Commentary

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Understanding the Role of Protein in Animal Diets

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Description

Feeding is vital for animal growth and the maintenance of health. However, the underlying mechanisms that mediate dietary performance have long been a so-called black box. It is only during recent years that studies have demonstrated that nutrients act as signals that can be sensed by cells and organisms and that play vital roles in gene expression and metabolism. Multiple signaling pathways have been identified as being responsible for the sensing of discrete nutrients. While successes have been achieved in the exploitation of nutrient-sensing signals in drug discovery and disease control, applications based on the sensing and metabolic control of major nutrients (proteins, lipids, carbohydrates, etc.) in land-farmed animals and aquaculture remain in their infancy. We thus provide a tentative perspective on future research topics and applications of nutrient sensing in animal nutrition.

Nutrition is vital for the growth and health of animals. Nutrients especially macronutrients, including amino acids, fatty acids, and carbohydrates provide energy and basic building blocks that are needed for homeostasis and biomass accretion. Traditionally, nutrition science has focused on the physiological processes of digestion, absorption, transport, and metabolism. However, starting in the beginning of this century, a great deal of attention has focused on how cells and organisms sense and metabolically respond to nutritional status through what is known as nutrient sensing a topic that has become a hot spot in the biological sciences. Numerous studies have demonstrated that nutrient sensing plays critical roles in the regulation of food intake, energy expenditure, hormone secretion, and metabolic processes in humans and other animals.

Nutrient-sensing signaling pathways and mTOR in particular receive external nutrients and environmental inputs to regulate biomass accretion and health. Dysregulated sensing signals have been shown to be involved in pathological processes such as cancer, cardiovascular diseases, and neuro degenerations. Lack of mTOR activity leads to early-onset myopathy and hinders growth in mice. mTOR is also an important regulator of immune responses. Accumulated evidence shows that mTOR promotes the differentiation, activation, and function of T cells, B cells, and antigen-presenting cells. Furthermore, mTOR activities are involved in driving the growth and proliferation of stem and progenitor cells, and in dictating the differentiation program of multipotent stem cell populations. In particular, mTOR regulates multiple intestinal epithelial cell lineages and promotes stem and progenitor cell activity during intestinal epithelium repair post injury. Taken together, this evidence highlights the importance and necessity of understanding and manipulating nutrient sensing in animals.

Numerous studies have confirmed the fundamental roles of nutrient sensing in farmed animals, both in vitro and in vivo. Most nutrient-sensing molecules and functions for amino acids, lipids, and carbohydrates are well conserved in farmed animals such as pigs [59]. Met, leu, Arg, and other amino acids have been found to activate the mTOR pathway in cell lines from quail, cow, porcine, and other domesticated animals. In addition, branched-chain amino acids are able to activate the mTORC1 pathway in lactating cows and piglets. Long-chain fatty acids stimulate the release of GLP-1 and GLP-2 from porcine ileal tissues, while linoleic acid input has been specifically correlated with CD36 levels in the skeletal muscle of broilers. The phosphoinositide 3-kinases (PI3K)–Protein Kinase B (PKB) mTOR pathway has also been found to be involved in the infections of porcine epithelial diarrhea virus. Dietary Leu supplementation could attenuate the decrease of mucin production in the jejunal mucosa of weaned pigs infected by porcine rotavirus. General decreases in villus height and intestinal dysfunction during weaning have been found to be accompanied by reduced mTOR activities in piglets. Dietary supplementation of glutamate improved mTOR signaling, suppressed inflammation, and alleviated intestine injury in weanling pigs challenged with lipopolysaccharide. mTOR activators, including branched-chain amino acids, have also been found to enhance muscle growth in weanling piglets.

Mechanism of Metallic

Nutrient sensing in the intestine plays a fundamental role in signaling the nutritional status to the central nervous system and regulating feeding behavior in pigs. Artificial sweeteners, which are routinely included in piglets' diet to reduce post-weaning enteric disorders and promote growth, are now believed to function through enhanced SGLT-1 activity and glucose absorption. Taste receptors and nutrient sensors in the intestine also play key roles in food intake and appetite control in chickens.

Selenium (Se), one of the indispensable nutrients for both human health and animal growth, participates in various physiological functions, such as antioxidant and immune responses and metabolism. The role of dietary Se, in its organic and inorganic forms, has been well documented in domestic animals. Furthermore, many feeding strategies for different animals have been developed to increase the Se concentration in animal products to address Se deficiency and even as a potential nutritional strategy to treat free radical-associated diseases. Nevertheless, studies on investigating the optimum addition of Se in feed, the long-term consequences of Se usage in food for animal nutrition, the mechanism of metallic Se nanoparticle (SeNP) transformation in vivo, and the nutritional effects of SeNPs on feed workers and the environment are urgently needed. Starting from the absorption and metabolism mechanism of Se, this review discusses the antioxidant role of Se in detail. Based on this characteristic, we further investigated the application of Se in animal health and described some unresolved issues and unanswered questions warranting further investigation. This review is expected to provide a theoretical reference for improving the quality of food animal meat as well as for the development of Se-based biological nutrition enhancement technology.