Relationship Between Nutrition and Immunity – determining the nutritional cost of immunity

The immune system plays a significant role in overseeing the interactions between the host and the outside environment through a network of tissues, membranes, cells and signaling molecules which collectively function to protect the host. This is carried out not only through the identification of pathogenic organisms, but also through elimination and resolution of the infection caused by the pathogenic organism. With all these components at its disposal, the immune system has the complicated and delicate task of balancing between the host living in a constant state of chronic inflammation through an overreacting immune system (causing damage to self-tissue), and aptly reacting to harmful agents (pathogens etc.) in a manner that will benefit the host (Brown et al., 2013).

Our knowledge of nutrition on animal performance is very robust, that includes a list of required nutrients, the minimum level required, in order to maximize production. More so, there has been extensive research on the bio availabilities of different raw materials or feedstuff, with more intensive research on gut health products in order to maximize production in an array of different programs that range from conventional to RAW/ABF. However, its not known if the nutrients levels needed for performance are in line with what is needed by the immune system as a whole and if they are met during different growth stages of the animal. To know whether nutritionists are meeting the requirements of all the effector functions that are performed by the immune system, is not plausible. However, there is a general understanding that severe nutrient deficiencies can inhibit the effector functions of the immune system (i.e. zinc), yet in some cases, marginal deficiencies have no negative impact at all compared to growth. Furthermore, certain nutrients such as Vitamin A, E and poly unsaturated fatty acids, can modify the intracellular communication within immune cells, which can change minimize disease specific disease susceptibility.

Robust activation of the immune system can be extremely beneficial for the host organism (i.e. pathogen elimination), depending on the nature of the stimuli. However, these host-protective responses can be nutritionally and metabolically expensive, which can have negative consequences on animal performance (Colditz, 2002). Granted, feed intake accounts for a large portion of the decrease in performance, yet it sets the stage for the immune system to utilize the host's resources and its nutrients needs become the priority. Thus, it changes the metabolic profile of the animal from anabolic to catabolic by altering protein, lipid, hormonal, to name a few, to drive nutrients to the immune system (Klasing, 1988). After antigenic stimulation, glucose consumption increases 20 fold within the first hour, which is facilitated by increases in glucose transporters (Greiner et al., 1994; Humphrey and Rudrappa, 2008). The significant increase in glucose uptake is to not only to provide enough energy for biochemical reactions, but to generate cellular components for the proliferating cell. Chicken muscles express relatively low

levels of the high affinity CAT isoform, whereas bursal tissue expresses high levels (Humphrey et al., 2004, 2006). We found that the liver and bursa upregulate high affinity isoforms and presumably become more competitive for the essential amino acids lysine and arginine during the acute phase response. In addition, significant changes can be seen in skeletal muscle with amino acids being released and utilized by tissues and cells involved in host defense (Klasing and Austic, 1984a, b).

Although the nutritional costs of many physiological processes such as growth and egg production have been well defined, there has not been a thorough quantification of the total nutritional costs of developing, maintaining, and using the immune system. This is probably due to the complexity of the immune system in which many cell lineages are located diffusely throughout the body. In addition, the diverse types of challenges (e.g., viral, bacterial), durations of challenge, types of immune response, and amounts of immunopathology create a situation in which interpretation can be difficult. The study by (Iseri and Klasing, 2014) supports the concept that the cost of an immune response is mostly due to protective processed unrelated to the needs to leukocytes. In which the increases in weight of cells and antibodies due to a response to *E. coli* were dwarfed by the increase in the weight of the liver and acute phase proteins. Thus, the acute phase response was markedly more costly than the adaptive response.

To prevent the loss of , the priority of minimizing an animal's susceptibility to intestinal diseases is by strengthening the positive interactions between microbiota, intestinal immune system and epithelial barrier – factors of gut health – which has led to the development of a wide array of feed additives. Developing or maintaining these positive interactions affects, for example, the host's intestinal architecture development, ability to absorb nutrients efficiently, immune tolerance, and the development of the intestinal immune system. Perturbations (i.e. leaky gut) in the epithelial lining disrupts both functions in addition to activating the intestinal immune system

Maintaining intestinal integrity by using butyric acid, allows the animal to not only absorb nutrients efficiently, but also minimizes immune activation incidences that can be arduous to an animal's growth.

To provide value to animal production systems, feed additives must significantly impact either the microbiota, intestinal immunity or epithelial barrier at the cellular level to minimize the negative effects of both disease and non-disease challenges to performance.

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