



A 100-Year Review: Total mixed ration feeding of dairy cows¹

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ABSTRACT

Total mixed rations (TMR) as we know them today did not exist in 1917. In fact, TMR are an invention of primarily the last half of the past 100 yr. Prior to that time many dairy herds were fed only forages, but dairy producers started moving toward TMR feeding as milk production per cow increased, herds became larger, freestall and large-group handling of cows became more common, and milking parlors became more prevalent. The earliest known reports in the *Journal of Dairy Science* of feeding “complete rations” or TMR may have appeared in the 1950s, but those studies were often reported only as abstracts at annual meetings of the American Dairy Science Association or in extension-type publications. The earliest full-length article on TMR in the journal was published in 1966. An advantage of feeding TMR as opposed to feeding forages supplemented with concentrates is the opportunity to make every bite of feed essentially a complete, nutritionally balanced diet for all cows. Nutritionally related off-feed (e.g., ingredient separation due to poor mixing, feed sorting by the animal, and so on), milk fat depression, and other digestive upsets were less likely to occur with TMR feeding. Feed mixer wagons, feed particle sizes, moisture content of diets, and other factors were not concerns before TMR feeding but are concerns today. Today, most dairy herds, especially larger herds in the United States and elsewhere, feed TMR.

Key words: total mixed ration, dairy cow

INTRODUCTION

Total mixed rations as we know them today did not exist in 1917. In fact, TMR are an invention of primarily the last half of the past 100 yr. The earliest known reports in the *Journal of Dairy Science* of feeding “complete rations” or TMR may have appeared in the 1950s (Harshbarger, 1952); however, this study and some

others were reported only in abstract form at annual meetings of the American Dairy Science Association. One of the earliest full-length articles (McCoy et al., 1966) indicated advantages of feeding TMR as opposed to feeding forages supplemented with concentrates (referred to as grain mixes in some studies). More is said later about TMR feeding, but first we start with an overview of earlier dairy cattle feeding systems.

This article reviews what was reported primarily in the *Journal of Dairy Science* regarding the development and use of TMR feeding of dairy cows. Many nutritional aspects of feeding dairy cattle are not covered in this article because those subjects are covered by other authors in other articles of this special issue. Although TMR feeding is used in many research experiments reported in the journal, many of the techniques involved in areas related to TMR feeding are reported in extension and industry publications and are not necessarily reported in scientific journals. Some of that information is cited in the review-type articles referenced in this article. Appendix Table A1 presents a timeline of major developments related to TMR feeding as well as some factors that are not directly related to TMR feeding but are related to why the industry moved toward TMR feeding.

HISTORY OF THE DEVELOPMENT OF TMR FEEDING

Prior to the 1960s, most dairy herds in the United States were housed in stanchion or tiestall barns with concentrates added on top of the forages (i.e., top dressed). That is the system that I, my parents, and my grandparents grew up with, which covers back to before the start of the *Journal of Dairy Science*. Even during my earlier years (1970s) at South Dakota State University (SDSU), we often fed concentrates as a top dress in our research diets. Cows are ruminants and thus designed to utilize forages. Therefore, rations were based on forages—often pasture in the warmer months and hay or silage especially in the cooler seasons. As production per cow increased, it became apparent that cows needed additional nutrients, which were supplemented as concentrates. Several *Journal of Dairy Science* articles through the years (Coppock et al., 1981) attest to various methods of supplying additional

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concentrates. The earliest reference to guidelines for feeding grain appeared in a 1930 extension bulletin by Frazer (cited by Huffman, 1939). Greater refinements in concentrate feeding by many researchers came later. Often the amounts of concentrates fed were based on milk production, such as 1 kg of concentrate/3 kg of milk produced; modifications were based on fat content of the milk, differences due to breed, and additional allotments for growth of younger cows. Such refinements were being put into place by the early 1950s. Concentrates fed typically contained locally available grains (e.g., corn, oats, wheat, barley) plus a protein supplement source (e.g., soybean meal, cottonseed meal, linseed meal). There was often little concern about nutritionally balanced diets other than the need for protein; the need for various vitamins and minerals often got minimal or no attention.

Starting in the 1960s, several concentrate feeding systems were developed in place of topdressing on forages (Coppock et al., 1981). Some of these were quite simple, whereas others were quite sophisticated. One of the earliest systems fed concentrates in relation to the amount of water consumed. A simple system gave cows wearing a magnet on a neck chain access to unlimited amounts of concentrates. More elaborate and accurate systems used computerized programming to determine how much and how often a cow could consume concentrates. Extensive research was conducted in this area during the 1960s and into the early 1980s, but these systems are less used today.

Another interesting aspect of feeding concentrates was density of the ingredients. Feeding was often based on volume by the "scoopful" with no regard to weight per volume. During the early 1960s when I was an undergraduate at the University of Illinois, increasing the amount of concentrates fed was becoming more popular; however, I was unsuccessful in convincing my dad, who was a very good dairy producer, of this until he learned it by accident. One summer we ran out of corn around the time we harvested oats. Rather than buy more corn to maintain our usual corn-oats-soybean meal blend, Dad switched to feeding only oats as the grain ingredient. Around the time he harvested corn he ran out of oats, so he immediately totally replaced ground oats with ground shelled corn but still put the same-sized pile of grain mix in front of the cows. Because corn is denser than oats (0.72 vs. 0.46 kg/L for corn and oats, respectively) and contains more energy per kilogram (3.12 vs. 2.78 Mcal of NE_L /kg; NRC, 2001), Dad was now feeding more grain mix and a grain mix with more energy. This resulted in approximately 74% more NE_L from the concentrate portion of the diet and an immediate increase in milk production from most cows. Increasing the amount of concentrates

fed was becoming more popular in the 1960s; however, excess concentrates that led to insufficient amounts of effective fiber in the diets often resulted in milk fat depression and digestive upsets.

The increased use of milking parlors, starting primarily in the early 1960s, led to additional ration and cow handling systems. The first large-scale milking parlor was the Rotolactor, which is a predecessor to today's rotary parlors. It was developed by Borden in 1930 and installed in the Walker-Gordon Laboratories Farm in New Jersey, where it remained functional until 1971. However, it was not until herringbone-style parlors were developed in New Zealand in the 1950s that milking parlors started to become popular in the United States and elsewhere in the 1960s (Weimar and Blayney, 1994). When I worked as a herd tester in northern Illinois during the summer of 1962, only 1 of the 25 herds I tested used a milking parlor. Today virtually all dairy herds in South Dakota and elsewhere in the United States use milking parlors. Initially, for many herds, some or all of the concentrate was fed in the milking parlor, often as an enticement to get cows into the parlor. This meant that all forages were fed separately from all or some of the concentrates, which sometimes led to digestive upsets and other problems (Rakes, 1969; Coppock, 1977; Eastridge, 2006). Dairy producers soon found that high-producing cows did not have sufficient time in the milking parlor to consume the amount of concentrate needed and that milking time was faster and cleaner without concentrate feeding in the parlor. Thus, few if any dairy operations today include concentrate feeding in the parlor, which means lower costs when building a parlor. However, with the more recent advent of robotic milking systems, dairy producers sometimes feed concentrates in the stall as an incentive to get cows to come into the milking stall.

Another change in cow handling that occurred around the time of milking parlors was increased size of dairy herds. The advent of bulk tanks in the 1950s replaced handling milk in cans and encouraged increased herd size because bulk tanks were a major economic investment (Weimar and Blayney, 1994). For instance, when my parents built a new milk house to accommodate a bulk tank on our Illinois farm, we doubled our herd size to 40 cows. Meanwhile, 4 neighbors quit dairying. We continued with stanchion barns, but larger herd sizes nationwide led to group housing with freestalls or large lots, group feeding, and the advent of partial or total TMR feeding. However, even into the early 1970s, the average dairy herd size in the Midwest and many other areas was only 20 cows; larger herds of several hundred cows could be found in the West and Southwest. Today, herds of several thousand cows can be found in many areas of the United States, Canada, and elsewhere. The

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