such as glutamic acid (Cheeke 1999; Leeson 1991). These forms are produced by reacting hydrogen cyanide with an aldehyde that has been treated with a sulfite source to form a cyanohydrin. The aldehydes used are prepared from either hydrogen sulfide or an alkyl mercaptan with an aldeyhde such as acrolein and are then hydrolyzed using sulfuric or hydrochloric acid (USPO 1956).

Regulatory status with EPA, FDA or state authorities:

The following text is taken from the May 21, 2001 Methionine Livestock TAP Review:

Regulated as a nutrient / dietary supplement by FDA (21 CFR 582.5475). The Association of American Feed Control Officials (AAFCO) set the standard of identity for DL-methionine as containing a minimum of 99% racemic 2-amino-4-methylthiobutyric acid (AAFCO, 2001). The AAFCO model regulation states that "the term Methionine Supplement may be used in the ingredient list on a feed tag to indicate the addition of DL-Methionine" (AAFCO, 2001). AAFCO also lists a feed definition for DL-Methionine hydroxy analogue calcium (min. 97% racemic 2-amino-4-methylthiobutyric acid, 21 CFR 582.5477) and DL-Methionine hdyroxy analogue, (min. 88% racemic 2-amino-4-methylthiobutyric acid, 21 CFR 582.5477).

Chemical Abstract Service (CAS) number or other product number, samples of labels:

The following text is taken from the May 21, 2001 Methionine Livestock TAP

Review:

Chemical Names:
2-amino-4-methylthiobutyric acid and
α-amino-©-methylmercaptobutyric acid

Other Names:
DL-methionine, D-methionine, L-methionine,
Met, Acimethin

CAS Numbers:
59-51-8 (DL-methionine)
63-68-3 (L-methionine)
348-67-4 (D-methionine)

Other Codes:
International Feed Names (IFN):
DL-methionine: 5-03-86
DL-methionine hydroxy analog
calcium: 5-03-87
DL-methionine hydroxy analog: 5-30-28

Physical properties of the substance and chemical mode of action: including environmental impacts, interactions with other materials, toxicity and persistence, effects on human health, effects of soil organisms, crops or livestock:

The following text is taken from the May 21, 2001 Methionine Livestock TAP.

Properties:
L-Methionine: Colorless or white lustrous plates, or a white crystalline powder. Has a slight, characteristic odor. Soluble in water, alkali solutions, and mineral acids. Slightly soluble in alcohol, insoluble in ether. MP 280-82°C. It is assymetric, forming both an L- and a D- enantiomer. Methionine hydroxy analog (MHA) is available in liquid form.

Action:
Amino acids form protein. Of the 22 amino acids found in body proteins, the National Research Council lists 13 as essential in poultry diets, and these must be consumed in feed. These 13 are: arginine, glycine, histidine, isoleucine, leucine, lysine, methionine, cystine, phenylalanine, proline, threonine, tryptophan, and valine (NRC 1994). Five that are deemed critical in poultry rations are methionine, cystine, lysine, tryptophan, and arginine (North, 1990).

Animals convert dietary protein into tissue protein through digestive processes. Proteins are metabolized by animals through two phases: catabolism (degradation from body tissue to the free amino acid pool) and anabolism (synthesis into body tissue). Amino acids utilized as proteins are primary constituents of structural and protective tissues, including skin, feathers, bone, ligaments, as well as muscles and organs.

Combinations:
Amino acids are combined in feed rations of grains, beans, oilseeds, and other meals with antioxidants, vitamins, minerals, antibiotics, and hormones (Pond, Church, and Pond, 1995). Methionine is a precursor in the diet to cystine, and the amount needed in the diet depends on the amount of cystine also present. Requirements for methionine are frequently cited in terms of methionine plus cystine, because methionine converts to cystine as needed.

OFPA 2119(m) Criteria:
(1) The potential of such substances for detrimental chemical interactions with other materials used in organic farming systems.
The primary chemical interaction is the dietary intake by animals. While many of the interactions may be regarded as beneficial, excess methionine in a diet may cause deficiencies in other amino acids and induce toxicity (D'Mello, 1994). Methionine, while often one of the most limiting amino acids, is also one that readily goes to toxic excess. Small excesses of methionine can be deleterious (Buttery and D'Mello, 1994). Errors in feed formulation or excess supplemental methionine can actually depress growth and development at levels of 40 g/kg (4.0%) (Baker, 1989, NRC 1994). Excess methionine exacerbates deficiencies of vitamin B-6, which results in depressed growth and feed intake (Scherer, 2000). Growth depressions resulting from excess supplemental amino acids include lesions in tissues and organs (D'Mello, 1994). Methionine is "well established as being among the most toxic of all amino acids when fed at excess levels in a diet" (Edmonds and Baker, 1987 cited in Scherer, 2000).

(2) The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.
While it is nutritionally essential, methionine excesses are far more toxic to poultry than similar excesses of tryptophan, lysine, and threonine (National Research Council, 1994). Force feeding methionine to excess can result in death to chicks (National Research Council, 1994). However, NRC acknowledges that such toxicities are unlikely in practical circumstances for poultry, in that an amino acid toxicity requires a particularly high level of an amino acid relative to all others. Supplemental levels fed to poultry are usually fed at lower levels, ranging from 0.3 - 0.5% of the diet. Susceptiblity of an animal to imbalances and excesses is influenced by the overall protein supply, and animals that are fed relatively high levels of protein are more tolerant (Buttery and D'Mello, 1994).

A dosage of 2 g / mature cat / day (20 to 30 g / kg dry diet) for 20 days induces anorexia, ataxia, cyanosis, methemoglobinemia and Heinz body formation resulting in hemolytic anemia (Maede, 1985). Rat studies of methionine is significantly toxic in excess (Regina, et al., 1993). High levels of methionine were found to be toxic to hepatic cells and liver function of the rat models. The results of this study indicated that the Biochemical reason for the extreme sensitivity of mammals to excess dietary methionine is thought to be due to the accumulation of toxic catabolites, most notably, S-adenosylmethione, resulting in liver dysfunction. L-methionine has an acute LD_{50} of 4,328 mg/kg (rat) (NIEHS, 1999b). NIEHS carcinogenicity and teratogenicity are not available, but reports positive mutagenicity (NIEHS, 1999b). Methionine is stable in crystalline form at standard temperature and pressure.

(3) *The probability of environmental contamination during manufacture, use, misuse or disposal of such substance.*
Synthetic production of DL-methionine involves a number of toxic source chemicals and intermediates. Each of the several manufacturing processes used to produce DL-methionine was rated as either "moderately heavy" to "extreme" (Fong, et al., 1981). Newer processes have not replaced many of the feedstocks. Several of the feedstocks are likely to result in ruptured storage tanks, leaking chemicals, and releases into the environment. The methionine production process is listed by EPA as a hazardous air pollutant (40 CFR 63.184).
Methyl mercaptan can react with water, steam, or acids to produce flammable and toxic vapors (Sax, 1984). The EPA rates methyl mercaptan fires as highly hazardous and can cause death by respiratory paralysis (EPA, 1987). Acrolein has a toxicity rating of 5 (on a scale of 1 to 6 with 6 being most toxic) (Gosselin, 1984) and it is also an aquatic herbicide (Meister, 1999). The acrolein process involves several steps that render it synthetic as well (1994). Acrolein itself is an extreme irritant.
Hydrogen cyanide is produced by further processing of methane and ammonia. Hydrogen cyanide is a gas that is highly toxic. Hydrogen cyanide has a toxicity rating of 6 and is one of the fastest acting poisons known to man (Gosselin, 1984). Exposure causes paralysis, unconsciousness, convulsions, and respiratory arrest. Death usually results from exposure at 300 ppm concentrations for a few minutes. Manufacture of hydrogen cyanide is a significant source of atmospheric release of cyanide (Midwest Research Institute, 1993). Ammonia is a corrosive agent. Methane is a central nervous system depressant (Gosselin, 1984).

(4) The effect of the substance on human health.
Methionine is essential in small amounts in the human diet, and is sold over-the-counter as a dietary supplement. The L- form of methionine is used extensively in human medicine for a variety of therapeutic purposes, including pH and electrolyte balancing, parenteral nutrition, pharmaceutical adjuvant, and other applications. It is in fact one of the top 800 drugs in human medicine (Mosby, 1997). Methionine may cause nausea, vomiting, dizziness, and irritability and should be used with caution in patients with severe liver disease (Reynolds, 1996).

The D- form of methionine is not well utilized by humans (Lewis and Baker, 1995). Individuals may have allergic reactions to the D- isomers or a racemic mixture of DL-methionine. While a number of amino acids are considered GRAS for human consumption and as feed supplements, DL-methionine is not (see 21 CFR 172, 21 CFR 184, and 21 CFR 570.35). DL-methionine is unique among amino acids cleared for food use in that it is the only one listed that explicitly says it is not for use in infant feed formulas (21 CFR 173.320). When heated to decomposition, methionine emits dangerous and highly toxic fumes (NIEHS, 1999).

(5) The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock.
<u>Interactions and Imbalances</u>
Protein is required for body development in all growing birds, and layers also need a good proportion since eggs consist of 13-14% protein. Broilers also need high energy diets as they are commericially raised to grow rapidly to reach about 4.4 lbs in 8 week at a desired food conversion rate of 1.8 (consuming less than 8 lbs of feed total) (Sainsbury, 2000). This is a 50-55 fold increase inbody weight by 6 weeks after hatching, which leads to a high amino acid requirement to meet the need for active growth (NRC 1994). The dietary requirement for protein is actually a requirement for the amino acids contained in the dietary protein. Protein quality is related to the proper balance of essential amino acids in the diet. The presence of nonessential amino acids in the diet also reduces the necessity of synthesizing them from the essential amino acids (NRC 1994).

Amino acids in the body are constantly in flux between three states: stored in tissue, oxidized from tissue to free amino acids, and digested and excreted as uric acid. If some nonessential amino acids are low, they may be synthesized from others in the free amino acid pool, or degraded from those stored in tissue. Deficiencies or excesses of a particular amino acids can cause problems in availability of other amino acids (Buttery and D'Mello 1994; Baker 1989). Intact proteins (as in natural grains) are more slowly available in the digestive system, while pure sources of amino acids are more bioavailable than intact-protein sources (Baker, 1989). Excesses of some amino acids in an unbalanced source of crude protein can reduce feed intake and depress amino acid utilization (Pack, 1995). Depressed feed intake and growth at excess intake levels of protein has recently been attributed to insufficient supply of vitamin B-6 which is required to metabolize the sulfur amino acids (Scherer and Baker 2000).

The requirement for sulfur containing amino acids of methionine, cystine, and cysteine can be misjudged due to inaccurate accounting for the availability of cystine in the diet (NRC, 1994).

Other cases have shown significantly higher weights and faster gains from amino acid (lys+met) supplementation (Slominski et al, 1999). Also, the digestibility of practical ingredients, such as corn and soybeans, appears to be on the order of 85% or more (NRC, 1994).

Amino acid requirements may be affected by environmental temperature extremes, basically because of the effect on feed intake, but amino acid supplementation will only affect weight gain if it improves feed intake (Baker 1989; NRC 1994). Interactions between deficiencies of methionine and several vitamins and minerals have also been documented, and suggest that other dietary factors in addition to total protein have an effect on the efficency of amino acid utilization (Baker, D.H. et.al, 1999).

<u>Environmental Impact</u>

Managing the nitrogen cycle is seen as a challenge to livestock producers (Tamminga and Verstegen, 1992; Tamminga, 1992; Morse, no date). Poultry layer operations are experiencing increased costs and regulations for manure management (Sloan, et al., 1995). Supplementation with amino acids may allow dietary protein and excretory nitrogen levels to be reduced with a minimum reduction in egg output and no loss in weight gain in broilers (Summers, 1993; Sloan et al., 1995, Ferguson, et.al 1998). Excess ammonia build up in poultry houses can be a hazard to workers and birds if not properly ventilated (Ferguson, 1998).

Feeding systems that reduce levels of protein fed using amino acid supplementation are not the only means identified to reduce nitrogen pollution from animal manure. Other potential solutions include lower animal densities; more frequent rotations; better manure storage, handling, and application techniques; use of enzymes; improved processing of the feed; and selection of more appropriate land and locations to graze and shelter animals (Archer and Nicholson, 1992; Tamminga, 1992; Tamminga and Verstegen, 1992). Increased digestiblilty of protein in feeds suplemented with microbial phytase provided better availabilty of most of the amino acids other than lysine and methionine and allowed for reduced P and Ca levels in feed, a goal in reducing phosphorus overload from poultry manure (Sebastian 1997). Another study found that reduced crude protein and energy content were needed in enzyme supplemented broiler diets, although availability of individual amino acids were not improved equally and were still deemed to need balancing (Zanella, et al 1999).

One grower reported success with innovative housing design that allows twice daily cleanout of manure, combined with a commercial composting operation (La Flamme, 2001). Manure from organic operations has potential added value to organic crop farmers seeking to avoid manure from conventional operations. Some markets in the EU require that imported crops are documented to be grown free of "factory farm" manure, requiring additional verification from U.S. certifiers (McElroy, 2001).

<u>Impacts on Bird Health</u>

A number of reports cite a benefit of methionine supplementation on reduced immunologic stress (Klasing, 1988; Tsiagbe et al, 1986). Immunologic stress is considered to be a response to microbial challenges, in these experiments due to injections of E. coli and Salmonella and other pathogens. This causes decreased feed rates and lower rates of growth. Chicks that received deficient levels of methionine were more subject to an impaired immune response. These experiments seem to be more applicable to a high density confinement system or high density production system in terms of bird treatment, and may not be very relevant to an organic system approach.

A problem exacerbated by excess methionine is hepatic lipidosis, a condition of excessive fat in the liver commonly associated with caged birds and is related to the fact that wild diets are much lower in fat than seed diets fed to captive species (Aiello, 1998). This can be mangaged by a well balanced diet, and is reportedly not a problem in free range birds in organic systems (Krengel, 2001). Enteritis is a disease frequently observed in poultry that do not have access to the soil and green growing plants (Titus, 1942). Well managed pasture would prevent this cause of the disease.

Reduced feathering has been reportedly linked to lack of methionine and cystine (Elliott, no date). Many other factors are also involved, including deficiencies of other amino acids, vitamins, zinc, feather pecking in cage systems, and cannibalism (Elliot, NRC 1994). Increased protein level is correlated with reduced feather loss and cannibalism (Ambrosen, 1997).

(6) The alternatives to using the substance in terms of practices or other available materials.
Birds raised on pasture with access to insects and worms historically did not need supplementation (Morrison, 1951), and smaller scale pastured operations have success without the need for synthetic supplements (Salatin, 1993). Pasture quality will vary according to field conditions and the season. However, free range poultry on well managed pasture are able to supplement their diets with insects, annelids, and fresh green forage (Smith and Daniel, 1982). The two most limiting amino acids, methionine and lysine, are found in richest sources in proteins of animal origin. Common natural sources of these amino acids have traditionally been fish meal and meat meal, especially for starter chicks and broilers (Sainsbury, 2000). The USDA organic program final rules do not allow the use of meat meal as feed for poultry or mammals and may or may not allow fish or crab meal (7CFR 205).

Diets can be formulated without supplemented synthetic acids to meet the objective of adequate methionine percentages, but this usually requires an increase in crude protein level of the diet (Hadorn, 2000). Many studies have been done to identify a cost effective method of lowering protein content by supplementing with methionine and lysine. Often the control treatments are non-supplement grain based diets. A comparison study using supplemented and non-supplemented diets found that adequate dietary methionine can be attained, at a cost of higher intake of protein and less protein efficicy ratio (Emmert 2000). Another study fed a control diet using only corn and soy to satisfy amino acid levels compared to reduced protein supplemented with methionine and lysine, and these treatments were considered successful because performance was not lowered in 4-5 experiments (Harms, 1998).

Rice and casein offer potential novel available sources of methionine (Lewis and Bayley, 1995). Yeast protein has long been known as a rich protein source relatively high in methionine+cystine (Erbersdobler, 1973; National Research Council, 1994), as well as phosphorous and B-complex vitamins (Morrison, 1951). As a natural feed supplement, NOSB should advise whether yeast is considered agricultural and required from organic sources or permitted as a natural substance. Other potential sources of available methionine for poultry appear to be sunflower meal and canola meal (Waibel et al., 1998). These natural sources are all currently of limited availability in organic forms. Alfalfa meal is reported to be a good additional protein source, though difficult to blend in commercial formulations. Optimally balancing these nutrients may be challenging to feed processors and livestock producers.

Feed sources with high percentages of methionine are bloodmeal, fish meal, crab meal, corn gluten meal, and sunflower seed meal (National Research Council, 1994). If fish meal were permitted, there is a lack of supply that does not contain ethoxyquin, a synthetic antioxidant not permitted under the final rules. A limited supply of fish meal preserved with natural tocophorols has gone mostly into the pet food market (Mattocks, 2001). Corn gluten and sunflower seed meal are not currently very available in organic form, and feed formulators and nutritionists have reported difficulty in meeting NRC requirements for methionine based on currently available organic plant protein sources (Mattocks, Morrisson, Simmons, 2001). One feed mill operator feels he can meet even broiler needs with a combination of crab meal (at 75 lbs/ton or 3.75%) and organic corn gluten (Martens, 2001). Crab meal is a by-product of crab processing and not treated with preservatives but has limitations due to salt content. Another certified feed mill produces layer and range broiler rations without synthetic amino acids based only on plant products, including corn, soy, barley, oats, wheat, field peas, and flaxmeal. These products are labeled at a minimum of 0.3% met and 0.6% lysine, but reportedly achieve good results (White 2001, VOG).

NRC requirements for amino acids and protein are designed to support maximum growth and production. The recommended levels for methionine in poultry depend on species, stage, and level of feed consumption. For chickens, recommendations for layers range from 0.25% to 0.38% and for broilers 0.32 - 0.50%. NRC notes that maximum growth and production may not always ensure maximum economic returns when protein prices are high, and that if decreased performance can be tolerated, dietary concentrations of amino acids may be reduced somewhat to maximize economic returns (NRC, 1994). Methionine is known to have a direct effect on egg weight (size) and rate of lay, and is used by some producers to manipulate egg production to meet market needs, such as to increase egg size in younger birds, reduce it in older birds, or produce more eggs in off peak market periods (NRC 1994; Harms 1998; Simmons 2001). A reduction in rate of gain in broilers (longer time to finish) would be an outcome of lower than optimal methionine levels. Unless the diet contained other forms of sulfur containing amino acids (cystine or cysteine), problems with inadequate feathering might be encountered (Simmons, 2001).

Temporarily confined poultry can be fed a practical organic corn / soybean ration. Depending on market conditions and on how other parts of the standards evolve, novel organic products can be developed as supplements. Among the potential alternative sources include organic dairy products such as casein (National Research Council, 1982 and 1994).

Macroorganisms commonly found in healthy pasture soils cannot be discounted as a source of nutrient cycling in free-range poultry systems. Given the natural feeding habits of poultry and other birds, the use of earthworms is a logical source of protein in chicken feed (Fisher, 1988). Earthworm populations in a pasture depends on a number of factors (Curry, 1998). The amino acid content of earthworms will vary depending on species and food source. However, earthworms have been found to accumulate and concentrate methionine found in the ecosystem in proportions greater than for other amino acids (Pokarzhevskii, et al., 1997). As a feed supplement, earthworms have been found to equal or surpass fish meal and meat meal as an animal protein source for poultry (Harwood and Sabine, 1978; Toboga, 1980; Mekada et al., 1979; and Jin-you et al., 1982 all cited in Edwards, 1998).

Earthworms can play a role in moderating nitrogen losses as well. Enzyme treatment of feedstuffs can improve amino acid availability and also reduce nitrogen pollution (Tamminga and Verstegen, 1992), as can changes in stocking density, rotations, and manure handling.

(7) Its compatibility with a system of sustainable agriculture.
In 1994 the NOSB recommended that feed and feed supplements be produced organically. When considering the review of feed additive vitamins and minerals, an NOSB statement of principles advised that non-synthetic vitamins and mineral sources are preferable when available. The NOSB also advised that a farm plan should reflect attempts to decrease or eliminate use of feed additives when possible (NOSB, 1995).

A constraint to optimal production in modern organic systems that are not able to utilize pasture based systems appears to be adequate organic sources of the first limiting amino acid, methionine. The allowance of isolated amino acids facilitates the use of the lowest cost, non-diverse corn-soy ration. It is the basis of conventional confinement animal production systems which may be considered as antithetical to the principals of organic livestock production. The source and method of production of synthetic amino from non-renewable fossil fuels and toxic chemicals is also questionable in compatibility with system of sustainable agriculture.

The use of synthetic amino acids increases animal production by increased efficiency of protein conversion, which lowers feeding costs and reduces nitrogen content of the waste output. While this is not by itself unsustainable, synthetic amino acids discourage the integration of a whole-systems approach to cycling nutrients, particularly nitrogen, as part of an integrated crop-livestock production system. Allowance of synthetic sources of amino acids may discourage market development of organic plant sources, such as seed meals.

Increased efficiency of protein conversion reduces the amount of nitrogen excreted (Summers, 1993; deLange, 1993). The cycling of nutrients from animals is part of an integrated farming system, and the environmental effects of manure management requires looking at the big picture (Archer and Nicholson, 1992). What is viewed as a liability in confinement animal systems—nitrogen production—is seen in cropping systems as a limiting factor resource. Reduction of nitrogen pollution may require improved range or pasture management, and with that either more frequent rotations or lower stocking rates

Safety information, including a MSDS (Material Safety Data Sheet) and report from National Institute of Environmental Health Studies (NIEHS):

A MSDS for DL Methionine is attached to this petition. A search of the National Institute of Environmental Health Sciences (NEIHS) website for Methionine and DL Methionine yielded no Substance Reports.

Petition justification statement which states why the synthetic substance is necessary, alternatives that could be used, beneficial effects to the environment, etc:

<u>Justification Statement</u>

1. **<u>The Role of Methionine in Poultry Nutrition</u>**
2. **<u>Why is Synthetic Methionine Needed?</u>**
3. **<u>Summary of Synthetic Methionine Levels in the Diet</u>**
4. **<u>History of Synthetic Methionine with the NOSB</u>**
5. **<u>Role of the Poultry Industry and the Methionine Task Force</u>**
6. **<u>What is New Since the Last Petition?</u>**
7. **<u>Conclusion</u>**

1. The Role of Methionine in Poultry Nutrition

Amino acids are the basic constituents of living matter because they are the building blocks of proteins. To create the proteins needed for its existence, an organism needs to have all of the amino acids that make up that protein. If any amino acids are missing, then certain proteins cannot be made.

Animals can make (synthesize) various amino acids. However, monogastrics (non-ruminants, such as poultry) cannot synthesize certain amino acids that are essential for the proteins they need. These are known as "**essential amino acids**", not because they are truly more essential than the others, but because it is essential that they be in the diet since the organism cannot make them itself. **In the specific instance of poultry, methionine is an essential amino acid meaning that it cannot be synthesized by the bird, but must be part of the bird's diet.**

Many monogastrics (including poultry) are omnivores, as meat, milk, and eggs contain biologically adequate proteins with all the essential amino acids that are required. The domestic bird evolved from an omnivore that was exposed to protein in the form of insects and small animals on the forest floor.

Animals consuming only a vegetarian diet need to eat a suitable mix of plant products to satisfy their amino acid requirements. Different plants have different mixes of amino acids depending upon species and age in the plant's life cycle. However, as a general rule, the level of methionine in plants is much lower than the level of methionine from animal sources. Again, in the specific instance of poultry, **a 100% organic vegetarian diet is not capable of providing the level of methionine necessary to meet the bird's basic maintenance requirement.**

Providing poultry with a nutritionally appropriate level of methionine is critical to animal health and welfare. As referenced in the TAP review from May 21, 2001:

> A number of reports cite a benefit of methionine supplementation on reduced immunologic stress (Klasing, 1988; Tsiagbe et al, 1986). Immunologic stress is

considered to be a response to microbial challenges, in these experiments due to injections of E. coli and Salmonella and other pathogens. This causes decreased feed rates and lower rates of growth. Chicks that received deficient levels of methionine were more subject to an impaired immune response.

The TAP review goes on to postulate that the impaired immune response is a result of high density confinement, which if true, would not be as relevant in an organic system. However, the trials conducted by the Methionine Task Force support the findings of increased immunologic stress when methionine is withheld, even in a less densely populated organic environment.

The TAP review also notes that "reduced feathering has been reportedly linked to lack of methionine and cystine (Elliott, no date)." The TAP reviewer appropriately notes that there may be other factors involved, including the deficiencies of other amino acids. Nonetheless, it needs to be restated that organic poultry producers have eliminated all other synthetic amino acids from the feed ration. Therefore, supplying sufficient balances of the other amino acids is continually challenging, and occasionally is not achieved. Consequently, providing the birds with nutritionally appropriate levels of methionine is even more critical in organic poultry production since one of the typical solutions (supplementation with other synthetic amino acids) is not available.

The traditional signs of methionine deficiency (feather picking, cannibalization, incomplete feather development, excessive mortality) have been well documented in scientific literature. All of these symptoms raise questions about animal health and welfare in the absence of methionine.

2. Why is Synthetic Methionine Needed?

As discussed above, poultry have evolved as omnivores. They need to integrate insects and meat into their diets to meet their essential amino acid requirements. Prior to the development of synthetic methionine [hereinafter referred to as MET], diets were supplemented with meat and bone meal to provide adequate methionine. Attached are sample rations from the 1940's which indicate how farmers met the nutritional needs of the birds before the advent of synthetics.

Even today, conventional poultry diets typically include meat meal, bone meal, poultry meal, or feather meal. In addition to these slaughter by-products, other highly processed plant based feed ingredients, such as corn gluten meal, can be used to provide adequate levels of methionine.

However, these conventional alternatives are not available to organic producers. The organic regulations expressly prohibit the feeding of "mammalian or poultry slaughter by products to mammals or poultry". Fish meal will be discussed below, but presents challenges from both consumer acceptance (imparts unpleasant flavors to meat and eggs) and organic certification. Corn gluten meal will also be addressed later, but it not only is typically derived from GMO source material, the manufacturing process is not organically approved.

Interestingly, the EU organic standards prohibit the use of synthetic methionine. However, EU organic poultry farmers are currently allowed to non-organic feed ingredients for up to 10% of the diet. Corn gluten meal is typically added within the 10% exclusion in order to satisfy the bird's methionine demand. But a problem is looming for EU farmers as, by 2012, the feed will need to be 100% organic. Many EU organic producers are already realizing that this will create a virtually impossible scenario for organic poultry production in the EU. Dr. Cliff Nixey, British Poultry Council, has already put forth the contention that synthetic methionine needs to be allowed as part of the EU organic standards by 2012.

Some have argued that the bird's methionine demand can be met if more pasture is provided. In reality, the pasture alternative is not practical for several reasons. First, plants in general have relatively low levels of methionine. Providing more pasture will not address the fundamental problem (lack of animal based proteins) in the diet. Second, greater utilization of pasture <u>will</u> provide the opportunity for birds to access insects and earthworms, both viable sources of methionine. However, in a commercial poultry operation the incremental level of methionine provided from insects and worms would be minimal and insufficient to meet the basic nutritional needs of the entire flock. Third, as discussed in the TAP review, pasture is not available year round in much of the US. Even if pasture were the solution, its seasonal availability (or absence) would create significant issues for both organic producers and consumers.

3. Summary of Synthetic Methionine Levels in the Diet

Synthetic MET is added to the diet to make up for deficiencies in both methionine and cysteine. Both methionine and cysteine are sulfur containing amino acids. While poultry cannot synthesize either methionine or cysteine, birds can metabolically convert methionine into cysteine.

Feathers are very high in cysteine, which consequently reflects the importance of this amino acid in poultry. Because birds can convert methionine into cysteine, and because both are so important to the bird's development, poultry nutritionists tend to focus on the bird's combined methionine + cysteine demand.

When calculating the level of synthetic MET to be added to the diet, the nutritionist first evaluates the level of these amino acids provided by the grains in the diet. As discussed previously, grains alone cannot provide the bird with sufficient levels of these amino acids to meet the minimum standards established by the NRC. Following is an excerpt from the TAP review:

> NRC requirements for amino acids and protein are designed to support maximum growth and production. The recommended levels for methionine in poultry depend on species, stage, and level of feed consumption. For chickens, recommendations for layers range from 0.25% to 0.38% and for broilers 0.32 - 0.50%.

As part of this petition, organic poultry producers are proposing a maximum limit on MET usage at levels that are approximately half the maximum amounts recommended by the NRC. The MET limits recommended in this petition are based on the amounts needed by birds for <u>maintenance</u>, not growth enhancement or production maximization.

Table 1 below shows the amount of methionine and cysteine provided by the grains in the diet relative to the amount of synthetic MET that is added. The data in the tables below are examples of <u>starter feeds,</u> shown for illustration purposes only. The amount of MET in the diet will vary considerably depending upon a variety of factors, including breed, bird age, production level, bird health, and external environmental factors.

Table 1 – Percent of Methionine in Starter Feed Diets

SUMMARY OF METHIONINE + CYSTINE DEMAND IN POULTRY
PERCENT OF DIET

Organic Poultry Type	Bird's Total MET Demand	MET From Grains in Feed	Synthetic MET Added
Chicken - Layers	0.36%	0.26%	0.10%
Chicken - Broilers	0.51%	0.32%	0.19%
Turkey	0.59%	0.42%	0.17%
Duck	0.53%	0.34%	0.19%
Geese	0.47%	0.33%	0.14%

Organic Poultry Type	Bird's Total CYS Demand	CYS From Grains in Feed	Synthetic MET Added
Chicken - Layers	0.30%	0.30%	0.00%
Chicken - Broilers	0.42%	0.37%	0.05%
Turkey	0.48%	0.39%	0.09%
Duck	0.43%	0.36%	0.07%
Geese	0.38%	0.35%	0.03%

Organic Poultry Type	Bird's Total MET+CYS Demand	MET+CYS From Grains in Feed	Synthetic MET Added
Chicken - Layers	0.66%	0.56%	0.10%
Chicken - Broilers	0.93%	0.69%	0.24%
Turkey	1.07%	0.81%	0.26%
Duck	0.96%	0.70%	0.26%
Geese	0.85%	0.68%	0.17%

Table 2 below expresses this same data with the unit of measure being pounds per ton of feed. The amounts at the far right represent the pounds of synthetic MET that need to be added to each ton of feed.

Table 2 – Pounds of Methionine in Starter Feed Diets

SUMMARY OF METHIONINE + CYSTINE DEMAND IN POULTRY
LBS PER TON

Organic Poultry Type	Bird's Total MET Demand	MET From Grains in Feed	Synthetic MET Added
Chicken - Layers	7.20	5.20	2.00
Chicken - Broilers	10.20	6.40	3.80
Turkey	11.80	8.40	3.40
Duck	10.60	6.80	3.80
Geese	9.40	6.60	2.80

Organic Poultry Type	Bird's Total CYS Demand	CYS From Grains in Feed	Synthetic MET Added
Chicken - Layers	6.00	6.00	0.00
Chicken - Broilers	8.40	7.40	1.00
Turkey	9.60	7.80	1.80
Duck	8.60	7.20	1.40
Geese	7.60	7.00	0.60

Organic Poultry Type	Bird's Total MET+CYS Demand	MET+CYS From Grains in Feed	Synthetic MET Added
Chicken - Layers	13.20	11.20	2.00
Chicken - Broilers	18.60	13.80	4.80
Turkey	21.40	16.20	5.20
Duck	19.20	14.00	5.20
Geese	17.00	13.60	3.40

This illustration uses representative diets for each species of poultry. They are intended to be general examples as it is not practical to list all the different feed formulations for each type of bird. Typically, there is a wide array of formulations used depending upon species, breed, stage of life cycle, rate of lay (production), and external factors (e.g. weather, environment).

4. <u>History of Synthetic Methionine with the NOSB</u>

In 2001, MET was approved for use in organic poultry production for use until October 2005. Three Technical Advisory Panel reviews were conducted prior to this approval. In 2005, there was a petition to extend the deadline to October 2008. This petition was approved unanimously by both the Livestock Committee and the NOSB.

In 2007, there was a petition to remove the annotation. While this petition was unanimously vetoed by the NOSB, the NOSB did recognize the industry's work on evaluating alternatives and the importance of methionine in poultry diets. As noted in the

Federal Register (Vol. 73, No. 135/Monday, July 14, 2008/Proposed Rules):

> Thus, the NOSB concluded that synthetic Methionine remains a necessary component of a nutritionally adequate diet for organic poultry. Loss of the use of Methionine, at this time, would disrupt the well- established organic poultry market and cause substantial economic harm to organic poultry operations.

Consequently, the NOSB voted unanimously to grant a two year extension to October 1, 2010 to allow the industry time to further develop natural or organic feed alternatives to the use of MET.

5. Role of the Poultry Industry and the Methionine Task Force

Since 2001, organic poultry producers have worked to reformulate vegetarian feed rations without MET, under the belief that this goal could be achieved. For example, in conventional poultry production, synthetic lysine (the second limiting amino acid for poultry) is routinely added to the diet. And yet, organic poultry producers have been able to successfully formulate feed without lysine. However, our reformulation efforts to eliminate MET have not been successful and the organic poultry industry still remains dependant upon the addition of small quantities of synthetic MET in the diet.

As will be discussed in more detail below, the 2001 TAP Review referenced a number of potential feed ingredients that could be used in lieu of synthetic MET. Unfortunately, while some of these alternatives have more methionine content than the typical ingredients in a poultry diet, none of the alternatives are particularly rich in methionine. Therefore, reformulation with these ingredients has not yet proved successful.

University research has been conducted on alternative breeds to determine whether heritage or slower growing breeds would have a lower methionine demand than the widely used commercial breeds. However, Dr. Anne Fanatico's work at the University of Arkansas has demonstrated that heritage and slow growing breeds have the same methionine demand as commercial breeds.

At this point in time, neither the industry's feed reformulation efforts nor the breed research has resulted in viable alternative to the use of MET.

The Methionine Task Force [hereafter referred to as MTF], consists of US organic poultry producers, many of whom were raising chickens organically even prior to the national standards. The MTF has existed since the first MET petition was approved and has continuously conducted and sponsored research into alternatives to MET. The results of these efforts are discussed in this petition.

6. What is New Since the Last Petition?

MTF Trials

A number of ranch trials have been conducted to determine the feasibility raising chickens without MET. Table 3 summarizes all recent MTF trials and is followed by a brief description of each of the trials.

Table 3 – Feeding Trial Summary

Trial Location -- Sponsor	**Date**	**Bird Type**	**No of Birds**	**Diets other than Control**	**Organic Feed Used?**	**Outdoor Access Provided?**	**Conclusions / Comments**
MN --University of MN / Organic Valley	2007	Layers (Bovan Browns)	75	High Methionine Corn	Yes	No	Feed consumption comparable, but lower egg weights and production levels in HM corn group
CA – MCM Poultry	May 2008 to May 2009	Layers (Hy-Line Browns)	22,000	Diet w/o MET	No	No	Egg production 91% of Control and 65% of Normal No difference in Mortality, Egg Weights, or Feathering. No signs of cannibalism or elevated ammonia levels
MI – Herbrucks	Started March 2009	Layers	250	Raised with standard diets, MET withheld during production in one group	Yes	Yes	Trial underway, no conclusion Behavioral data will also be monitored
CA- Coleman Trial No. 1	August 2007	Broilers (Ross 708)	1,680	1) No MET 2) No MET, but included Betaine 3) No MET, but Betaine + Corn Gluten Meal	Yes	No	Significantly poorer meat yields and feed conversions than Control Comparable mortality loss
CA- Coleman Trial No. 2	October 2007	Broilers (Cobb 500)	1,680	1) No MET 2) No MET, but included Betaine 3) No MET, but Betaine + Corn Gluten Meal	Yes	No	Similar results to Coleman Trial No. 1 Significantly poorer meat yields and feed conversions than Control Comparable mortality loss
CA- Coleman Trial No. 3	April 2008	Broilers (Ross 708)	1,680	1) No MET, but included Betaine 2) No MET, but Betaine + Rovabio 3) No MET, but Betaine + Sesame Meal	Yes	No	No significant variances in performance metrics between the groups. Nutritionist noted large variances between actual feed assay results and theoretical values and stated "I have reservations on drawing any specific conclusions from this trial's data."
PA – Penn State	December 2007	Broilers (Ross 708)	648	1) No MET 2) No MET, but included Betaine 3) No MET, but Betaine + Corn Gluten Meal	Yes	No	Similar results to Coleman Trial No. 1 Significantly poorer meat yields and feed conversions than Control Comparable mortality loss
PA – Kreamer Feeds	March 2009	Heritage Breed Broilers (Pollo Rosso)	6,000	Diet w/o MET	Yes	Yes	Very informal trial. Normally these birds are raised for 10 weeks. The No MET group was raised 2 additional weeks, but still did not reach market size. Birds lacked adequate nutrition and were thin.

Layer Trial – University of MN, sponsored by Organic Valley/CROPP Cooperative
This layer trial was conducted in 2007 at the University of Minnesota, and was led by Dr. Jacquie Jacobs. The trial evaluated the performance of a control group (standard organic diet) against a diet without MET, but using high methionine corn in the place of standard organic corn. Feed consumption in both groups was comparable but lower egg weights and production levels were seen on the High Methionine (HM) corn group. The sample size used in this trial was extremely small. As discussed below, the MTF has worked with MFAI to plant HM corn in the US to conduct additional feeding trials in 2009-10.

Layer Trial – MCM Poultry
This layer trial ran for approximately one year, from May 2008 through May 2009. This was the first commercial scale trial ever attempted in which one group received a diet without any synthetic MET. In order to save cost, conventional feed was used instead of organic feed. The birds were cage free, but did not have access to the outdoors.

The egg production levels between the control group and the No MET group were fairly close, with the No MET group producing at 91% of the control. However, production in <u>both</u> groups was significantly lower than standard and in particular the No MET group only produced at 65% of standard.

Although the No MET birds were observed to be more nervous, there were no signs of cannibalism or poor feathering. Mortality, egg weights, and ammonia levels were comparable between the two groups.

Layer Trial – Herbruck's
This layer trial just started in March 2009. The trial is being conducted at a Herbruck's farm in Michigan, but is being overseen by researchers from Michigan State and Dr. Woodie Williams, professor emeritus at Clemson University. In this trial, there are two groups of birds, both of which have been raised with standard organic rations. Both groups are being provided with outdoor access. However, during the egg production cycle, one group is being fed a diet without MET. No trial results are available yet, although production and behavioral data is being collected.

Broiler Trials – Coleman Natural and Penn State University
A total of three broiler trials were conducted with identical diets. Two of the trials were in California (Coleman Trials 1 and 2) and the third was performed at Penn State University. In all three broiler trials, there were 4 feed groups:

1. Standard organic diet (control group)
2. Standard diet, but without MET
3. Standard diet, excluding MET, but including Betaine*
4. Standard diet, excluding MET, but including Betaine and Corn Gluten Meal

**Betaine is an alkaloid commonly used in poultry diets. It is a methyl donor which spares methionine in the bird. It is currently approved for use in organic production.*

In all cases, the control groups performed the best, followed by group 4 (Betaine & Corn

Gluten Meal). Field observers could readily pick out the non MET groups, particularly group 2. These birds were smaller and less developed. All of the non MET groups had unfavorable feed conversions and meat yields relative to the control group.

Broiler Trials – Coleman Natural using Sesame Meal
A broiler trial was also conducted by Coleman using:

1. Standard organic diet (control group)
2. Standard diet, excluding MET, but including Betaine
3. Standard diet, excluding MET, but including Betaine and Rovabio**
4. Standard diet, excluding MET, but including Betaine and Sesame Meal

***Rovabio is an enzyme used in poultry diets. It is currently approved for use in organic production.*

In this trial, all 4 groups had comparable feed conversions and meat yields and all were considered acceptable. However, the nutritionist reviewing the feed assays noted that there was a large variance between the actual nutritional value of the finished feeds and the theoretical values based on the ingredient profiles, suggesting some sort of error in the trial execution. Consequently, the nutritionist noted that "I have reservations on drawing any specific conclusions from this trial's data." This trial needs to be replicated to see if comparable results are achieved.

Broiler Trials – Kreamer Feeds, using Italian heritage birds
This was a very informal trial, but the birds without any MET in the diet were extremely variable with very poor feed conversion and body development. Although informal, the trial supports the findings of Dr. Anne Fanatico, whose work with other heritage breeds indicates that heritage birds have a methionine need equivalent to modern commercial breeds.

Feeding Trials – General Observations
As a general observation, the traditional signs of a methionine deficiency (e.g. feather picking, cannibalization) were not seen in any of the groups without MET. Although these findings are encouraging, it needs to be pointed out that majority of the trials consisted of small lots of birds raised in test housing. We recognize that most organic producers grow chickens in a commercial setting with a higher level of basic challenges (e.g. disease, rodents, housing quality). Chickens given low levels of methionine may perform acceptably in an ideal setting, but the same birds may exhibit the traditional signs of methionine deficiency in a commercial setting.

Health through good nutrition is the fundamental key to successful organic livestock production. MET is considered a "Maintenance Nutrient" added to organic poultry rations only in amounts necessary to achieve the basic nutritional level necessary to maintain good health and avoid disease. Unlike conventional production, there is little recourse available to a producer once disease manifests. In trial settings, with optimal housing, MET deficiencies may not have tipped the balance towards disease outbreaks and corresponding performance breakdowns. But MTF members are very concerned that on the practical scale of commercial poultry production, different results may be experienced.

The higher feed conversions seen in the "no methionine" trials have other implications. Higher feed conversions mean that more organic grains need to be produced and fed. From a whole systems perspective, this does not appear to be a prudent utilization of resources and our limited organic acreage.

General Discussion of Alternatives

The Methionine Task Force has previously commissioned a Literature Review to identify the methionine needs of poultry, summarize the organic livestock standards nationally and internationally, and discuss the viability of potential alternatives. This review as conducted by Dr. Bonny Burns-Whitmore at the California State Polytechnic University in Pomona, CA. A summary of this report was previously provided to the NOSB / NOP.

The TAP review originally identified several potential feed ration alternatives. One of the important findings in this Literature Review is that while all of these alternatives carry "more" methionine than the traditional corn and soybean meal poultry diet, they do not carry "sufficient" methionine to meet the bird's methionine demand unless included at very high rates (resulting in other nutritional imbalances). A Table entitled SUMMARY OF METHIONINE SOURCES is attached for reference.

In addition, many of the alternatives cited in the TAP review are either not available in organic form, or are only available in organic form in a very small quantity (i.e. not commercially available).

Alternatives Evaluated But Not Considered Viable

A. Insect Meal / Ento Protein

This is a prototype product under development by Neptune Industries. The MTF has contacted Neptune and learned that the methionine and protein levels are very similar to soybean meal (which is readily available in organic form and is already present in all poultry diets). Additionally, the Neptune product is in the R&D phase and is not available in sufficient quantities to even run a small scale trial.

B. Peas

Peas are actually lower in methionine and cysteine than soybean meal.

C. Sesame Meal

Sesame Meal was used in one of the diets in the Coleman Broiler Trial No. 3 and as noted above, the results in this trial were inconclusive. The primary drawback with sesame meal is that it is low in lysine (lysine is the second limiting amino acid in poultry behind methionine). If sesame meal were used in the ration, producers might be able to eliminate MET but would need supplemental lysine.

Status of Most Viable Alternatives

A. Alternative Feed Ingredients

High Methionine Corn

As evidenced by the University of Minnesota / Organic Valley layer trial high methionine corn is one alternative feed ingredient with considerable promise. Much of the work to develop these hybrids has been done by Dr. Walter Goldstein of the Michael Fields Agricultural Institute (MFAI).

As Dr. Goldstein points out, and as summarized in Table 4 below:

> The floury-2 corn and the hard endosperm corn have a lot more protein, methionine, and lysine in the kernel than is expected for normal corn.

Table 4

	14 Prairie Hybrid cultivars			Methionine Hybrid W64:AR21/Oh43:BS29	
	average	Low	High	Average	% increase
Cysteine	**0.17**	**0.15**	**0.21**	**0.20**	15
Methionine	**0.18**	**0.16**	**0.22**	**0.31**	70
Lysine	**0.26**	**0.22**	**0.27**	**0.43**	69
Tryptophan	**0.06**	**0.06**	**0.07**	**0.08**	30
Total Protein	**8.1**	**7.2**	**9.6**	**12.3**	51

Based on the results from the University of Minnesota / Organic Valley trial referenced earlier, the above levels of methionine may be sufficient for laying hens. But with turkeys and broilers, even though corn is a large part of the organic poultry diet (60% or more), this higher level of methionine alone is not sufficient to eliminate the need to use synthetic MET.

Nonetheless, because of the promise that high methionine corn, the MTF has worked with MFAI to support seed trials in Chile and Hawaii over the last several years. In 2009, the MTF is partnering with MFAI to raise seed corn in Indiana and feed corn in Iowa with SunOpta. In addition, an MTF member, Herbruck's, has planted high methionine organic corn in Michigan for use in a feeding trial.

A continuing obstacle to more widespread planting of high methionine corn is its poor and inconsistent yields. Per Dr. Goldstein:

> The floury-2 corn has yielded almost exactly 1/3rd less than checks and the hard endosperm high methionine corn has yielded on average 1/4th less. For the hard methionine corn the average may be closer to 1/5th less if it is planted in areas to which it is adapted on time. Both kinds of cultivars did just as well in WI, IA, and MN, but in 2008 they did relatively worse at a later June planting in MN, and poorly in Ohio.

Table 5 – High Methionine Corn Crop Yields
Yearly average for yields of hybrid checks and high methionine corn

	floury-2 trials				**hard endosperm methionine**			
Year	**no. of sites**	**Checks**	**floury-2 hybrids**	**yld rel to check**	**no. of sites**	**Checks**	**hard kernel methionine**	**yld rel to check**
		-------bu/acre-----		%		-------bu/acre-----		%
2008	1	161	88	55	5	150	108	72
2007	3	147	97	66	3	165	130	79
2006	2	125	110	88				
2005	9	129	80	62				
yearly average		**141**	**94**	**67**		**158**	**119**	**76**
site average		**134**	**88**	**66**		**156**	**116**	**75**

The floury-2 (soft endosperm) hybrids tend to carry higher levels of methionine, but also have generally poor yields. On a floury-2 planting in Pennsylvania in 2008, Kreamer Feeds (an MTF member) reported receiving only 50 bushels per acre. Farmers understandably want a price premium that compensates them for the yield loss. Unfortunately, given the magnitude of the yield loss, the price premium required becomes exorbitant.

The hard endosperm corn tends to have better agronomic performance with less yield drag. Unfortunately, the methionine levels are not as consistent as the floury-2. Dr. Goldstein has recently done some work with a soft endosperm opaque that shows promise as having the methionine consistency of the floury-2 with the better crop yields found in the hard endosperm.

Insufficient corn has been available for the MTF to conduct any additional feed trials since the Organic Valley layer trial. Development of high methionine corn on a commercial scale will require the following:

- Improved agronomics, including more consistent methionine levels and yields equivalent to standard organic hybrids. It is hoped that Dr. Goldstein's continued research with the soft endosperm opaque varieties can work to close the yield gap.
- Verification, through replicated poultry feeding trials, that the methionine content is sufficient to meet the needs of all poultry. Feeding trials should also consider the effectiveness of high methionine corn when used in conjunction with other feed ration additives (e.g. Betaine), which serves to spare some of the bird's methionine demand.
- Significant additional time to conduct farming and feeding experimentation. It is believed that commercial scale implementation is at least five years away.

Corn Gluten Meal

As referenced earlier, the best performance in the broiler trials resulted when corn gluten meal was included in the feed ration. In Dr. Bonny Burns-Whitmore's report, several feed producers indicate that organic corn gluten meal is available. ***However, no member of the Task Force has ever been able to source this product in organic form.*** As the MTF understands it, the problem is two fold:

- **Process**
  As noted in the TAP Review, the corn gluten meal manufacturing process appears to be inherently in conflict with organic principles. Unless an alternative processing technology were to be used, the manufacturing process is unlikely to meet the organic criteria. For example, sulphurous acid is used in the fermentation and steeping process. The current production standards and technologies will have to change to resolve this issue.
- **Inputs**
  The current corn gluten plants are all "conventional" operations which do not segregate their input sources (organic vs. non-organic). The plants are large and require huge input volumes to maintain their productivity. No current plant in the US is appropriately sized or economically incented to segregate out organic inputs.

MTF members have heard rumors that there may be some interest in developing organic processing materials (e.g. high fructose corn syrup) which in turn might lead to the production of organic corn gluten meal (as a by-product).

Fish Meal

As noted in the TAP Review, fish meal has potential as a methionine source. But as with Corn Gluten Meal, there are several issues:

- **Process**
  As noted in the TAP Review, most forms of fish meal contain ethoxyquine, which is not permitted under the final organic rules.
- **Inputs**
  At present, there is no defined standard for organic aquaculture. Consequently, the poultry industry could, at best, only use conventional sources of raw material for fish meal, which would not meet the 100% organic feed requirement for organic livestock.
- **Sensory**
  Fish meal can impart undesirable taste to poultry and eggs. Care needs to be taken to balance taste and flavor issues against the amount needed in the diet to provide adequate methionine to the bird.

Alfalfa Nutrient Concentrate

A product is currently under development by Vitalfa, LLC that is an alfalfa nutrient concentrate. To date, all of the feeding trial work that has been done with this product has been with a balanced diet in which MET is already a component. No work has been done to formulate a diet and run field trials without MET and using the alfalfa nutrient concentrate. While the task force is working with the vendor to implement some trials, this alternative still has some issues that need to be resolved:

- **Amino Acid Imbalance**
  While the concentrate is relatively high in methionine, it is low in cysteine. As noted previously, MET is included in the diet to offset a deficiency of both methionine and cysteine. The alfalfa concentrate has a methionine + cysteine profile that is similar to soybean meal, which is already part of the poultry diet.
- **Not Organic**
  Although the vendor is working diligently to correct this, at present the product is not

available in organic form.

B. Naturally Produced MET

The MTF is most intrigued by the development of methionine produced naturally through fermentation methods. From the perspective of organic poultry producers, this represents the most effective and likely economically viable alternative. Consequently, the MTF has embarked on a one year project with Dr. Steve Ricke, Food Safety Endowed Chair and Director of the Center for Food Safety, University of Arkansas. The project is entitled "Screening and Identification of Natural Microbial Sources for Methionine Production for Organic Poultry Feed". A detailed summary of the project is attached to this petition, but in general terms, the research has two primary objectives.

1. Isolation of naturally occurring methionine feedback insensitive bacterial strains from natural sources to identify efficient methionine producing bacteria.
2. Optimization of bacterial growth media for the industrial production of natural methionine.

Dr. Ricke has developed a three stage research plan with the ultimate goal of developing a method to produce methionine naturally.

In addition, the MTF continues to take inquiries from private firms who believe that development of this product is possible. The MTF will continue to work with any and all parties on developing such a product.

7. <u>Conclusion</u>

Methionine is an essential amino acid in poultry. Since birds cannot synthesize methionine on their own, it must be included in their diet in nutritionally sufficient quantities. Since organic poultry are required to have a vegetarian diet, birds are not able to satisfy their requirement demands from meat sources (which carry substantially higher levels of methionine). Without supplemental methionine and a nutritionally balanced diet, bird health and growth performance suffer.

The current temporary allowance for the use of synthetic methionine expires on October 1, 2010. As demonstrated in this petition, organic poultry producers are not currently able to eliminate MET from organic poultry rations. Although the MTF has identified several viable alternatives to MET through its research efforts, none of them are currently commercially available.

The ongoing cycle of annotations and petitions every 2-3 years has become problematic for the NOSB, the NOP, and organic poultry farmers. **The Methionine Task Force is requesting a five year extension of the current temporary allowance for the use of 100% synthetic methionine in organic poultry production, with a concurrent limit on maximum usage as follows (expressed as average lbs per ton of feed):**

Laying chickens	**4 pounds**
Broiler chickens	**5 pounds**
Turkey and all other poultry	**6 pounds**

Under this recommendation, producers would be able to exceed the above maximum levels on a particular formulation, provided that there was an offsetting formulation below the maximum level, such that the **average** inclusion rate of 100% synthetic methionine over the entire life cycle of the bird was below the recommended maximum level.

The maximum pounds as shown above is based on the 100% synthetic methionine equivalent so that a consistent standard can be applied to all organic operations, irrespective of the form of MET they are using (e.g. wet vs. dry).

Commercial Confidential Information Statement - describing information that is considered to be confidential business or commercial information:

- *None of the information submitted in this report is considered confidential.*

LIST OF ATTACHMENTS AND STATUS

Current as of July 31, 2009

- **Methionine Task Force Members** –*attached*
- **MSDS Sheet for DL Methionine** –*attached*
- **Screening and Identification of Natural Microbial Sources for Methionine Production for Organic Poultry Feed**–*attached*
- **Poultry Diets from the 1940's** –*attached*
- **Summary of Methionine Sources** –*attached*
- **A Review of Recent Scientific Research of Methionine** – *not attached but provided with prior petition*

Methionine Task Force Members

Company Name	***Representatives***
Eberly Poultry	Bob Eberly
Kreamer Feed	Bob Schwartz
	Steve Smelter
	Billy Robinson
Heritage Poultry	Chris Pierce
	Mel Gehman
Organic Valley / CROPP Cooperative	David Bruce
Chino Valley Ranchers / MCM Poultry	David Will
	Steve Nichols
Free Bird Chicken / Hain Celestial	Joe DePippo
Organics Unlimited	Ken Rice
Foster Farms	Dr. Alfonso Mireles
	Shivi Rao
Coleman Natural Foods	Dave Martinelli
	Mike Leventini
Hidden Villa Ranch	Mike Sencer
Pete and Gerry's Organic Eggs	Jesse Laflamme
Herbruck's	Greg Herbruck
SonCrest Eggs	Randy Boone
Delta Egg Farm	Sherman Miller
Nature Pure, LLC	Kurt Lausecker
Centurion Poultry	Gijs Schimmel

Material Safety Data Sheet (MSDS) for DL Methionine

SIGMA-ALDRICH

Material Safety Data Sheet

Date Printed: 03/AUG/2005
Date Updated: 16/MAR/2004
Version 1.1
According to 91/155/EEC

1 - Product and Company Information

Product Name	DL-METHIONINE
Product Number	M9500
Company	Sigma-Aldrich Pty. Ltd. 12 Anella Avenue Castle Hill NSW 2154
Technical Phone #	+61 2 9841 0555 (1800 800 097)
Fax	+61 2 9841 0500 (1800 800 096)
Emergency Phone #	+44 8701906777 (1800 448 465)

2 - Composition/Information on Ingredients

Product Name	CAS #	EC no	Annex I Index Number
DL-METHIONINE	59-51-8	200-432-1	None

Formula	$C_5H_{11}NO_2S$
Molecular Weight	149.21 AMU
Synonyms	Acimetion * alpha-Amino-gamma-methylmercaptobutyric acid * DL-2-Amino-4-(methylthio)butyric acid * Banthionine * Cynaron * Dyprin * Lactet * Lobamine * Meonine * Methilanin * (+-)-Methionine * DL-Methionine (9CI) * Metione * Mertionin * Neston * Racemethionine

3 - Hazards Identification

SPECIAL INDICATION OF HAZARDS TO HUMANS AND THE ENVIRONMENT
Not hazardous according to Directive 67/548/EEC.

4 - First Aid Measures

AFTER INHALATION
If inhaled, remove to fresh air. If breathing becomes difficult, call a physician.

AFTER SKIN CONTACT
In case of contact, immediately wash skin with soap and copious amounts of water.

AFTER EYE CONTACT
In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.

AFTER INGESTION
If swallowed, wash out mouth with water provided person is conscious. Call a physician.

5 - Fire Fighting Measures

EXTINGUISHING MEDIA
Suitable: Water spray. Carbon dioxide, dry chemical powder, or appropriate foam.

SPECIAL RISKS
Specific Hazard(s): Emits toxic fumes under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIREFIGHTERS
Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.

6 - Accidental Release Measures

PROCEDURE(S) OF PERSONAL PRECAUTION(S)
Exercise appropriate precautions to minimize direct contact with skin or eyes and prevent inhalation of dust.

METHODS FOR CLEANING UP
Sweep up, place in a bag and hold for waste disposal. Avoid raising dust. Ventilate area and wash spill site after material pickup is complete.

7 - Handling and Storage

HANDLING
Directions for Safe Handling: Avoid inhalation. Avoid contact with eyes, skin, and clothing. Avoid prolonged or repeated exposure.

STORAGE
Conditions of Storage: Keep tightly closed.

8 - Exposure Controls / Personal Protection

ENGINEERING CONTROLS
Safety shower and eye bath. Mechanical exhaust required.

GENERAL HYGIENE MEASURES
Wash thoroughly after handling.

PERSONAL PROTECTIVE EQUIPMENT
Respiratory Protection: Wear dust mask.
Hand Protection: Protective gloves.
Eye Protection: Chemical safety goggles.

9 - Physical and Chemical Properties

Appearance — Physical State: Solid
Color: White
Form: Powder

Property	Value	At Temperature or Pressure
pH	N/A	
BP/BP Range	186 °C	
MP/MP Range	280 °C	
Flash Point	N/A	
Flammability	N/A	
Autoignition Temp	N/A	

Oxidizing Properties	N/A
Explosive Properties	N/A
Explosion Limits	N/A
Vapor Pressure	N/A
SG/Density	1.34 g/cm3
Partition Coefficient	N/A
Viscosity	N/A
Vapor Density	N/A
Saturated Vapor Conc.	N/A
Evaporation Rate	N/A
Bulk Density	N/A
Decomposition Temp.	N/A
Solvent Content	N/A
Water Content	N/A
Surface Tension	N/A
Conductivity	N/A
Miscellaneous Data	N/A
Solubility	Solubility in Water:soluble

10 - Stability and Reactivity

STABILITY
Stable: Stable.
Materials to Avoid: Strong oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous Decomposition Products: Carbon monoxide, Carbon dioxide, Nitrogen oxides, Sulfur oxides.

HAZARDOUS POLYMERIZATION
Hazardous Polymerization: Will not occur

11 - Toxicological Information

RTECS NUMBER: PD0456000

SIGNS AND SYMPTOMS OF EXPOSURE
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

ROUTE OF EXPOSURE
Skin Contact: May cause skin irritation.
Skin Absorption: May be harmful if absorbed through the skin.
Eye Contact: May cause eye irritation.
Inhalation: May be harmful if inhaled. Material may be irritating to mucous membranes and upper respiratory tract.
Ingestion: May be harmful if swallowed.

CHRONIC EXPOSURE - REPRODUCTIVE HAZARD

Species: Rat Rat
Dose: 40 GM/KG 40 GM/KG
Route of Application: Oral Oral
Exposure Time: (1-20D PREG) (1-20D PREG)
Result: Effects on Fertility: Other measures of fertility Effects on Embryo or Fetus: Extra embryonic structures (e.g., placenta, umbilical cord). Effects on Embryo or Fetus: Fetotoxicity (except death, e.g., stunted fetus). Effects on Fertility: Other measures of fertility Effects on Embryo or Fetus: Extra embryonic structures (e.g., placenta, umbilical cord). Effects on Embryo or Fetus: Fetotoxicity (except death, e.g., stunted fetus).

12 - Ecological Information

No data available.

13 - Disposal Considerations

SUBSTANCE DISPOSAL

Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber. Observe all federal, state, and local environmental regulations.

14 - Transport Information

RID/ADR

Non-hazardous for road transport.

IMDG

Non-hazardous for sea transport.

IATA

Non-hazardous for air transport.

15 - Regulatory Information

Not hazardous according to Directive 67/548/EEC.

COUNTRY SPECIFIC INFORMATION

Germany

WGK: 1

16 - Other Information

WARRANTY

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Inc., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

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Cover Sheet

Methionine Task Force
Coleman Natural Foods
PO Box 7368
Petaluma, CA 94955-7368

Screening and Identification of Natural Microbial Sources for Methionine Production for Organic Poultry Feed

Principal Investigators

Steven C. Ricke
Center of Excellence for Poultry Science and Department of Food Science
University of Arkansas, Fayetteville, AR 72701
Telephone: (479)575-4678
Fax: (479)575-6936
Email: sricke@uark.edu

Arunachalam Muthaiyan
Department of Food Science
University of Arkansas, Fayetteville, AR 72704
Telephone: (479)575-7110
Fax: (479)575-3941
Email: amuthai@uark.edu

Jody Lingbeck
Department of Food Science
University of Arkansas, Fayetteville, AR 72704
Telephone: (479)575-3481
Fax: (479)575-3941
Email: jlingbec@uark.edu

Title

**Screening and Identification of Natural Microbial Sources for Methionine Production
for Organic Poultry Feed**

Investigators

Steven C. Ricke
Center of Excellence for Poultry Science and Department of Food Science, University of Arkansas
Fayetteville, AR 72701
Telephone: (479)575-4678
Fax: (479)-575-6936
Email: sricke@uark.edu

Arunachalam Muthaiyan
Department of Food Science
University of Arkansas,
Fayetteville, AR 72704
Telephone: (479)575-7110
Fax: (479)575-3941
Email: amuthai@uark.edu

Jody Lingbeck
Department of Food Science
University of Arkansas,
Fayetteville, AR 72704
Telephone: (479)575-3481
Fax: (479)575-3941
Email: jlingbec@uark.edu

Overall Research Objectives

1. Isolation of naturally occurring methionine feedback insensitive bacterial strains from natural sources to identify efficient methionine producing bacteria.
2. Optimization of bacterial growth media for the industrial production of natural methionine.

Research Project Timeline

Phase 1: Development and optimization of a selective medium for isolating methionine overproducing microbes

Phase 2: Isolation of methionine overproducing microbes from environmental sources

Phase 3: Characterization of isolated microbial methionine overproducers and quantifying methionine production.

Research Task	Project Period (in months)											
	1	2	3	4	5	6	7	8	9	10	11	12
Phase1						Report - I						
Phase 2									Report - II			
Phase 3												Final Report

Importance of the Proposed Project

Methionine

Methionine is a nutritionally essential amino acid required in the diet of humans and livestock, including poultry. The term “essential amino acid” means that it cannot be synthesized from other amino acids or that it is synthesized in amounts too small to maintain sufficient protein synthesize in the body. Among the proteinogenic amino acids, methionine displays many essential direct and indirect functions in cellular metabolism. Methionine plays a number of important roles in biosynthetic processes in human, animals, and birds.

Methionine and Poultry Feed

All animals utilize two sources of protein, exogenous proteins (ingested from the diet), and endogenous or recycled body proteins (Hesse and Hoefgen, 2003). Methionine is an essential amino acid and must be supplemented in the diet for normal growth and function of the body. In order for an animal to form a protein, all amino acid amounts must be present in a certain ratio or amount. If one of the amino acids essential for building a protein absent, the protein may not be formed. Generally methionine is the limiting amino acid in the poultry feed. Methionine deficiency has been linked to development of various diseases and physiological conditions in human and animals. Deficiencies can be overcome by supplementing the diet with methionine and is extensively used in the poultry and feedstock industry (Tabor et al., 1958; Campbell, 2001). Larger amounts of DL-methionine are used to improve the nutritional value of animal feed. Currently, methionine is produced either by chemical synthesis or by hydrolyzing protein. These processes are expensive. Chemical production of the racemic mixture (DL- Methionine) is undesirable as it requires hazardous chemicals such as acrolein, methyl mercaptan, ammonia and cyanide (Fong et al., 1981).

Microbial Sources for Naturally Fermented Methionine

Chemical synthesis of methionine is considered to be more economical, but microbial production of methionine has the advantage that the products are biologically active L-stereoisomers. Biologically active methionine can be produced either by enzymatic synthesis (bioconversion of precursors), or by submerged fermentation using microorganisms. A number of microorganisms capable of producing amino acids have been isolated and the production of amino acids has become an important aspect of industrial microbiology. Amino acids such as lysine, threonine, isoleucine, and histidine have been produced successfully by fermentation. Attempts have been made to overproduce biologically active L-methionine using microbial fermentation, but no methionine fermentation has been commercialized. This is due to the highly branched pathway with complicated metabolic controls in methionine biosynthesis. However, under precisely controlled culture conditions ***with proper strain selection it is possible to achieve production of methionine***. To successfully establish a commercially viable process for microbial production of methionine, an efficient organism must be isolated. We strongly believe that ***it would be possible to select microorganisms having comparatively simple regulatory mechanisms for producing methionine***.

Justification and Approach

Obstacle for Finding Highly Methionine Producing Bacteria

All microorganisms have mechanisms for regulating the quantities and types of enzymes so that only the needed amount of amino acids is synthesized. This regulatory mechanism must be inactivated or otherwise modulated to ensure the production of a target amino acid in large amounts. The biggest problem with large-scale production of L-Methionine in microbes is that L-Methionine creates a feedback inhibition. This means that large quantities of L-Methionine production stops production of the L-Methionine through a feedback loop (Fig 1).

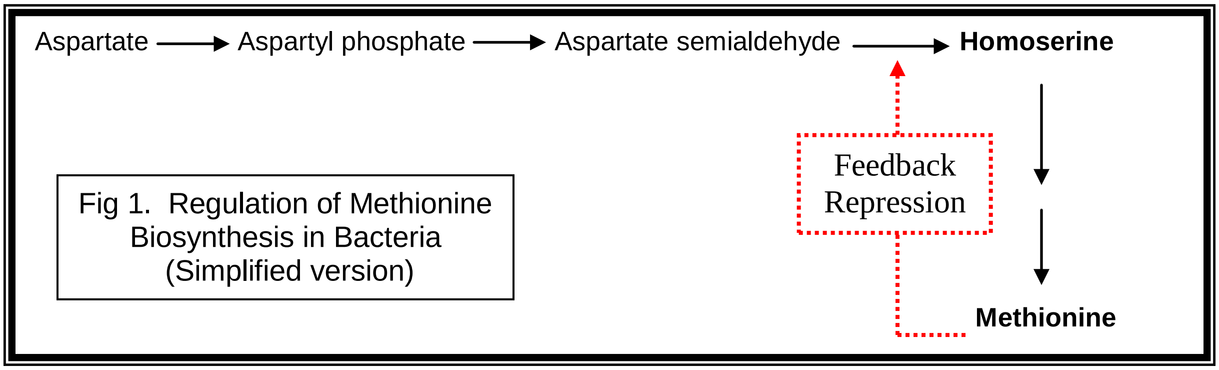

Fig 1. Regulation of Methionine Biosynthesis in Bacteria (Simplified version)

Strategy to Identify Efficient Methionine Producing Bacteria

Success of fermentation processes depends on the potential of the producing strain. Methionine analogues can effectively function as true feedback inhibitors without participating in other functions in the cells. Wild strains resistant to methionine analogues have altered and deregulated enzymes that are not sensitive to feedback inhibition and repression. Such strains in the absence of analogues can synthesize methionine in excess and eventually excrete it into the fermentation broth (Fig 2).

In addition, lysine and threonine dual auxotrophs with resistance to methionine analogues will overproduce methionine because in such strains there will be neither undesirable inhibition of aspartate kinase and homoserinedhydrogenase by lysine and threonine, nor a wastage of carbon for the production of these metabolites.

Rowbury (1965) reported that resistance to norleucine (analogue of methionine) in a microorganism is associated with a failure of methionine to repress any of the methionine biosynthetic enzymes by feedback effect. Based on this concept, various methionine analogues (ethionine, norleucine, seleno-methionine) will be used to screen the methionine overproducing wild bacterial strains from various natural sources. This is an efficient and robust method for the identification of commercially important methionine producing bacterial strains. During the screening process methionine producing *Corynebacterium glutamicum,* and *Escherichia coli (*Kromer et al. 2006) strains will be used as positive controls to standardize the screening procedure.

Mechanism behind the overproduction of methionine in naturally occurring methionine analogue resistant bacterial strains

The major cause of inhibition appears to be that the methionine analogues mimic the way the methionine regulates its own production. Thus analogues may bind to the product site of the enzyme or may bind effectively to the repressor and consequently shutdown the pathway for the synthesis of the methionine. Analogues inhibit growth by starving the cell of the methionine. Therefore, methionine analogues act as pseudo-feedback inhibitors or repressors, thereby inhibiting or repressing the synthesis of the methionine. Only strains having resistance to analogues may overproduce methionine (Fig 2). These strains are able to resist the analogues either because of an alteration in the structure of the enzyme or an alteration in the enzyme formation system. These methionine analogue resistant strains are naturally insensitive to methionine accumulation and therefore they will overproduce the methionine and excrete in the fermentation broth.

Media composition and culture conditions

Success of an industrial fermentation depends greatly on careful selection of the nutrient medium (Mondal et al. 1996). Media must contain all the requisite components in appropriate concentrations. Media composition has a profound influence on microbial physiology and the ability to maximally produce a product is often associated with particular physiological forms. Carbon sources, nitrogen sources, and their ratio in fermentation media play a significant role in the production of particular metabolites. Use of organic nitrogen sources is not advisable because they typically contain many amino acids (including methionine) and if a microorganism is provided with methionine in the medium it will not produce this amino acid. Selecting the optimal media for the over production of methionine from the efficient strain is the second objective of this proposed project.

Recovery of methionine

An inexpensive downstream recovery process that is capable of achieving the requisite recovery yield and purity is essential for producing any metabolite. There is possible usage of prebiotics as an absorbent material that can be directly added to the poultry feed.

In Summary

- The essential sulfur-containing amino acid methionine is one of the most important industrial amino acids.
- Worldwide annual production of synthetic methionine is about 500,000 tons.
- Methionine is the most limiting amino acid in usual poultry feed.
- Methionine is almost exclusively applied as a (DL) racemate produced by chemical synthesis.
- There is a large interest to replace the existing chemical production by a biotechnological process. This is due to the fact that, at lower levels of supplementation, L-methionine is a better source of sulfur amino acids than D-methionine. Moreover, the chemical process uses rather hazardous chemicals and produces substantial waste streams. This could be avoided by developing a sustainable biotechnological process.
- No industrially competitive methionine over-producing organism has been discovered so far.
- The goal of this proposal is to isolate naturally occurring methionine feedback insensitive bacterial strains and optimize the growth media to identify efficient methionine producing bacteria for the industrial production of natural methionine.

References

Hesse, H., and R. Hoefgen. 2003. Molecular aspects of methionine biosynthesis. Trends Plant Sci. 8: 259 – 262.

Tabor, H., S.M. Rosenthal, and C.W. Tabor. 1958. Biosynthesis of spermidine and spermine from putrescine and methionine. J. Boil. Chem. 233: 907-917.

Campbell, K.C.M. 2001. Therapeutic use of D-methionine to reduce the toxicity of platinum-containing anti-tumor compounds and other compounds, US patent 617817.

Fong, C.V., G.R. Goldgraben, J. Konz, P. Walker, and N.S. Zank. 1981. Condensation process for DL-methionine production. In: Goldfrab, A.S. (Ed.) organic chemicals manufacturing hazards. Ann Arbor: Ann Arbor Science Publishers. P. 115 – 194.

Rowbury, R.J. 1965. Resistance to norleucine and control of methionine synthesis in *Escherichia coli.* Nature 206: 962-963.

Kromer, J.O., C. wittmann, H. Schroder, and E. Heinzle. 2006. Metabolic pathway analysis for rational design of L-methionine production by *Escherichia coli* and *Corynebacterium glutamicum*. Metabol. Engineering 8:353-369.

Mondal, S., Y.B. Das, and S.P. Chatterjee. 1996. Methionine production by microorganisms. Folia Microbiol. 41: 465-472.

Poultry Diets from the 1940's

		Weaning to 50 lbs.	50 to 75 lbs.	75 to 125 lbs.	125 to 175 lbs.	Over 175 lbs.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
4.	Barley	79	86	92	99	99
	Tankage, meat scraps, or fish meal	8	6	3.5	..	..
	Linseed meal	13	8	3.5	..	..
	Bone meal	..	..	0.6	0.6	0.6
	Ground limestone	..	..	0.4	0.4	0.4
	Total	100	100	100	100	100
5.	Grain sorghum	78	83	91	95	96
	Tankage, meat scraps, or fish meal	8	6	4	..	..
	Soybean oil meal	14	11	5	4	3
	Bone meal	..	..	..	0.6	0.6
	Ground limestone	..	..	..	0.4	0.4
	Total	100	100	100	100	100

POULTRY*

Laying hens and laying pullets

In addition to the mash and scratch grain in these rations, oyster shell or another source of calcium should be available at all times in hoppers. Plenty of fresh water should also be furnished. Cod-liver oil or other suitable vitamin-rich fish oil should be added to the mash when the hens are confined. To insure an ample supply of manganese, 0.25 lb. of manganese sulfate should be added to each ton of mash.

A. Laying mashes with which an equal weight of grain is to be fed

1. Ground yellow corn, 20 lbs.; ground heavy oats, 12.5 lbs.; wheat bran, 20 lbs.; wheat flour middlings, 20 lbs.; dried skimmilk or buttermilk, 2.5 lbs.; meat scraps, 17.5 lbs.; alfalfa meal (low fiber), 5 lbs.; ground limestone or oyster shell flour, 2 lbs.; salt, 0.5 lb. Add 0.4 lb. vitamin A and D feeding oil when hens are not on range.

2. Ground yellow corn, 25 lbs.; ground oats, 10 lbs.; wheat standard middlings, 10 lbs.; soybean oil meal, 24 lbs.; peanut oil meal or other suitable plant-protein supplement, 5 lbs.; meat scraps, 4 lbs.; alfalfa meal, 9 lbs.; distillers' dried solubles, 2 lbs.; ground limestone, 5.5 lbs.; bone meal, 3.5 lbs.; salt, 1.6 lbs.; vitamin A and D feeding oil, 0.4 lb.

3. Ground barley, 30 lbs.; ground wheat, 12 lbs.; soybean oil meal, 20 lbs.; corn gluten meal or soybean oil meal, 7.5 lbs.; peanut oil meal or other suitable plant-protein supplement, 4 lbs.; meat scraps, 3.5 lbs.; dried whey, 2 lbs.; alfalfa meal, 10 lbs.; ground limestone, 5.5 lbs.; bone meal, 3.5 lbs.; salt, 1.6 lbs.; vitamin A and D feeding oil, 0.4 lb.

4. Ground grain sorghum, 30 lbs.; ground barley, 13 lbs.; soybean oil meal, 22.5 lbs.; peanut oil meal or other suitable plant-protein supplement, 7.5 lbs.; meat scraps, 4 lbs.; alfalfa meal, 10 lbs.; distillers' dried solubles, 2 lbs.; ground limestone, 5.5 lbs.; bone meal, 3.5 lbs.; salt, 1.6 lbs.; vitamin A and D feeding oil, 0.4 lb.

5. For hens on good pasture: ground yellow corn, 100 lbs.; ground oats, 100 lbs.; wheat bran, 100 lbs.; wheat middlings, 100 lbs.; meat scraps, 100 lbs.; salt, 5 lbs.

*Unless otherwise indicated, these rations are chiefly from: Titus, Hammond, Whitson, and Bird, U. S. Dept. Agr., Special Cir., Dec., 1946; Heuser, Feeding Poultry, 1946.

B. Grain mixtures to be fed with laying mash

Almost any mixture of grain that does not contain too large a proportion of oats is suitable. Popular combinations are:

1. Equal weights of yellow corn (cracked or whole) and wheat.
2. Yellow corn, 40 lbs.; wheat, 40 lbs.; oats, 20 lbs.
3. Grain sorghum, 30 to 50 lbs.; yellow corn, 25 to 40 lbs.; wheat, 20 lbs.

C. All-mash rations for laying hens and laying pullets

1. Ground yellow corn, 50.5 lbs.; wheat bran, 10 lbs.; wheat flour middlings, 20 lbs.; meat scraps, 7.5 lbs.; dried skimmilk, 2.5 lbs.; alfalfa meal, 5 lbs.; salt, 0.5 lb.; oyster shell meal or ground limestone, 3 lbs.; cod-liver oil, 1.0 lb.
2. Ground yellow corn, 42.5 lbs.; ground oats, 10 lbs.; wheat standard middlings, 15 lbs.; wheat bran, 5 lbs.; soybean oil meal, 12 lbs.; peanut oil meal or other suitable plant-protein supplement, 3 lbs.; meat scraps, 2 lbs.; alfalfa meal, 4 lbs.; ground limestone, 3 lbs.; bone meal, 2.5 lbs.; salt, 0.8 lb.; vitamin A and D feeding oil, 0.2 lb.
3. Ground barley, 30 lbs.; ground wheat, 36.5 lbs.; soybean oil meal, 12 lbs.; corn gluten meal or soybean oil meal, 4 lbs.; peanut oil meal or other suitable plant-protein supplement, 3 lbs.; meat scraps, 2 lbs.; alfalfa meal, 6 lbs.; ground limestone, 2.5 lbs.; bone meal, 3 lbs.; salt, 0.8 lb.; vitamin A and D feeding oil, 0.2 lb.
4. Ground grain sorghum, 40 lbs.; ground barley, 28 lbs.; soybean oil meal, 12.5 lbs.; peanut meal or other suitable plant-protein supplement, 5 lbs.; meat scraps, 2 lbs.; alfalfa meal, 6 lbs.; ground limestone, 2.5 lbs.; bone meal, 3 lbs.; salt, 0.8 lb.; vitamin A and D feeding oil, 0.2 lb.

D. Mashes for breeding hens

For hens producing eggs for hatching, the same sort of mashes are satisfactory, except that a mash to be fed with grain should contain at least 7 to 9 per cent of protein supplements of animal origin (including meat scraps, fish meal, and dried dairy by-products). Also, the content of riboflavin should be increased. (1409)

Chicks and growing chickens

A. All-mash chick starters

1. Ground yellow corn, 20 lbs.; ground wheat, 32 lbs.; soybean oil meal, 21 lbs.; other suitable plant-protein supplement, 10 lbs.; dried skimmilk or buttermilk, 5 lbs.; alfalfa meal, 7.7 lbs.; bone meal, 2 lbs.; ground limestone or oyster shell, 1.2 lbs.; salt, 1 lb.; vitamin A and D feeding oil, 0.1 lb.
2. Ground barley or grain sorghum, 42 lbs.; ground wheat, 10 lbs.; soybean oil meal, 21 lbs.; other suitable plant-protein supplement, 10 lbs.; meat scraps, 2.5 lbs.; dried whey, 5 lbs.; alfalfa meal, 6 lbs.; bone meal, 1.1 lbs.; ground limestone or oyster shell, 1.3 lbs.; salt, 1 lb.; vitamin A and D feeding oil, 0.1 lb.
3. Ground yellow corn, 42 lbs.; ground oats or wheat middlings, 10 lbs.; soybean oil meal, 24 lbs.; other suitable plant-protein supplement, 10 lbs.; fish meal, 2 lbs.; dried whey, 5 lbs.; distillers' dried solubles, 2.7 lbs.; bone meal, 2 lbs.; ground limestone or oyster shell, 1.2 lbs.; salt, 1 lb.; vitamin A and D feeding oil, 0.1 lb.
4. Ground wheat, 52 lbs.; soybean oil meal, 21 lbs.; other suitable plant-protein supplement, 10 lbs.; meat scraps, 3 lbs.; alfalfa meal, 8 lbs.; distillers' dried solubles, 2.6 lbs.; bone meal, 1 lb.; ground limestone or oyster shell, 1.3 lbs.; salt, 1 lb.; vitamin A and D feeding oil, 0.1 lb.

SUMMARY OF METHIONINE SOURCES

Alternative	Approx. Methionine %	Synthetic	Natural	Organic	Commercially Available	Other Comment
Dl Methionine	99.00	Yes				Included as 0.001
Corn	0.18			Yes	Yes	*Currently in Poul*
Hi Methionine Corn	0.36			Yes	No	In R&D Phase
Soybean Meal	0.60			Yes	Yes	*Currently in Poul*
Sesame Meal	1.26			Yes	No	Deficient in Lysin
Sunflower Meal	0.72			Yes	No	Relatively Low M
Canola Meal	0.75			Yes	No	Relatively Low M
Alfalfa Meal	0.20			Yes	No	Very Low Methio
Corn Gluten Meal	1.50		Yes			Not available in o
Flax Meal	0.50			Yes	No	Relatively Low M
Blood Meal	1.00			No		Not allowed: Anir
Insects	Unknown				No	Pilot project unde
Earthworm Meal	1.60				No	Not being produc
Crab Meal	0.50					Not available in o
Meat Meal	0.81					Not allowed: Anir
Rice	0.22			Yes	No	Very Low Methio
Casein	2.56			Yes	No	Ratio of methioni
Milk Powder, Skim	0.79			Yes	Yes	Relatively Low M
Potato Protein	1.60		Yes		No	Not available in o
Fish Meal	1.68		Yes	??		Not available in o methionine to cys