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Major Advances in Applied Dairy Cattle Nutrition

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ABSTRACT

Milk yield per cow continues to increase with a slower rate of increase in dry matter intake; thus, efficiency of ruminal fermentation and digestibility of the dietary components are key factors in improving the efficiency of feed use. Over the past 25 yr, at least 2,567 articles relating to ruminant or dairy nutrition have been published in the *Journal of Dairy Science*. These studies have provided important advancements in improving feed efficiency and animal health by improving quality of feeds, increasing feedstuff and overall diet digestibility, better defining interactions among feedstuffs in diets, identifying alternative feed ingredients, better defining nutrient requirements, and improving efficiency of ruminal fermentation. The publications are vital in continuing to make advancements in providing adequate nutrition to dairy cattle and for facilitating exchange of knowledge among scientists.

Forages have been studied more extensively than any other type of feed. Cereal grains continue to be the primary contributors of starch to diets, and thus are very important in meeting the energy needs of dairy cattle. Processing of cereal grains has improved their use. Feeding by-products contributes valuable nutrients to diets and allows feedstuffs to be used that would otherwise be handled as wastes in landfills. Many of these by-products provide a considerable amount of protein, nonforage fiber, fat, and minerals (sometimes a detriment as in the case of P) to diets. The primary feeding system today is the total mixed ration, with still considerable use of the pasture system. Major improvements have occurred in the use of protein, carbohydrates, and fats in diets. Although advancements have been made in feeding practices to minimize the risk of metabolic diseases, the periparturient period continues to present some of the greatest challenges in animal health.

Computers are a must today for diet formulation and evaluation, but fewer software programs are developed by universities. Several nutrition conferences are held regularly in the United States that are vital for transferring knowledge to the feed industry and the producers of food; the attendance at such programs has increased about 4-fold over the past 25 yr. More emphasis on animal welfare will direct some of the areas of nutrition research. Challenges ahead include having adequate funding for conducting applied nutrition research and for training of students as scientists and for employment in the feed industry.
Key words: feeds, feeding system, nutrient, technology transfer

INTRODUCTION

Since the 75th year dedication of the *Journal of Dairy Science*, at least 2,567 articles relating to ruminant or dairy nutrition have appeared in the journal. Most of these research studies have related to mature dairy animals, but many have focused on the growing heifer and a few studies were conducted with goats or sheep. During the last 25 yr, milk yield per cow has increased about 2% per year (Figure 1). With this increasing milk yield per animal, DMI has increased to supply the increased demand for nutrients. However, the rate of increase in energy requirement has increased more rapidly than DMI, thus leading to diets with higher nutrient density. The average increase in animal performance for the United States helps us visualize this change in nutrient density, but the top performing herds put this in more perspective. It is common for herds to average 12,500 kg/cow of milk per lactation with cows that consume 25 to 27 kg/d of DM. With the increases in performance per animal and limits to increases in DMI caused by rumen fill or satiety, diet density has continued to increase (e.g., from 1980 to 2003, NE_L density needed to support average milk production has increased from 1.23 to 1.36 Mcal/kg of dietary DM; ≥1.6 Mcal/kg is now typical for high-producing cows), and considerable focus in research has occurred on improving feed efficiency (increased from 0.91 to 1.20 kg of 4% FCM/kg of DMI; common goal = 1.5) and animal health by improving quality of feeds, increasing feedstuff and overall diet digestibility, better defining interactions among feedstuffs in diets, identifying alternative feed ingredients, better defining nutrient re-

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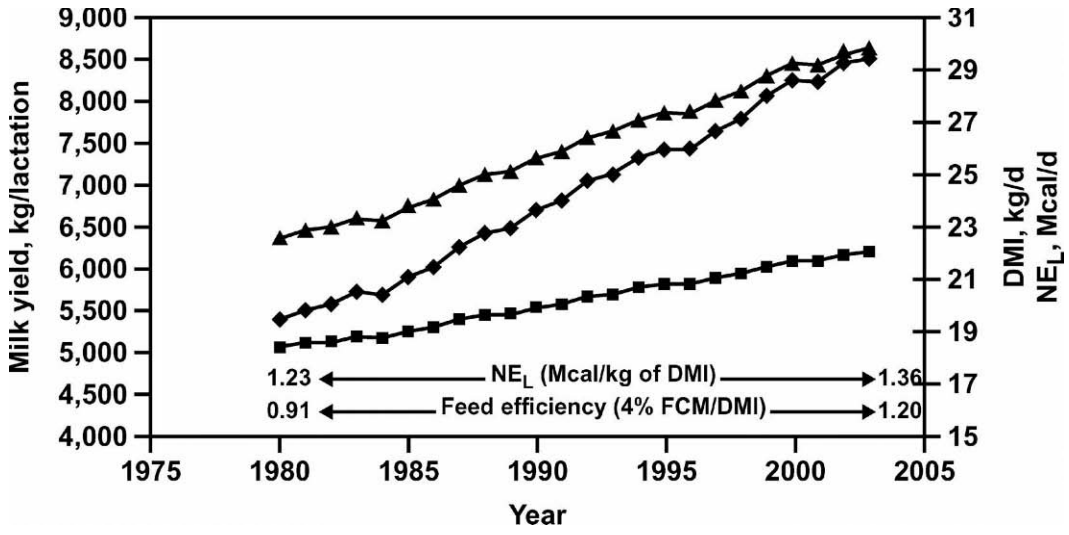

Figure 1. Changes from 1980 to 2003 in milk yield (◆), DM intake (■), NE_L required (▲), NE_L concentration of diets, and feed efficiency.

quirements, and improving efficiency of ruminal fermentation.

The NRC publications on the Nutrient Requirements of Dairy Cattle (e.g., NRC, 1989; 2001) have provided an excellent mechanism whereby the scientific community can integrate the data published in the *Journal of Dairy Science* and other peer-reviewed journals. The information in the NRC publications has been used extensively in teaching and research. Moreover, these publications have served as the handbook for dairy nutritionists in the field and for the basis of computer software development for formulation and evaluation of diets for dairy cattle. However, the new discoveries occur much more rapidly than do new editions of the NRC. Because of this and to increase the dialogue among the scientific community and personnel in feed companies, feed ingredient suppliers, and commercial laboratories, nutrition conferences and the corresponding proceedings published from the conferences have become very important vehicles in communicating new scientific data.

The manuscripts published in the *Journal of Dairy Science* are primarily for the purpose of communicating discoveries and for exchange within the scientific community. Educators and service providers to the dairy industry must be able to apply the scientific information to assist farmers in making feeding decisions and improving the profitability of the dairy enterprise and the health of the animals. The major advances in applied dairy cattle nutrition made during the past 25 yr will be presented in this paper.

FEEDS

Forages

Forages remain a vital part of the diet for dairy cattle to maintain rumen health, and in many cases, for reducing costs associated with feeding; therefore, more research has been reported with forages than with other types of feed (Figure 2). Forages under primary investigation include alfalfa, whole plant corn, whole plant sorghum, cereal grains, and grasses, including cool-season (orchardgrass, ryegrass, and fescue) and warm-season (bermuda) grasses. The inverse relationship between advancing maturity and forage quality was well established decades ago, resulting in few publications in this area during the last 25 yr. Research on storage of wet forages for silage has focused mostly on minimizing DM losses and proteolysis during harvest and storage. Minimizing losses during storage is primarily dependent on adequate DM at time of storage and optimizing anaerobic fermentation. The DM at the time of storage is affected mostly by stage of maturity at harvest and weather conditions. Anaerobic fermentation is affected by the DM content, chemical composition of the forage, and exclusion of oxygen in the storage structure. Silage additives are used to accelerate the anaerobic fermentation. Organic acids (especially propionic acid) are commonly added at the time of ensiling to hay-crop forages or to grain-crop forages harvested in less than ideal conditions. Inoculation of silages (especially hay-crop silage) with lactic acid bacteria may improve fermentation characteristics of the silage, but animal and economic responses are variable. Cuttings of hay-crop silage (e.g., alfalfa) in the spring or late fall when cool temperatures exist have lower populations of indigenous organisms and may be better preserved with addition of inoculants. Inoculation of silages with *Lactobacillus buchneri* at the time of ensiling increases acetic acid in the fermented silage and improves aerobic stability in the feed bunk. Ammoniation of whole plant corn and alfalfa for silage may increase fiber digestibil-