We're learning more about how cows resist disease

by Neil E. Forsberg and Yongqiang Wang

STRESS has potential to reduce immune function and make animals more susceptible to infections. Recent studies have shown how stress suppresses immune function and allows pathogens to grow. Let's review the basics of immunity in dairy cows, how stress reduces immune function, and look at nutritional approaches to restore immunity.

The dairy cow's immune system can be divided into two systems: the innate immune system and the adaptive (antibody-mediated) immune system. The innate system functions as the first line of defense against pathogens and consists of several elements:

- Physical and chemical barriers to pathogens are provided by epithelial lining, gastric acid, and digestive enzymes.
- There are cells which engulf and digest invading pathogens. Neutrophils are examples.
- Receptors on the surface of these cells recognize and bind to pathogens.
- Signaling molecules (cytokines) communicate sites of infection and regulate expression of immune genes.

Neutrophils are the first cells to arrive at a site of infection. Dairy cows possess about two hundred billion neutrophils. As they circulate, neutrophils express an extracellular binding protein called L-selectin. L-selectin interacts weakly with the blood vessel wall, thereby allowing the neutrophil to "roll" and to search for signals which indicate a local infection. When neutrophils detect a pathogen, they migrate through the endothelial cell wall toward the invading pathogen, engulf it, and kill it.

You can observe the actions of the innate immune system in your cows day to day by monitoring somatic cell counts (SSC) in milk. Somatic cells primarily are neutrophils which have invaded the mammary alveolus in response to pathogen. High levels of SSC reflect an active infection and active killing of pathogens by invading neutrophils.

"Stress" develops whenever an animal experiences events which lie outside of the ordinary. Examples include being trucked, hot and cold weather, and distress from inappropriate handling.

Burton and co-workers at Michigan State University recently have documented mechanisms by which stress suppresses immunity in cows. They measured glucocorticoid levels in cows during lactation and found two "spikes" in glucocorticoids . . . one right at calving and one at time of drying off. Both parturition and drying off can be stressful events, and the associated release of glucocorticoids has potential to reduce immunity. As most of you are well aware, these are two times when cows are most susceptible to mastitis infections.

What stress does . . .

The Michigan State workers reported that glucocorticoids reduce immune function by causing neutrophils to "shed" L-selectin. This loss of L-selectin eliminates the first line of defense which cows use to fight infections. As a result, stressed cows become more susceptible to a wide range of disease-causing bacteria and fungi present in the environment.

Stress-related loss of immune function at calving is, unfortunately, a natural aspect of dairy cow physiology. Therefore, we must be vigilant and provide good care to minimize infections in cows with weakened immune systems. Maintaining clean, dry environments; sound vaccination programs; and teat dipping are essential to reduce udder infections. Proper harvest and storage of silages are essential to reduce opportunities for feed-borne pathogens to infect the cow's gastrointestinal tract.

Nutrition's role . . .

The immune system, like any other aspect of an animal's physiology, depends upon proper nutrition. Inadequate nutrition compromises the immune system. During the past 20 years, we've made progress in understanding how nutrients specifically support the immune system. In a recent review on nonruminants, deficiencies in linoleic acid, vitamin A, folic acid, vitamin B_6, vitamin B_{12}, vitamin C, vitamin E, zinc, copper, iron, and selenium all have potential to depress immune function.

In dairy cattle, less is known about nutritional support of the immune system. However, it is well-known that antioxidants (selenium and vitamin E) play strong roles. For example, Ohio State workers found that vitamin E and selenium supplementation of cows improved the ability of isolated neutrophils to kill *S. aureus* and *E. coli*. High levels of vitamin E supplementation (up to 4,000 IU/day) raised neutrophil vitamin E concentrations and reduced incidence of clinical mastitis from 25 percent to 2.6 percent.

Other nutrients implicated in strengthening the immune system in dairy cattle include chromium, cobalt, copper, and vitamin A. Spears, from North Carolina State, recently has published a review on the nutritional support of the immune system in dairy cattle. He reported that low levels of cobalt, copper, selenium, and vitamin E in the diet reduced ability of neutrophils to kill yeast and bacteria. Copper deficiency reduced antibody production but did not adversely affect cell-mediated immunity. Cobalt deficiency reduced resistance to parasites, and vitamin A deficiency reduced immunity partly through its role as an antioxidant. These observations, coupled with data emerging from nonruminant literature, imply that dairy producers, veterinarians, and nutritionists need to be fully aware of the potential for diet to support the immune system.

Other approaches . . .

The gastrointestinal tract is an extremely complicated, yet interesting, organ. Not only does it serve to digest and absorb food, it also is the largest immune organ in the body. The gastrointestinal tract continually monitors its contents for the presence of pathogens and thereby serves to defend animals against disease.

Insight into the mechanisms by which the gastrointestinal tract monitors digesta for pathogens has allowed development of feed additives with ability to boost immune function in stressed and immuno-suppressed ruminants. For example, those of us at Oregon State University recently have developed a feed additive which has shown specific ability to boost neutrophil function in immunosuppressed livestock. With legislation in Europe and elsewhere restricting use of antibiotics in livestock production, we anticipate that many more products with similar purpose will be designed within the coming decade.

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