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Major Advances in Our Understanding of Nutritional Influences on Bovine Health

J. P. Goff
National Animal Disease Center, USDA-Agricultural Research Service, Ames, IA 50010

ABSTRACT

The *Journal of Dairy Science* has increasingly become a primary outlet for scientific research concerning the health of the dairy cow and her calf. This paper attempts to highlight *Journal of Dairy Science* articles that have linked nutrition and nutritional strategies to reduce disease incidence on the dairy farm. Disorders associated with an animal's inability to cope with the demands of high production include diseases such as milk fever and ketosis, which clearly are related to the cow's inability to maintain bodily functions in the face of negative calcium or energy balance. Improved nutrition of the late gestation cow can reduce the incidence of some of these disorders. Susceptibility to infectious disease is dependent on the integrity of the immune system, and recent studies have shed light on nutritional factors that affect leukocyte function. Other disorders, such as retained fetal membranes, udder edema, and displacement of the abomasum are not easily categorized as to their cause, but nutritional strategies have been developed to help prevent these disorders as well.
Key words: immunology, metabolic disease, milk fever, ketosis

INTRODUCTION

Although articles examining the effects of nutrition and management on milk production remain a *Journal of Dairy Science* standard, papers concerning the effects nutrition can have, for better or worse, on the health of the dairy cow and calf are increasingly common. When cattle become unhealthy (or die), they quickly become unprofitable. More importantly, the public expects the milk cow and her calf to be well cared for and healthy. A healthy calf is a calf that grows well and is free of disease. A healthy cow produces profitable amounts of milk, is capable of reproducing, and is free of disease, both infectious and metabolic. Some disorders, such as milk fever and ketosis, are related to the cow's inability to maintain bodily functions in the face of negative calcium or energy balance, and there is a clear effect of nutrition on the susceptibility to these disorders. Malnutrition clearly influences the ability of the immune system to function, which affects the incidence of diseases such as mastitis, *Salmonellosis,* and metritis.

The properly functioning immune system does 3 things well. 1) It recognizes and eliminates foreign invaders such as bacteria, viruses, and parasites. 2) It recognizes and does not initiate attacks on the tissues of the body. 3) In the case of the female, the immune system must also recognize and then tolerate the presence of sperm and a fetus within the reproductive tract to allow successful reproduction. In the September 1971 issue of the *Journal of Dairy Science,* a symposium entitled "Bovine Immune System" was published, highlighting the state of the knowledge of bovine immunology at the time. Looking back at the papers now it is interesting to note that nearly all the scientific work focused on the role of antibody as an index of disease resistance. Cell-mediated immunity was not yet on the radar screen. This presentation will try to highlight some of the advances made in our understanding of the interaction between nutrition and bovine metabolic and infectious disease resistance using the scientific knowledge described in the 1971 symposium as the starting point.

To help put health issues in perspective in the US dairy industry, Table 1 summarizes data from the 1996 and 2001 National Animal Health Monitoring System (**NAHMS**) reports. Mastitis remains the number one health problem of the dairy cow, followed by lameness, and retained fetal membranes. Keeping in mind that it is statistically invalid to compare data in the 2 surveys, it is interesting to note that over the 6 yr between the 2 surveys, it would appear that we have not made great gains in preventing these 3 disorders; in fact, the incidence of these disorders may be on the rise. More disturbing from the surveys is a 25% increase in the incidence of displaced abomasum over the 6-yr period. The only disease with a decreasing incidence was clinical milk fever, which may reflect research leading to a better understanding of the causes of milk fever. It is

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E-mail: jgoff@nadc.ars.usda.gov

Table 1. Incidence of major health problems in US dairy herds in 1995 and 2001 as a percentage of total number of dairy cows or calves (modified from the 1996 and 2002 NAHMS surveys)

	Cattle affected, %	
	1995	2001
Mastitis	13.4	14.7
Lameness	10.5	11.6
Retained fetal membranes	7.8	7.8
Milk fever	5.9	5.2
Abomasal displacement	2.8	3.5
Heifers dying before weaning	10.8	8.7

also very disturbing that 1 in 11 heifer calves born alive in 2001 failed to survive to weaning, though some solace may be had by noting that this is a big improvement over 1995, when nearly 1 in 9 heifer calves born alive failed to survive until weaning.

The published research from the last quarter-century that will be highlighted in this presentation shares the common characteristics of providing major insight into the etiology of a health problem in dairy cows or calves or providing a practical means of resolving these problems on dairy farms. The insight provided by some of these papers was not recognized until many years later. It will be interesting to see what other hidden gems emerge over the next few years from papers already published in the *Journal of Dairy Science*. I briefly discuss a few papers that I think fit into the 'hidden gem' category.

Effects of Nutrition on Immune Function and Disease Resistance of the Growing Calf

The newborn calf is devoid of protective antibodies in its bloodstream because maternal immunoglobulins do not cross the placenta in the bovine. Nature solved this problem using colostrum, the first secretion of the mammary gland after giving birth. Colostrum should contain large amounts of immunoglobulin. The antibodies are generally directed against the pathogens the cow succeeded in fending off during her lifetime. Ingestion of colostrum in the first hours after birth allows effective transfer of maternal antibody to the calf's circulation and provides immediate protection from septicemic disease caused by many bacteria and viruses. Absorption of colostral immunoglobulin represents a unique aspect to nutrition of the calf vital to the health of the calf on a dairy. Papers in the 1971 *Journal of Dairy Science* symposium recognized the importance of colostrum as a source of immunoglobulin for the calf but also recognized that nearly 30% of calves fed colostrum failed to have adequate levels of protective antibody in their blood following colostrum ingestion. Experiments conducted after 1971 helped describe the subtleties of colostrum biology, which explained why failure of passive transfer of antibody was occurring in such a large proportion of calves. University of Arizona studies led by Stott determined that the age of the calf when colostrum was fed affected antibody absorption. Other studies demonstrated that breed, age of the cow (older cows had better colostrum), and quantity of first milk (the more secretion obtained at first milking, the lower the quality) affected colostrum quality.

How nutrition of the newborn calf affects disease resistance is very poorly understood. Numerous papers have addressed the effects that inclusion of antibiotics and coccidiostats had on health of the calf, but the nutrition of the calf and the subsequent disease resistance and health of the calf were largely ignored. In general, it is assumed that if growth is good, health must be good. When calves were fed diets supplying less protein and energy than was required to obtain growth, death loss also was higher. However, recently there has been a movement toward increasing the protein and sometimes the energy content of milk replacers (and/or starter rations) to obtain growth that is "accelerated" over that obtained with more traditional milk replacers, which are about 20% protein and 20% fat. These intensified diets do cause calves to grow faster although there is considerable debate as to whether the quick early growth translates into a more profitable cow. These diets might still be worth feeding if they improved disease resistance of the calves and a recent study by Nonnecke and coworkers demonstrated that feeding milk replacer with higher concentrations of fat and energy influenced some in vitro measures of immune function; some positively, some negatively. One problem with this and similar studies is that we do not necessarily know if these in vitro assays of cell function translate into real disease resistance in the calf. Also, the advantage in immune function, if there is one, may only become manifest in calves that are challenged with a disease. For instance, the extra body reserves of a calf on an "intensified diet" may allow that animal to rebound from disease faster or be able to mount an immune response for a longer time than a traditionally fed calf. Unfortunately, these studies are expensive and until they are conducted, we cannot fully answer these questions.

Although effects of protein and energy on the immune response have not been addressed well in the calf, the role that vitamins and trace minerals have on health of the calf has been examined numerous times. Frank (and in some cases, marginal) deficiencies of any of the required vitamins or minerals affect calf health and often the immune system of these animals is impaired. Research published during the last 25 yr reported that various measures of immune function were improved