The impact of feeding effects on the dairy cow’s immune system

The immune system is a biological defence system comprised of different structures, cell types and processes that act to protect the host animal from pathogens. Pathogens include micro-organisms, viruses and parasites. The immune system is also primed to identify and destroy tumour cells. As such, the immune cells must be able to differentiate between healthy host tissues and cells and those of a pathogen or tumour.

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The immune system is a complex, tiered arrangement that facilitates the detection of pathogens. The initial line of defence is usually in the form of a physical barrier, such as the epithelium. Cuts or abrasions to the skin can allow the entry of pathogens into the body that subsequently stimulates the next step in the defence process: the innate immune response. This dominant response is immediate but non-specific, meaning that it reacts in the same way, whatever the pathogen. Inflammation, white blood cells and other molecules aid in halting pathogens from proliferating.

In certain vertebrates, another part of the immune system exists: the adaptive, or acquired, immune response. This is more complex than the innate system, as it involves recognition of specific, individual pathogens. Recognition occurs via antigen-presenting cells (APCs) that interact with targets and activate the adaptive immune response. This system also possesses immunological memory, whereby memory cells from a previous infection remain in circulation. This means that if the same pathogen is encountered for a second time, the response is more rapid and of greater magnitude.

The failure of any stage of defence leaves the animal at greater risk of succumbing to infection and/or disease. Effective host defence requires that both innate and acquired protective factors be highly interactive and coordinated to provide optimal resistance to disease.

Factors affecting immune function

The periparturient period is by far the most physiologically demanding time in the production cycle. It is well-established that immune function during the periparturient period is compromised, and research has looked at targeting factors that contribute to this immunosuppression, often with an emphasis on mastitis.

Numerous factors influence immune function, including genetics, hormones, oxidative stress and nutrition. There appears to be substantial genetic variability in resistance to certain diseases, and selection for animals showing lower disease susceptibility during periods of immunocompromise may significantly improve overall herd health.

Hormones, such as corticosteroids, can have direct effects on immune function via a reduction in numbers of certain white blood cells. Reduced levels of thyroid hormones can have negative effects on the body's innate (non-specific) response, and elevated and suppressed levels of oestrogen and progesterone, respectively, affect both innate and adaptive responses.

Oxidative stress occurs when the balance between oxidants, such as reactive oxygen species (ROS) and the body’s antioxidant system, shifts toward the former. The abundance of ROS, including hydroxyl radicals and peroxides, increases when there is an increased demand for oxygen. These ROS are potent mediators of cell and tissue damage, putting additional strain on the immune system.

Nutritional effects

One of the most influential factors regarding immune function is nutrition, and much data exists to demonstrate the adverse effect of malnutrition on immune function in mammals.

As mentioned, the transition period represents the greatest physiological stress to a dairy cow, and physiological stress also has a negative impact on the body's ability to fight disease. Physiological stress is the adaptation of the body's functions to try to cope with the current situation (calving).

Certain processes occur, leading up to and during calving, that allow the animal to cope with what is happening. Hence, optimal nutrition is vital to avoid exacerbating the situation. Both deficiencies and excesses of various nutrients can result in impaired immune function, so careful attention must be paid to transition cow diets.

Energy balance represents a key attribute to successful dairy production, and negative energy balance (NEB) is an omnipresent issue during the immediate post-partum period. Animals with a NEB tend to have elevated levels of circulating non-esterified fatty acids (NEFA). These compounds are associated with an increase in inflammatory conditions, though the exact mechanism is unclear.

Negative energy balance results in mobilisation of adipose tissue to provide additional energy, as nearly all the glucose available is directed to the mammary gland. This creates a shift in the profile of circulating fatty acids (FA), which has knock-on effects for compounds generated from these FA. Douglas et al. (2007) highlight the reduction in cell membrane concentrations of the polyunsaturated FA (PUFA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

PUFA are also the precursors for many compounds, such as eicosanoids, prostaglandins, leukotrienes and thromboxanes, which are all involved in the immune response. Eicosanoids show varying degrees of inflammatory stimulation, and, thus, alterations in FA profiles due to NEB will influence the inflammatory response. Promoting a positive, or less negative, energy balance is therefore vital during the transition period.

This requires a healthy and efficient rumen, which can be encouraged by feeding a balanced ration using good quality ingredients. As foetus size increases, dry matter intake decreases, meaning adjustments in the energy density of the

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Aerobic biological processes require oxygen and, thus, generate ROS. These damaging oxidants can impair immune function, as the process of phagocytosis generates free radicals. Hence, ensuring rations support antioxidant systems is essential for supporting immune function, and not only supporting immune function but also maintaining the integrity of the primary barrier, the skin. Cells involved in the innate response require zinc for normal function and development. Copper is also crucial for immune function. It affects the IL-2 responsible for T-cell proliferation in the adaptive response. Neutrophil proliferation is also affected by copper deficiency. Hence, copper deficient animals often show immunosuppression.

Fig. 2. Effect of copper source on E. coli in milk (log10 CFU/mL) following E. coli challenge (adapted from Scaletti et al., 2012).

Organic copper was better at reducing levels of E. coli in milk compared to inorganic copper. This indicates that copper is crucial for immune function and should be paid during times of physiological stress (parturition).

Essentially, the immune system must be promoted at all times throughout the lactation cycle, but particular attention should be paid during times of physiological stress (parturition).

Feeding to enhance immunity is vital and should focus on maintaining a less negative energy balance as well as building tissue reserves of key minerals, which is most effectively done by feeding them in the organic form.