Poultry Nutrition

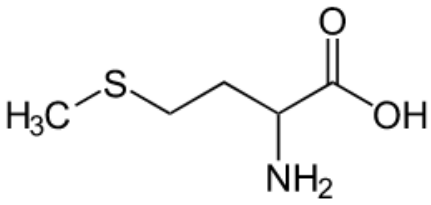
The Protein

Protein means in Greek language “first position”. Proteins are compounds composed of C (carbon), H (hydrogen), O (oxygen), N (nitrogen) and in some cases, S (sulfur). In general, protein contains an average of 16% nitrogen. Crude protein uses the term “crude” on purpose because this value reflects not only amino acids, but also anything with organic nitrogen. Protein is like "building blocks" for making animal and plant tissue. Bird's bodies are very largely composed of protein. Whenever birds are growing, or producing eggs they use up a lot of protein. This protein must be gotten in the diet.

Protein molecules composed of smaller molecules called amino acids (AAs). Amino acids are organic building blocks that combine to form proteins.

Proteins are long chains of up to 22 amino acids that have been linked together by peptide bonds. The physical and chemical characteristics of proteins are derived from their amino acid sequence and the subsequent linkages formed between the different amino acids and other compounds. There are only 22 known AAs. Just as the 26 letters of the alphabet can make billions of words, so the 22 AAs can make billion kinds of proteins (1-Glycine , 2-Alanine, 3-Serine, 4-Threonine, 5-Valine, , 6-Leucine, 7-Isoleucine, 8-Phenylalanine, 9-Tyrosine, 10-Cysteine, 11-Methionine, 12-Tryptophan, 13-Proline, 14-Hydroxy proline, 15-Aspartic acid, 16-Aspargine, 17-Glutamic acid, 18-Glutamine, 19-Arginine, 20-Histidine, 21- Lysine, 22-Citrulline). Since living organisms are extremely complex, there are literally billions of different types of protein molecules.

Amino acids are compounds that contain both an amino (-NH2) and a carboxyl (COOH) group attached to a carbon skeleton.



Methionine structure

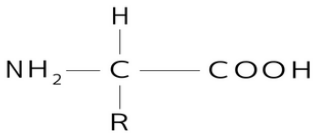


Figure 3: The general structure of amino acids

Most of the 22 amino acids can be synthesized in animals' bodies out of other foods they eat. But 10 of the amino acids cannot be synthesized by chickens, only by plants. These are famously known as the "Ten Essential Amino Acids.". These amino acids are classified as ‘indispensable’ or ‘essential’ because the birds lack one or more of the enzymes required for the biosynthesis of those carbon skeletons from non-AA materials and provision of these nutrients is mandatory through the diet.

When supply of a single amino acid does not meet the bird’s requirement, it is considered to be “limiting”. Two materials can have the same crude protein level, but have very different levels of individual amino acids. So, to fully evaluate the value of an ingredient or diet, we have to get to the level of amino acids.

Poultry will receive the essential amino acids via the diet, but ruminants may also acquire substantial amounts of these amino acids through the digestion of microbial protein synthesized in the rumen. Those amino acids which animals are able to synthesize are termed ‘dispensable’ or ‘non-essential’.

Why it's in the first position?

Proteins have special functions:

1. All molecular transformations that define cellular metabolism are mediated by protein catalysts, or enzymes.
2. It composing > 50% of total dried weight of the living cell.
3. Genetic information's are stored and transported by DNA between two generations,
4. Proteins Like “building blocks” for making muscle tissues, conducted tissues, skin, feather and chicken beak,
5. Transportation function (hemoglobin) and Transportation of fat soluble vitamins
6. As hormones
7. Functioning in immune system

Classification of proteins

Its classified due to:

- **Metabolic function** (Enzymes like Pepsin)
- **Storage** (Eggs Albumin, Ferritin {Fe storage In spleen})
- **Transporting** (hemoglobin)
- **Immune** (Antibodies)
- **Hormones** (Insulin {Sugar in the blood}, Sex hormones {Prolactin})
- **Structure** (collagen and keratin)

Amino Acids: Looking beyond Protein Levels for poultry Performance

Dietary crude protein (CP) requirements are somewhat of a misnomer as the requirement is based on the amino acids content of the protein. Once digested and absorbed, amino acids are used as the building blocks of structural proteins, metabolic proteins, enzymes, and precursors of several body components. Because body proteins are constantly being synthesized and degraded, an adequate amino acid supply is critical to support growth or egg production.

Essential amino acids must be supplied by the diet, and a sufficient amount of non-essential amino acids must also be supplied to prevent the conversion of essential amino acids into non-essential amino acid. Additionally, if the amino acids supplied are not in the proper, or ideal, ratio in relation to the needs of the bird, then essential AAs will be used as a source of energy rather than towards body protein synthesis. This breakdown of amino acids will also result in higher nitrogenous excretions. As for other animals, adequate intakes of dietary AAs are crucial for the optimum efficiency of poultry production. Either an excess or a deficiency of AAs has negative impacts on the health and productivity of chickens.

A soy meal has a certain protein level, or a complete fish diet has been formulated to contain a certain protein percentage, and so on. This is all appropriate to do, but sometimes this creates confusion because birds don’t need protein – it is the amino acids that make up proteins which are actually required. Without adequate amounts of these amino acids, it would not be possible to maintain muscle mass, create hormones that perform numerous functions, secrete enzymes that allow digestion, or repair muscle.

Essential AAs for poultry

They are 10 essential AAs, which are:

Isoleucine, Leucien, Phenyl alanine, Valine, Methionine, Threonine, tryptophan, Lysine, Arginine and cysteine.

Non-essential AAs are:

There are 9 non-essential AAs, which are:

Alanine, Aspartate, Glutamine, Aspartic acid, Hydroxy proline, Glutamic acid, glycine, serine, proline.

Non-essential under certain condition

Tyrosine, cysteine, hydroxyl lysine

Tyrosine can be synthesized by the bird by using of the phenylalanine, and cystine from the methionine, and hydroxylisine from the lysine.

Different kinds of plants supply different amounts of these Essential Amino Acids. The beauty of nature is that the two major plant groups, the *grains* and the *beans*, complement each other beautifully in the amounts of different essential amino acids they supply. Together, grains and beans make "complete protein." A food source protein is called a "complete protein" if it supplies all ten Essential Amino Acids in balanced amounts. Meat, or most any animal tissue, is a complete protein, since animal tissues are made of protein. Protein is also expensive! Finding good quality, cheap protein is one of the challenges of raising and keeping chickens.

Amino acids are building blocks of protein. The feeding value of proteins depends not only on amino acid composition, but also on the effective utilization of the amino acids by the animals. Dietary protein supply is one of the major factors influencing the productivity of farm animals.

Amino acids function in poultry

Amino acids	Functions
Methionine	Methionine is usually the first limiting amino acid in most of the practical diets for broiler chicken. 1. Protein synthesis 2. Influence the birds ability to absorb amino acids in the intenstines 3. It acts as methyl doner, for example during DNA replication 4. It is a substrate in polyamine synthesis 5. Is required for cell proliferation 6. It plays a role in immune responses 7. Is involved as substrate for antioxidants to regulate oxidative stress 8. Methionine is an essential amino acid for poultry and has an important role as a precursor of cystine
Lysine	1. The main role of lysine is to participate in protein synthesis. 2. Lysine is required for growth and maintenance, and 3. it is considered a reference amino acid in the ideal protein diets
Therionine	1. Threonine (Thr) is the third limiting amino acid in poultry, and 2. it has a vital role in improving growth, 3. intestinal morphology, 4. barrier function, 5. immune system functions, 6. antioxidant ability
Valine	The main biological function of valine is its involvement in muscle protein synthesis, It is used by muscles as an energy source.

Leucine	play critical roles in protein synthesis, in reducing muscle damage, and in glucose or lipid metabolic activity
Isoleucine	is essential for growth, optimum egg mass, and egg production Regulation of fatty acid metabolism in the liver where production of lipoprotein could be rate-limiting for egg yolk formation
Phenylalanine	chickens can convert phenylalanine into tyrosine in the liver and kidneys.

Broiler chicks grow rapidly and typically receive diets high in protein or amino acids. It is common practice in the poultry industry to provide varying diets during the growing period.

Protein is an essential constituent of all tissues of animal body and has major effect on growth performance of the bird. A better understanding of the nutritional requirements of amino acids:

1. Allows a more precise nutrition,
2. Offering the possibility for the formulator to optimize the requirement of at least minimum levels of crude protein by essential amino acids requirements,
3. Generating better result and lower costs for the producer.
4. Feeding high amino acid density diets improves feed conversion and increases weight gain and breast meat yield of broiler chickens.

Lysine is often one of the limiting amino acids in broiler diets. As such, it used as the reference amino acid to which all other essential amino acids are rationed in the ideal amino acid pattern. Therefore, it is crucial to obtain an accurate Lys and Met + Cys requirement to support optimum growth of fast-growing commercial broilers.

Many poultry nutritionists use the levels recommended by the National Research Council as a guideline in establishing their own amino acid requirements.

Although most amino acid requirements established by the NRC considered safe estimates for broiler chicks, some researchers have indicated that the NRC lysine requirement for chicks is too low. Other studies have reported that Met + Cys levels should be above NRC recommendations.

Protein metabolism

In the growing animal there is a balance between protein synthesis and protein degradation. Amino acid catabolism and protein synthesis would appear to be linked processes. When the supply of an amino acid is low it is used relatively efficient enough for protein synthesis, but as the supply of amino acid is in excess of that required for protein synthesis amino acid oxidation increases. This mechanism ensures that when amino acids are in short supply they are preferentially used for body protein synthesis..

Protein requirements

The dietary requirement for poultry is for essential amino acids rather than protein *per se*. Amino acids are required for maintenance of protein in body tissues and for protein deposition in the carcass and other body tissues. Methionine, arginine, and threonine are required at proportionally high levels.
Dietary amino acid levels slightly below maintenance can sustain life, but muscle mass and function are impaired. The balance of amino acids required for growth closely reflects the pattern of amino acids incorporated into tissue proteins. This is because needs for protein accretion are considerably greater than

needs for maintenance. For example, in young growing chickens, 94% of the valine requirement is used to support growth and only 6% is required to replace obligatory losses.
Fractional rate of growth (% increase/day) of chicks is highest after hatching and decreases steadily until an adult lean body mass is achieved.
The requirement at any given age varies directly with a bird's fractional growth rate. Thus, the amino acid requirements (% of the diet) decrease with age and, at the same time, the ideal balance of amino acids changes gradually to reflect those of maintenance.
Birds laying eggs need dietary amino acids for normal maintenance, growth of the oviduct, and accretion of egg proteins. The growth of the oviduct and the synthesis of several yolks are mostly complete before the first egg is laid. Consequently, the female's requirement increases at least a week prior to her first oviposition.
Amino acid requirements are based on many aspects of poultry nutrition. For example, dietary metabolizable energy has an important impact on feed intake, therefore amino acid requirements change as the dietary metabolizable energy changes.

Reduced Dietary Protein

Reducing the amount of CP and excess amino acids being fed is the most obvious method to curb N excretion and the amount of ammonia (NH_3) that can be formed and volatilized.

Unfortunately, there is a wide-spread belief that whenever CP concentrations are lowered, performance is negatively affected. On a practical basis, however, bird performance will be reducing by excessively lowering CP in diets due to a number of factors other than the reduction of CP itself. these factors can include: **reduced potassium levels**, **altered ionic balance**, **lack of nonessential amino acids**, **imbalances among certain amino acids** (e.g. branched chain amino acids), and/or **potential toxic concentrations of certain amino acids**.

Formulation based on bird amino acid requirements rather than CP can minimize N excretion by simply reducing total dietary N intake. Researches demonstrated with broilers that litter N could be reduced more than 16% when dietary CP was reduced by 2%, while maintaining similar levels of dietary amino acids.

The best way to reduce N in poultry excreta is to lower the amount of CP that is fed by supplementing diets with amino acids. Reductions in the non-essential amino acid pool, coupled with supplying a more "ideal" amino acid profile in the diet can substantially increase the efficacy of overall N retention by the bird. On a practical basis, however, bird performance can be difficult by these lower CP diets due to a number of factors that tend to be associated with dietary CP and amino acid reductions.

Benefits of formulation on a Digestible Amino Acid Basis

Digestible amino acid systems offer nutritionists an opportunity to formulate more precise diets. Ileal digestible amino acid values were shown to offer advantages in feed formulation compared to total amino acid values, particularly when ingredients of low digestibility are incorporated into diet formulations. Broilers fed those based on ileal digestible amino acids increased weight gains by 14%, reduced feed per gain by 6 points, increased breast meat yield by 21% and reduced abdominal fat by 18%.

The current emphasis of broiler nutrition is not only on *improving the efficiency of nutrient utilization*, but also on *maximizing lean meat production*. The *deposition of protein* and *amino acids* in broilers was significantly affected by *dietary amino acid levels*. These data could be used to manipulate lean meat output

Age of broilers had significant effects on protein and amino acid utilization, which *decreased* with *advancing age*.

Digestible amino acid values are considered by many to be the best measure of the amino acid value of ingredients. Formulation on a digestible amino acid basis can:

1. Reduce the total amount of CP fed
2. Limit the excessive amount of non-essential amino acids fed – particularly if higher digestible CP feedstuffs are available.
3. Decreasing safety margins
4. Increasing the accuracy of predicting performance
5. Formulation on a digestible basis can have large economic and environmental benefits, particularly when formulating with ingredients known to have lower digestibility.

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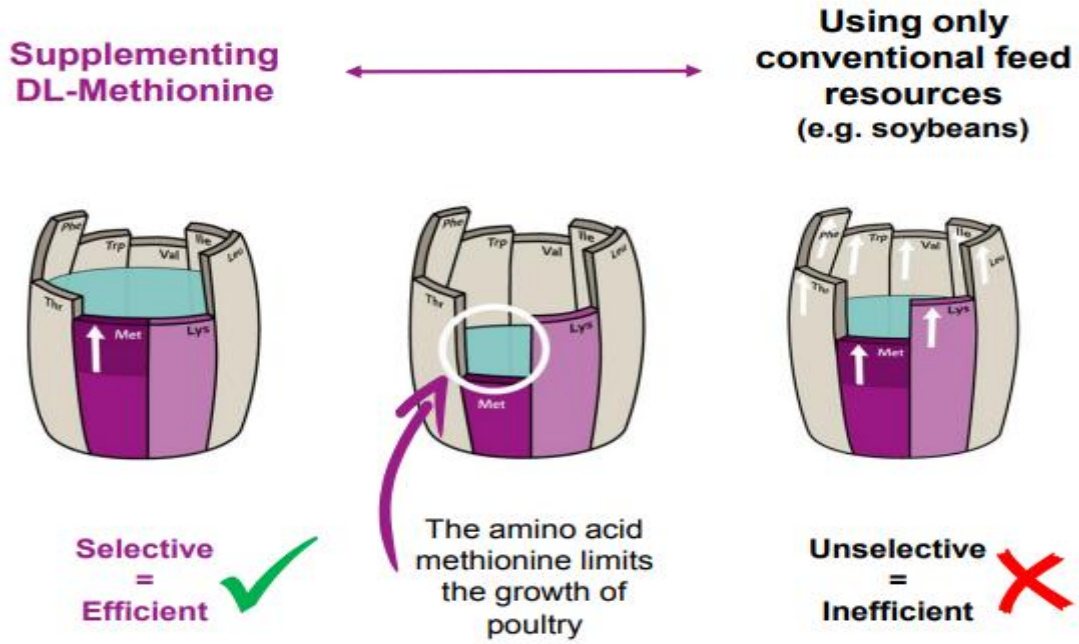
Most of the grow-out poultry studies focusing on use of digestible amino acid formulations have only focused on performance and economic considerations and not necessarily on N excretion or emission reduction.

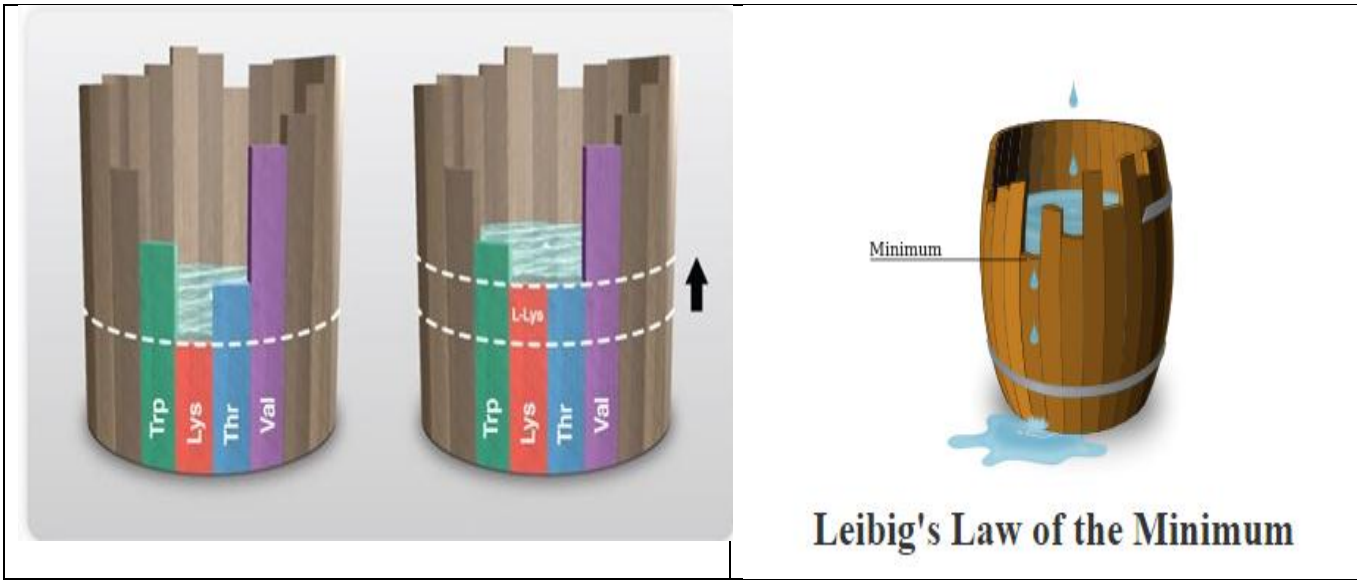
Depending on phase feeding programs, studies indicate that 100 to 107% of NRC (1994) recommendations for essential amino acids were needed to maximize growth and breast meat yield.

In the case of laying hens, CP and amino acid formulations are largely over-formulated with the hopes of getting a return in either egg size or egg number.

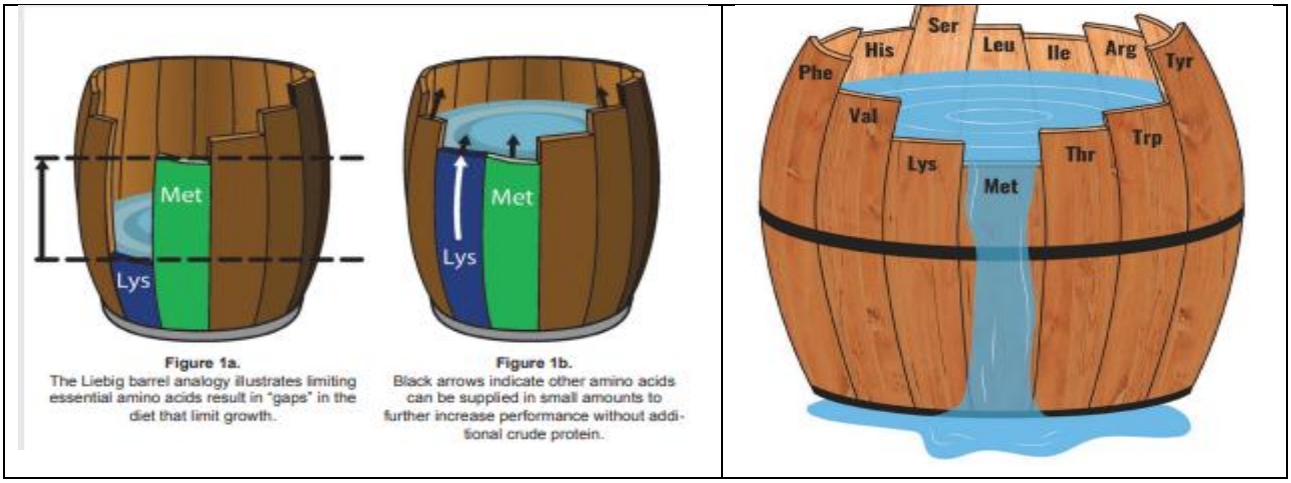
Amino Acid Requirements

For the past couple of decades, the broiler industry has utilized feeding strategies in phases that are shorter as to more closely meet the nutrient needs of the developing bird. More recent research also suggests that the amino acid needs of the broiler differ substantial from that presented in the *NRC (1994).*





Liebig's barrel illustrates the usefulness of targeted amino acid supplementation.



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