Perspective

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Several feed-grade methionine products for animal

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Description

Methionine (Met) is a non-polar, sulphur-containing amino acid (AA) that was originally isolated from casein in 1922 by Mueller, and its chemical formula was described in 1928 as γ-methylthiol-α-aminobutyric acid by Barger and Coyne. Despite its late discovery, Met has received great attention because it serves as the initiating AA for nearly all eukaryotic protein synthesis. This essential AA participates in several fundamental biological processes, including protein biosynthesis, methyl transfer reactions, formation of polyamines, and synthesis of cysteine and other metabolites. Animals are incapable of synthesizing Met and need to ingest it in food. Since Met content is low in most common plant-based ingredients and some animal-derived protein sources (e.g., feather meal), diets are often supplemented with synthetic Met to meet nutritional requirements. Common sources are L-Met, DL-Met, and the liquid DL-methionine hydroxyl analogue (DL-MHA, also known as DL-2-hydroxy-4-(methylthio) butanoic acid (DL-HMTBA)). Due to its low industrial production and high price, L-Met derived from microbial synthesis is primarily used in human food additives and pharmaceutical applications.

AA Transporters

A possible reason for the varying results in effectiveness between DL-Met and DL-MHA is the differences in the chemical structures of these compounds. Different structures likely require different transporters to cross the intestine and may be affected by different experimental conditions such as diet formulation. The chemical structure of Met includes an amine group (NH_2), a carboxyl group (COOH), a hydrogen atom, and an R group (C_3SH_7). In the MHA molecule, however, the amino group is substituted with a hydroxyl group (OH). This substitution makes MHA more closely similar to a monocarboxylate molecule rather than to a true AA.

Methionine is the second or third limiting amino acid in typical swine diets, and exogenous methionine supplementation can improve the efficiency of dietary protein utilization by swine when dietary methionine is limiting. Several feed-grade methionine products, such as DL-methionine and DL-methionine hydroxy analogue free acid, have been on the market for feed formulation. Recently, some feed-grade l-methionine products also became available on the market for swine. However, questions often asked by producers and nutritionists are whether or not more crystalline methionine should be used, and which product should be used. Although a simple answer does not exist, this paper was written to comprehensively summarize our current knowledge in methionine nutrition with an attempt to provide a single source of reference for swine nutritionists and scientists to develop more pertinent answers for different swine production systems.

Intestinal Transport

Therefore, in this paper, firstly, different forms of commercially available feed-grade methionine products were reviewed chronologically. Secondly, the overall effectiveness of methionine on swine growth performance was summarized. Thirdly, our current understanding of methionine metabolism in animal body was updated. Fourthly, various biochemical and physiological functions of methionine in swine were described. Lastly, dietary methionine deficiency and toxicity to the animal were pointed out. In brief, it is understood from the cellular metabolism standpoint that methionine functions primarily as a substrate for protein and peptide biosyntheses in the body. From a regulatory standpoint, methionine is an initiator amino acid for universal protein translation. Methionine is also an essential source of methyl groups for methylation of at least seven classes of bioactive compounds, such as DNA, RNA, and proteins.

Microcystis spp., are Gram-negative, oxygenic, photosynthetic prokaryotes which use solar energy to convert carbon dioxide (CO_2) and minerals into organic compounds and biomass. Eutrophication, rising CO_2 concentrations and global warming are increasing Microcystis blooms globally. Due to its high availability and protein content, Microcystis biomass has been suggested as a protein source for animal feeds. This would reduce dependency on soybean and other agricultural crops and could make use of “waste” biomass when Microcystis scums and blooms are harvested. Besides proteins, Microcystis contain further nutrients including lipids, carbohydrates, vitamins and minerals. However, Microcystis produce cyanobacterial toxins, including microcystins (MCs) and other bioactive metabolites, which present health hazards. In this review, challenges of using Microcystis blooms in feeds are identified. First, nutritional and toxicological (nutri-toxicogical) data, including toxicity of Microcystis to mollusks, crustaceans, fish, amphibians, mammals and birds, is reviewed. Inclusion of Microcystis in diets caused greater mortality, lesser growth, cachexia, histopathological changes and oxidative stress in liver, kidney, gill, intestine and spleen of several fish species.

Estimated Daily Intake

Estimated daily intake (EDI) of MCs in muscle of fish fed Microcystis might exceed the provisional tolerable daily intake (TDI) for humans, 0.04 µg/kg body mass (bm)/day, as established by the World Health Organization (WHO), and is thus not safe. Muscle of fish fed M. aeruginosa is of low nutritional value and exhibits poor palatability/taste. Microcystis also causes hepatotoxicity, reproductive toxicity, cardiotoxicity, neurotoxicity and immunotoxicity to mollusks, crustaceans, amphibians, mammals and birds. Microbial pathogens can also occur in blooms of Microcystis. Thus, cyanotoxins/xenobiotics/pathogens in Microcystis biomass should be removed/degraded/inactivated sufficiently to assure safety for use of the biomass as a primary/main/supplemental ingredient in animal feed. As an ameliorative measure, antidotes/detoxicants can be used to avoid/reduce the toxic effects. Before using Microcystis in feed ingredients/supplements, further screening for health protection and cost control is required.

Meanwhile, methionine and some of its derivatives are endogenous antioxidants which can protect living cells from oxidative stress. Synthesized from methionine, a myriad of proteins and peptides are involved in immune system for maintaining animal health. Dietary methionine deficiency negatively affects pig growth performance, while supplementation of more methionine may cause toxic effects. Overall, this paper not only can endorse animal scientists to further explore the underlying metabolic and molecular mechanisms that are responsible for methionine nutrition, particularly in pigs, but also can help the field nutritionists to determine methionine requirements of pigs with different production purposes and to selectively use certain commercial methionine products during their diet formulation practice.