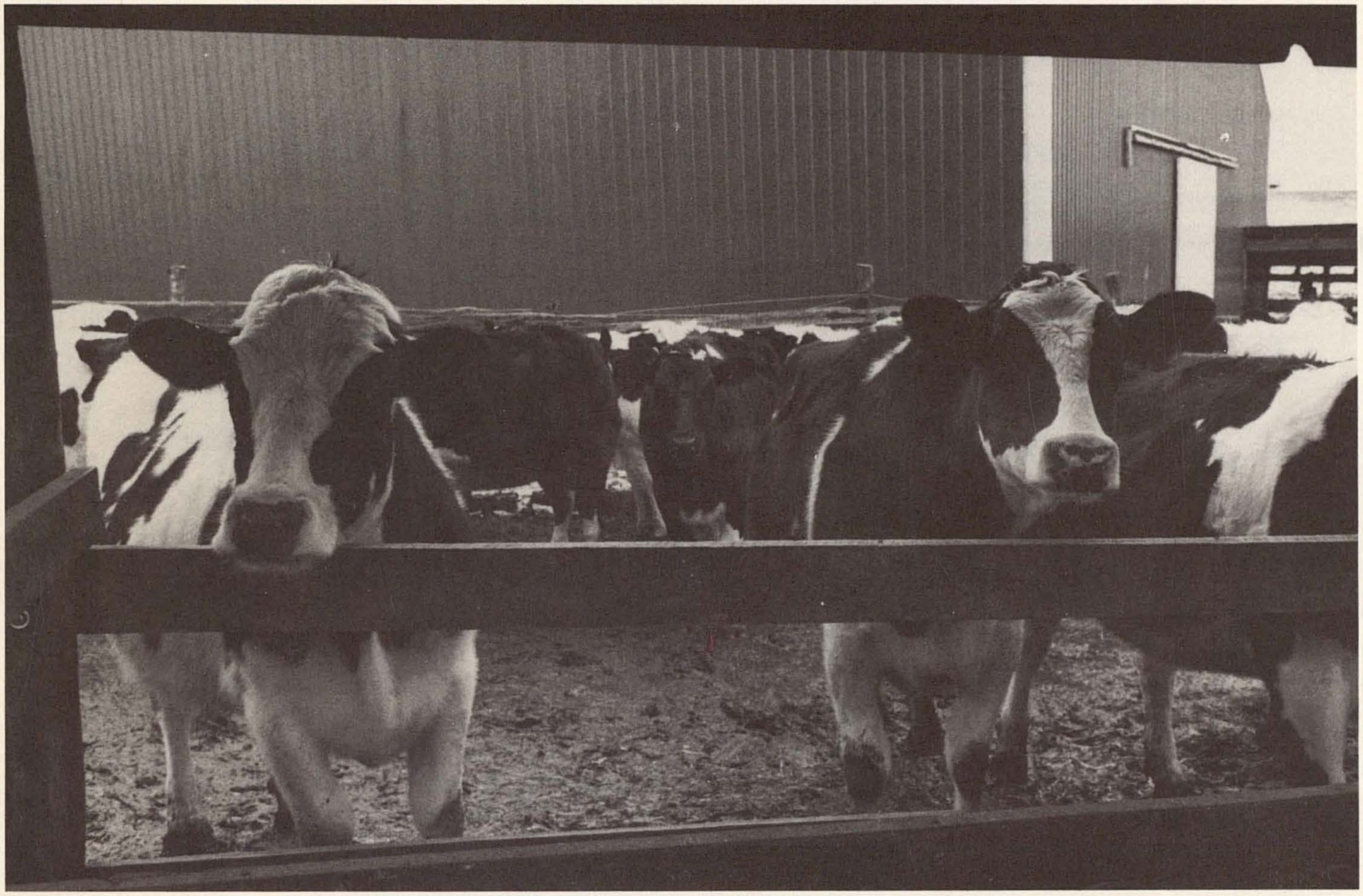
TOTAL MIXED DAIRY RATIONS

Plans, Uses and Economics by Herd Size



Jim Spain
Extension Dairy Specialist
Animal Science Department

Myron Bennett
Agricultural Economist
and
Professor Emeritus
Agricultural Economics Department

David Williams
Extension Agricultural Engineer
Agricultural Engineering Department

Donald Osburn
Professor
Agricultural Economics Department

University Extension Commercial Agriculture Program
Missouri Agricultural Experiment Station

University of Missouri

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Commercial Agriculture Program

MISSOURI AGRICULTURAL EXPERIMENT STATION

Contents

Executive Summary

Feed, the major cost item in dairying, offers an opportunity for managers to control and/or reduce costs by feeding balanced rations according to the level of milk production, reduction of feed wastage, and the use of least costly feed ingredients.

Objectives of this study are to: (1) describe various feeding systems and evaluate advantages and disadvantages of total mixed dairy rations (TMR); (2) provide a list of facilities and equipment, by herd size, needed to prepare, mix and distribute rations; (3) evaluate the economic advantage of a TMR system; (4) identify the minimum size herd needed to feed total mixed rations at an economic advantage; and (5) identify the optimal size herd needed to justify the added investment in facilities and equipment required for storing, processing and feeding total mixed rations.

We investigated the expected benefits and costs associated with a TMR approach in feed preparation and delivery for different size dairy herds (100, 200, 300, 500, 750 and 1,000 cows).

Major conclusions

1. Sizing and coordinating the different parts of a TMR system are very important functions. Errors can result in distorted cost estimates and the system may not perform as expected.

2. Size economies (costs per cow fall as herd size increases) were observed for the TMR system. Most cost savings were realized as herd sizes reached 300; with the maximum advantage associated with a 750-cow herd.

3. Other benefits associated with TMR are improved milk production, reduced feed wastage and increased butterfat content. In spite of conservative estimates, these combined benefits were substantial. Benefit size can vary dramatically depending on current feed preparation and delivery systems, plus the nutritional aspects of current rations. TMR has the potential of correcting current problems in these areas.

4. Cost estimates were based on new equipment required for implementing a TMR system. Dairies may reduce new investment costs substantially by using present tractors (power) and then modifying buildings and equipment. Purchasing used equipment may also reduce system costs. This cost reduction would enhance the profitability and feasibility of TMR relative to our estimates.

5. The cost by herd size shows that cost relative to benefits for small herds (less than 100 cows) would not likely warrant adopting TMR. Again, however, use of current power and equipment could modify our cost estimates dramatically.

6. If expected production gains per cow are at a medium to high level (1500 to 1800 pounds or 8 to 10 percent), then clearly TMR is a profitable system for dairies, regardless of herd size.

Methods and Assumptions

Feed cost is the major expense of the dairy business. Data from the University of Missouri Management Information Records (MIR) program shows feed cost averaged 53.8 percent of the total production costs from 1983 through 1988. These feed costs include replacement heifer feed with home raised feeds priced at the dairy market value. Given the importance of feed cost, feeding and nutrition programs should be designed to meet the needs and goals of the individual farm while allowing flexibility in purchasing and blending feeds.

Herd size influences flexibility in nutritional considerations and feed management systems. Storage, processing and time for feed management differs with feed volume. Commercial dairy rations may be purchased to utilize technical services (i.e. forage testing) and expertise (i.e. ration balancing). When hired labor is required, capital investments to replace labor and improve labor efficiency should be considered. A feed management system designed to fit individual needs should be conducive to animal productivity and health, flexibility and labor efficiency.

The degree of profitability/feasibility is influenced by a number of factors, among which are the status of current nutritional practices, herd health and labor efficiencies. Expected production gains associated with TMR (including changes in butterfat content) were investigated. Benefits from reduced feed waste and labor saving considerations were also noted.

The general approach of this investigation was to specify feed requirements by herd size. Feed ingredients most likely fed (forage and concentrate) to Missouri dairies were identified. Amounts and storage requirements were determined for these ingredients.

Once these requirements were determined, an "engineering approach" was used to appropriately size all facilities and equipment associated with TMR for different herd sizes.

Cost estimates were attached to these new facilities and equipment needs. Quantifying the value of added production gains with annual production assumptions of 18,000 pounds of milk per cow at $11.50 per hundred weight (cwt.) was accomplished by economic analysis. Milk production increases, because of TMR, were specified as percentages of the initial annual production level. Also, benefits from reduced feed wastage were considered (3-5 percent reduced wastage).

All added (marginal) costs associated with TMR were compared to added benefits. This showed the final economic assessment of TMR.

Many basic assumptions were made to evaluate the use and economic advantages of feeding total mixed rations. A discussion of these assumptions follows.

Herd size

Six different herd sizes (100, 200, 300, 500, 750 and 1,000 cows) were used to study the economics of total mixed rations. Missouri's commercial herd size averages 65 to 70 cows. Farmers participating in Missouri's DHI record association are reported below.

Herd size	No. dairy farms
<100	699
100 - 200	145
200 - 300	12
> 400	4

A large number of farms, 81 percent of the total DHI program participants, supports the thesis that the average herd size is fewer than 100 cows. Although average herd size is gradually increasing, only a very small percent of producers have a 1,000-cow herd as a business goal. Therefore, a wide range of herd sizes (100 to 1,000 cows) is addressed by this study; as it provides guidelines and ideas for expansion of dairies to larger sizes as economic conditions warrant business adjustments.

Milk production

We assumed most producers interested in a TMR system would have above average producing herds. According to the USDA, Missouri's average annual milk production per cow was 13,048 pounds in 1989. The national average was 14,244 pounds. Also, in 1989, the top 25 percent of all cows (DHI) had a rolling herd average of 18,997 pounds per cow. The next 25 percent averaged 16,779 pounds. For this investigation, annual milk production of 18,000 pounds per cow was assumed.

Rations and feed ingredients

Daily rations fed to lactating cows consisted of alfalfa hay (9 pounds), alfalfa haylage (18 pounds), grain silage (23 pounds) and concentrates (26 pounds). The concentrate portion of the ration consisted of corn (20 percent) and byproduct feeds [whole cottonseed (18 percent), corn gluten feed (26 percent), soy hulls (18 percent) and distillers grain (18 percent)].

One advantage of a TMR system is the flexibility allowed in changing the ration mix based upon ingredient cost. In practice, the ingredients will not be as fixed as in the assumed ration above or those described in Appendix Table 6.

As stated, forages fed include hay, haylage and silage. Combinations were used to maintain quality during Missouri's changing weather patterns. Alfalfa is harvested as haylage in early summer during the rainy season and as hay during the drier months. Silages are harvested in the fall and can follow wheatlage, wheat hay, etc., which are harvested as the first crop.

New investments and power costs for TMR

Most Missouri dairies were not originally designed for TMR feeding systems. Animal traffic, resting and feeding areas may not be designed to group and handle cattle efficiently. If modification of existing facilities is needed the costs must be charged against the TMR system. Because of variations found on dairy farms, all additional costs may not be included in the economic analysis. However, where buildings can be remodeled, the purchase of used equipment or the use of present equipment may enable producers with small herds to adopt the system at a lower cost than is illustrated in this publication. Regardless, it's important that the added costs be weighed against the potential increases in income from improved milk production and/or decrease in costs. Then it can be determined whether or not the adoption of a TMR system will be profitable for a specific farm.

As a base for economic analysis, we assumed the set-up of a TMR system on most farms would require the purchase of a mixer-wagon with scales capable of handling small amounts of hay, a front-end loader, additional feed storage (commodity barn) for byproduct feeds, a roller mill to process corn, additional bunk space and metal panels for dividing lots.

Section 1

Feeding Systems

James N. Spain
Extension Dairy Specialist

There are as many feeding systems as dairy farms. Each system has its advantages and disadvantages or limitations. The following discussion describes some of the systems commonly found on commercial dairy farms and the pros and cons of each.

Individual animal feeding

Feeding individual cows based on their production level can be done with several different feeding systems: stanchion barns, parlor feeding or electronic feed delivery systems (magnet and computer feeders). Each system can be successful, but each also has its limitations and problems.

In the 1989 Continuing Market Study, published by Hoard's Dairyman, 55.6 percent of the respondents reported they used stanchion or stall-barn housing for their milking herd. With this system, feeds can be blended and fed to individual cows to match production. Feed can also be delivered as forage with grain top-dressed at a given rate based on milk production. Grain delivery systems that allow for the individual feeding of grain several times a day to enhance rumen fermentation are now available. Those with smaller herds might try the tie stall system, although it is more capital and labor intensive.

In Missouri, the most common concentrate delivery system is the parlor feeder. The majority of Missouri dairy producers surveyed in 1988 reported using parlor feeders. In fact, 94 percent fed all (72 percent) or part (22 percent) of the concentrate during milking. While this system allows for individual feeding, there are limitations. First, intake of concentrate in large amounts (slug feeding) can reduce rumen fermentation efficiency. In many cases, the concentrate mix contains large amounts of soluble carbohydrates. With this type concentrate, rumen contents can become acidic, resulting in acidosis, digestive tract ulcers, low milkfat and in some cases off-feed problems. Many cows exhibiting these problems are described as being "up and down" in milk production, never reaching their potential. These problems can be overcome by incorporating fibrous byproducts, that decrease the rumen starch load, into the diet. Rumen buffers may also be useful. Secondly, while this method is considered a labor-saving system, feed and manure clean-up in the parlor after milking can often decrease those savings. Likewise, milking time and labor may increase as animals are allowed to stand and finish the grain allotment. Finally, while in theory individual cows can be fed based on production, in reality this may not be the case. In fact, some cows may have insufficient time to eat the concentrate they require, while cows with later lactations may receive more grain than is needed to keep them "still and quiet" until milking is finished. The overfeeding of grain increases feed cost and can lead to fat cow problems at calving. Parlor feeding is used effectively, but it must be closely managed to minimize the problems discussed above.

Computer feeding

Electronic feeding is also used to feed cows individually. Magnet feeders allow ad libitum intake for cows with magnetic neck chains. However, there is no control over individual intake and slug feeding can occur. Also dominant cows without magnets may bully timid cows for the extra grain. Although this problem can be circumvented by proper stall design, the major limiting factor in this system is no control over individual intake.

Computer feeders are also used for individual feedings. These feeders dispense a predetermined amount of concentrate to individual cows with the levels based on many factors (production, body condition, stage of lactation, age, etc.). Therefore, this system meets the needs of the individual cow. In a 1988 survey by the University of Missouri, dairy producers reported an increase of nearly 1700 pounds per cow when switching to the computer feeders as their primary means of concentrate feeding. Computerized feeding also provides a feed intake record for each cow, which may be used in improving herd health and reproduction programs. These feeders can also blend concentrate mixes for a better balance between intake and requirements. One disadvantage of the computer feeding system is that it must be reviewed and adjusted on a regular basis. And one must remember that computers do only what they are told.

Total mixed rations

As herd size increases; hired labor increases. At the same time, however, there is a need to increase mechanization and maximize labor efficiency. One way to do this has been with total mixed ration or complete blended rations. With this system, diets are mixed so that each bite is part of a balanced diet. With smaller herds, the limiting factor is balancing the TMR for the range of production. Diets too low in energy and protein may limit production of early lactating cows or result in thin cows with lower reproductive efficiency. On the other hand, diets too high in energy and protein can result in overconditioned cows with fat cow problems (ketosis, dystocia, etc.). In larger herds, cows can be grouped more homogeneously to better balance nutrient requirements. In considering the use of TMR, several advantages and limitations should be considered.

Advantages

Compared with grain feeding twice a day, TMR usually increases milk production. Increases of 5 to 10 percent or 1,000 to 2,000 pounds of milk is possible. Improved milk production is associated with improved rumen function with minimized changes in the rumen pH. Sutton, et al., (Br. J. Nutr., 53:117; 1985) reported improved milkfat production during two studies due to the increased frequency of grain feeding. During TMR experiments, there was also a trend towards higher milk production. These experiments involved low fiber and high concentrate diets typical of those fed to early lactating cows. Also associated with TMR versus twice-a-day feeding is an improved milkfat test. This response is again related to improved rumen fermentation and fewer large swings in rumen pH. Sutton, et al. (1985), also found increased milkfat percentage (.1 to .2) and higher fat and protein yields with increased frequency of grain feeding. Protein increases may be related to enhanced microbial efficiency and the subsequential flow of rumen bacteria to the small intestine.

Health problems caused by slug feeding grain may also be reduced. The number of "poor-doers" and off-feed problems are also reduced. This is especially important in achieving peak lactation which affects the total lactation production and is probably associated with reported increases in milk production. Maximizing peak production by minimizing health problems is an important advantage of TMR. Total mixed rations have also been associated with decreased feed waste compared to parlor feeding — one author reported a 5 percent decrease in feed wastage.

So, total mixed rations can be closely balanced to meet nutritional needs and improve animal health which results in improved performance (milk production and milkfat). TMR also allows for flexibility in feed purchasing opportunities. For example, high moisture byproduct feeds that cannot be used in parlor feeders can be used to extend forages in TMR. Unpalatable feedstuffs can also be blended with silage to improve intake. Dry and wet forages can both be used in TMR. Relatively new hay choppers and mixer wagons with knives can be used to incorporate dry hay into TMR systems. This new equipment increases the flexibility of the TMR system. Therefore, total mixed rations can be used to provide balanced diets in a cost effective fashion that are conducive to animal productivity and health while maintaining flexibility in types of feeds purchased and used.

Disadvantages

Total mixed rations do have limitations or disadvantages. First, obviously, is the cost of the system. Section 2 discusses equipment and building requirements. These capital investments must be considered in an economic comparison of alternative feeding systems.

The need to group cows based on nutrient requirements has been discussed. On some dairy farms, facilities and layout of those facilities may limit grouping cows. Grouping cows may also interfere with cow movement to and from the parlor, exercise lot, etc. A few Missouri dairy farms circumvent this problem by feeding a base TMR and supplementing high producing cows with computer feeding. This combination increases feeding system flexibility. Adequate bunk space is also necessary to ensure timid cows (i.e. first calf heifers) adequate feeding time. Any changes in facilities should be considered when comparing and choosing feeding systems.

The level of on-farm expertise must also be considered. If owner/operators cannot balance a diet based on the use of several feed sources and the economics of alternative feed costs, then the services of a nutritional consultant may be required.

Summary

Many feeding systems are presently used on commercial dairy farms. Some of the systems discussed are used in an efficient and profitable manner. However, in many instances, the feeding system (not the quality or quantity of feed) limits the herd's performance. Farm management includes an evaluation of current management systems and the potential for improvement. In designing or planning feeding management changes, many factors must be considered. Overall, the feeding system must match the needs and capabilities of the operation while providing a balanced, healthy and economical diet.

Section 2
Facilities and Equipment

David Williams
Extension Agricultural Engineer

Planning

Careful planning is required for the successful incorporation of facilities and equipment needed in feeding total mixed rations into already existing farmsteads. This is especially true as herd sizes increase. The efficient use of labor and equipment associated with the feeding system is largely determined by farmstead arrangement.

The first step in planning is to prepare a scaled drawing of the farmstead on a large sheet of graph paper. A 17 by 22 inch sheet of paper (10 squares per inch) will accommodate most farmsteads; using a scale of one inch equaling 40 feet. All existing feedlots, silos, feed storages, fences, power lines, water supplies, buildings (including home), waste management structures and drainage patterns should be shown on this drawing.

The second step is to determine the changes desired. These changes should include both immediate and long-term (5 to 10 year) needs. The required sizes of buildings, equipment, lots, etc., should be determined based on sound planning guidelines and experience. This section of the publication is designed to assist you in this process.

Once the dimensions of new facilities and equipment have been determined they should be incorporated into the layout drawing, leaving adequate room for future expansion. Projecting now for long-term needs will likely result in less expensive and better modifications if and when those changes occur. Invariably, a system planned and sized based only on present needs will be difficult and expensive to expand and more costly to operate.

The Midwest Plan Service (MWPS) has publications that provide more details and information related to planning and layout of dairy farmsteads. MWPS-2, Farmstead Planning Handbook, and MWPS-7, Dairy Housing and Equipment Handbook, can be obtained through county extension offices.

Sizing facilities and equipment for different herd sizes

Determining the size of buildings, equipment and other facilities which are part of the feeding system is a somewhat arbitrary procedure. The size and type of facilities and equipment must be consistent with each individual operation and management style. For a given herd size, the rations fed and the proportion of each ingredient in the ration are the overriding factors in determining ingredient storage requirements, equipment size, etc. Herd grouping, labor and capital availability are also important considerations. The following information, data and examples are provided as guidelines to assist producers in planning for their individual operations.

The basic facilities needed for a TMR program include:

1. Silo(s) and/or bags for silage and haylage (not necessary with an all-hay TMR)
2. Shed for hay storage
3. Grain storage/handling
4. Storage for commodity ingredients

Additional feeding equipment needed or desirable includes:

1. TMR feed mixer with scales
2. Roller mill or crimper for processing grain
3. Loader for handling commodities and other ingredients
4. Tractor for pulling mixer wagon
5. Hay shredder or processor

Planning for these facilities and equipment will be discussed in this section as a background to the economic analysis.

Silage and haylage storage

For this analysis, horizontal silos were selected as the method of storing silage and haylage. For the range of herd sizes used, it appears that with proper management, this method results in lower costs per ton of for-

Table 1. Recommended Sizes for Horizontal Silos with Daily Silage Feeding

Dry matter in 4-in. slice (lbs.)	Face area (sq. ft.)	Silo height and width (ft. x ft.)	Capacity* (wet tons per 120 ft.)**
800	170	8 x 21	410
900	195	8 x 24	460
1000	215	10 x 21	510
1100	235	10 x 24	570
1200	257	10 x 26	620
1400	300	12 x 25	720
1600	345	12 x 30	850
1800	385	12 x 32	925
2000	430	12 x 36	1030
2200	470	12 x 40	1150
2400	515	12 x 43	1240
2600	560	14 x 40	1340
2800	600	14 x 43	1450
3000	645	14 x 46	1550
3500	750	16 x 47	1800
4000	860	16 x 54	2070
4500	965	16 x 60	2300
5000	1070	16 x 67	2570
6000	1290	16 x 80	3070

*Capacity is level-full volume for 35 percent dry matter.

**Length based on 4-inch daily removal x 360 days.

age than upright silos.

In determining silo sizes, it was assumed that both grain silage and haylage would be fed. This means at least two horizontal silos will be needed for each herd regardless of herd size. It was also assumed that a minimum thickness of 4 inches in silage and 5 to 6 inches in haylage would be removed daily to minimize freezing and spoilage. This fixes silo lengths at 120 feet for silage (.33 feet/day x 360 days = 120 feet) and 150 feet for haylage (5/12 feet/day x 360 days = 150 feet). Average packed silage density of 40 pounds per cubic foot and haylage density of 30 pounds per cubic foot were used in capacity calculations. With the overall silo length fixed, only the silo depth and width varies. If terrain or other factors limit silo length to less than 120 or 150 feet, divide the required storage between two silos, keeping the total length of both silos combined equal to 120 feet for silage and 150 feet for haylage.

Tables 1 and 2 give recommended horizontal silo sizes for silage and haylage, respectively. In using these tables to estimate silo dimensions, calculate the total dry matter weight of silage and haylage consumed daily. Then find the "dry matter slice" in the left column of Table 1 or 2 which most closely matches that daily consumption. Any combination of silo height and width which equals the "face area" corresponding to the chosen "dry matter slice" will work. Silo heights of 8 to 16 feet are typical. One possible combination of height and width are given for each dry matter slice and face area.

Example

Find silo sizes for a 200-cow herd using the daily ration shown in Table 6 of the Appendix.

Each cow is fed 23 pounds of silage and 18 pounds of alfalfa haylage daily (as-fed weight). This is 4600 pounds of silage (23 pounds x 200 cows) and 3600 pounds of haylage (18 pounds x 200 cows). Assuming 35 percent DM for silage and 45 percent dry matter (DM) for the haylage, the daily dry matter consumption is 1610 pounds of silage and 1620 pounds of haylage.

From Table 1 for silage, the nearest "dry matter slice" to 1610 pounds is 1600 pounds, with a corresponding face area of 345 square feet and a suggested height of 12 feet and width of 30 feet. (Remember that the length is fixed at 120 feet for a 4-inch daily slice.) This silo would have a level capacity of 850 wet tons.

From Table 2 for haylage, find the "dry matter slice" of 1600 pounds (compared to the calculated daily consumption of 1620 pounds), with a corresponding face area of 282 square feet and a suggested height of 10 feet and width of 28 feet. Note, if it is desirable for this silo to have the same 12 feet height as the first silo, the silo width would have to be 24 feet (282 square

Table 2. Recommended Sizes for Horizontal Silos with Daily Haylage Feeding

Dry matter in 5-in. slice (lbs.)	Face area (sq. ft.)	Silo height and width (ft. x ft.)	Capacity* (wet tons per 150 ft.)**
800	141	8 x 18	320
900	159	8 x 20	360
1000	176	8 x 22	400
1100	194	8 x 24	430
1200	212	8 x 27	490
1400	247	10 x 25	560
1600	282	10 x 28	630
1800	317	10 x 32	720
2000	353	10 x 35	790
2200	388	10 x 39	880
2400	423	10 x 42	950
2600	459	12 x 38	1030
2800	494	12 x 41	1110
3000	529	12 x 44	1190
3200	564	12 x 47	1270
3500	617	14 x 44	1390
4000	705	14 x 50	1580
4500	794	14 x 57	1800
5000	882	14 x 63	1980
6000	1058	14 x 76	2400

*Capacity is level-full volume for 45 percent dry matter.
**Length based on 5-inch daily removal x 360 days.

feet ÷ 12 feet) to maintain the 5-inch daily slice.

For this example, the estimated silo sizes would be:

For silage: 12 feet deep x 30 feet wide x 120 feet long
For haylage: 10 feet deep x 28 feet wide x 150 feet long
or 12 feet deep x 24 feet wide x 150 feet long

In general, use the deepest practical silo. Deeper silos result in better packing and lower losses. On the other hand, the initial cost per ton will usually be less for a shallow, wide silo than for a deep, narrow silo due to the extra cost of forming and reinforcing associated with constructing tall walls. Also, the safety in loading and unloading is an important consideration with deeper silos. So using trench silos (walls partially or completely below ground level) can be safer and more convenient due to the natural ramp on the uphill end.

Table 3. Estimated Silo Dimensions for Various Herd Sizes

Herd size (cows)	Silage silo (ft. x ft. x ft.)	Haylage silo (ft. x ft. x ft.)
100	8 x 21 x 120	8 x 18 x 150
200	12 x 30 x 120	12 x 24 x 150
300	12 x 43 x 120	12 x 36 x 150
500	16 x 54 x 120	14 x 50 x 150
750	16 x 80 x 120	16 x 66 x 150
1000	16 x 54 x 120 *	14 x 50 x 150*

*Two silos of this size required.

Using the above procedure, estimated silo sizes were determined for herd sizes from 100 to 1,000 cows assuming the daily ration given in Appendix Table 6. The results are given in Table 3.

Hay storage

Hay storage requirements are based on densities of 265 cubic feet per ton for alfalfa hay and 290 cubic feet per ton for mixed hay. These densities are based on stacked small square bales. The total annual storage volume needed is determined by multiplying the yearly tonnage of each hay type fed times the appropriate density and then adding the volume of alfalfa hay to the volume of mixed hay.

Most pole hay storage sheds have either 17-foot or 20-foot sidewalls. Plans for these sheds are available through University Extension Offices. The buildings described in these plans have a 17-foot interior clearance with clear-span construction.

As herd size increases, it is less likely that all of the herd's hay requirements can be produced on the farm. For this analysis, assume storage on the farm for 50 percent of the annual requirement for the 100- and 200-cow herd sizes, and 25 percent storage for the 300-cow and larger herds. For smaller herds, storage is not needed for 100 percent of the alfalfa production since hay is being fed during the 4- to 5-month growing and harvesting season.

Example

Determine the approximate annual hay storage requirements and storage shed dimensions for a 200-cow dairy herd using the ration in Appendix Table 6.

The herd would be fed 275 tons of alfalfa hay (line 10) and 420 tons of mixed hay (line 13) annually. The estimated storage volume for a year's supply of alfalfa is 73,000 cubic feet (275 tons x 265 cubic feet per ton). The volume required for mixed hay is 122,000 cubic feet (420 tons x 290 cubic feet per ton). The total volume requirement for both types of hay is 195,000 cubic feet (73,000 + 122,000). Assume storage size will be for only 50 percent of this volume or 98,000 cubic feet.

If the storage shed has 17-foot sidewalls, the shed floor area needed is 98,000 cubic feet divided by 17 feet, or 5750 square feet. If the building width is 48 feet, the length must be 120 feet. (5750 square feet ÷ 48 feet wide). Similar calculations can be made for a build-

Table 4. Hay Storage Shed Dimensions for Various Dairy Herd Sizes

Herd size (cows)	Shed clearance (ft.)	Shed width and length (ft. x ft.)
100 *	17	40 x 80
	20	36 x 68
200 *	17	48 x 120
	20	48 x 102
300 **	17	48 x 144
	20	48 x 240
500 **	17	48 x 240
	20	48 x 200
750 **	17	48 x 360
	20	48 x 300
1000 **	17	48 x 480
	20	48 x 400

*Dimensions based on 50 percent of annual herd hay requirements.

**Dimensions based on 25 percent of annual herd hay requirements.

ing with 20 foot clearance, resulting in dimensions of 48 foot wide x 102 foot long.

Table 4 shows estimated hay storage requirements for all herd sizes. These requirements are based on the hay component of the ration shown in Appendix Table 6.

Grain storage

Many factors affect the grain storage volume needed on a dairy farm. Economic factors and grain prices play an important role in determining the amount of grain to store on the farm at any one time. These factors are discussed elsewhere in this publication. Also, it is more difficult to maintain the grain quality when stored over long periods of time. For the purposes of this analysis, it was assumed the entire annual grain usage would be purchased at one time for herd sizes up to and including 300 cows. For larger herds, storage plans included an 8 month supply. This allows most of the grain to be purchased at harvest when prices are usually lowest. Another alternative is to contract purchase (lock in), so that on-farm grain storage is not so large.

For large volumes of grain (over 3,000 bushels) it is beneficial to equip the grain storage structure with aeration fans and ducts to help maintain the temperature and quality of the grain. From a handling standpoint, the most convenient form of grain storage is a conventional round steel bin set on a concrete foundation. The information in Table 5 is for this type of storage.

As with other ingredients, the estimated annual supply of corn is the daily amount per cow multiplied by the herd size and then multiplied by 305 days (to account for the dry period). The conversion from pounds to bushels is 1 bushel = 56 pounds for both corn and grain sorghum. The conversion from tons to bushels is 1 ton = 35.7 bushels. A base moisture content of 15.5 percent for corn was used to obtain these conversions.

Example

Estimate the bin size required for a 200-cow dairy herd using the ration in Appendix Table 6 and assuming purchase of a 12 month grain supply at harvest.

From Line 15 of Appendix Table 6, each cow is fed 1634 pounds of corn annually (during lactation and dry period). The entire herd is fed 163 tons annually (1634 pounds/cow x 200 cows ÷ 2,000 pounds/ton). Converting to bushels, 163 tons X 35.7 bushels/ton = 5800 bushels. A bin or combination of bins would be chosen to provide about 6,000 bushels of grain storage.

Table 5 shows bins and combinations of bins in storing grain for different herd sizes. Although the initial cost per bushel of storage volume is usually lower for a single large bin, having more than one bin provides some flexibility in management.

Table 5. Suggested Grain Storage Capacities

Herd size (no. cows)	No. bins	Bin capacity (bu.)	Bin diameter and height (ft. x ft.)
100	1	3,000	18 x 16
200	2	3,000	18 x 16
300	2	4,500	21 x 16
500 *	2	5,000	21 x 18
750 *	2	7,000	24 x 20
1000 *	2	10,000	30 x 18

*Storage volume calculated for an 8 month supply.

Commodity (byproduct) storage

The full economic benefits of TMR feeding requires commodity storage in truckload quantities. The physical characteristics, primarily flowability, of most commodity ingredients prevents them from handling well in conventional feed storage structures such as hopper bottom bins. Using flat storage for these commodities allows fast unloading from trucks and easy movement from storage to the feed mixer.

Table 6 shows the approximate number for truckloads for commodities used annually in the rations shown in the Appendix for various herd sizes. The values will change as the number of commodities included in the ration and the amount fed per cow changes.

Table 6. Approximate Annual Commodity Consumption (truckloads)

	Herd size, (no. cows)					
Commodity	100	200	300	500	750	1000
Cottonseed[1]	3	7	9	15	22	30
Corn gluten[1]	4	9	13	21	32	43
Soy hulls[2]	4	7	10	17	25	34
Dist. grain[3]	4	8	11	19	28	37

[1]25 tons per truck load.
[2]22 tons per truck load.
[3]20 tons per truck load.

When the values in Table 6 are divided into 52, the length of the annual storage period for the commodity can be estimated. This period varies from about 4 months for cottonseed feeding 100 cows, to just over a

Table 7. Approximate Commodity Storage Period (weeks per truckload)*

Commodity	Herd size (no. cows) 100	200	300	500	750	1000
Cottonseed	17	9.0	6	3.5	2.5	2.0
Corn gluten	13	6.0	4	2.5	1.5	1.0
Soy hulls	13	7.0	5	3.0	2.0	1.5
Dist. grain	13	6.5	5	2.5	2.0	1.5

*Using capacities from Table 6.

week for corn gluten feeding 1,000 cows.

Storage periods are shown in Table 7. These values are only estimates since the density of commodities and the tonnage per truck load will vary load to load, even for the same commodity. For herd sizes below 200, it may be more practical to split a truckload with a neighbor. This would decrease the amount of storage volume needed and in some cases, provide fresher feed.

Determining the needed commodity storage volume is not a straightforward process. Much depends on byproduct prices, transportation costs and availability. Table 8 provides some suggested configurations of storage for commodities based on the ration used in the previous examples. Suggestions for larger herds include extra storage bays to provide some flexibility in receiving and storing commodities.

Table 8. Suggested Commodity Storage Shed Sizes*

Herd size (no. cows)	No. of shed bays	Shed dimensions (ft. x ft.)
100	4	40 x 48
200	4	40 x 48
300	4	40 x 48
500	5	40 x 60
750	6	40 x 72
1000	6	40 x 72

*Based on MU Plan no. 1-904-C7 available from Agricultural Plan Service, 205 Agricultural Engineering Building, University of Missouri, Columbia, MO 65211

Feed milling

Nutritionists say dairy cows should not receive finely ground grain in their ration. With this in mind, milling costs can be reduced by using roller mills or crackers instead of hammer mills. The required mill capacity can be determined from the amount of grain in the ration and the desired frequency of mill operation (daily, weekly, etc.). The required horsepower will depend on the type of mill used, the type of grain processed and the screen size (hammer mill) or number of roller grooves (roller mill).

If grain is processed less frequently than the feeding frequency, some storage is needed for processed grain. Processing frequency is a compromise between using equipment and labor efficiently and maintaining fresh feed. In this analysis, once-a-week processing for grain was assumed.

The approximate capacities of the roller mills in Table 9 for processing dry shelled corn are: 3 horsepower mill, 225 bushels/hour; 5 horsepower mill, 335 bushels/hour; 7.5 horsepower mill, 550 bushels/hour; 15 horsepower mill, 850 bushels/hour. Mill capacities were selected to limit grain processing time to approximately one hour or less per week. Actual capacities will vary with mill type, grain type, screen size, roll size and grain moisture.

Table 9. Feed Processing Capacities for Shelled Corn

Grain consumption			Processing roller mill		
Herd size	Tons/ day	Tons/ week	Bu./ week	Labor (hr./wk.)	Size (hp)
100	.22	1.54	55	.5	3.0
200	.45	3.15	112	1.0	3.0
300	.67	4.69	167	1.0	5.0
500	1.12	7.84	280	1.0	7.5
750	1.68	11.76	420	1.2	7.5
1000	2.24	15.68	560	1.0	15.0

Selection of feed mixing equipment

Feeding TMR essentially limits mixers to horizontal mixers capable of handling a variety of ingredients, including roughages. Although stationary horizontal mixers can be used, the need to deliver mixed feed to a large number of cows often grouped by production seems to favor portable mixing and delivery equipment. A portable TMR mixer also allows more flexibility when locating feeding and feed storage areas. A mixer equipped with electronic scales is an absolute necessity for a TMR feeding system.

Many portable mix-wagons currently on the market are capable of mixing long-stemmed hay with silage/haylage and other ingredients as long as the amount of hay in the ration doesn't exceed 8-10 percent. However, these mixers will not appreciably reduce the stem length of hay. If size reduction of hay is desired, a specialized hay shredder or processor is needed to prepare the hay for mixing. For this analysis, it is assumed the hay is processed in a mixer rather than preprocessed by a separate piece of equipment. It is also assumed that baled hay is hand fed into the mixer.

Portable mixers can be either truck mounted or trailer type powered by tractor. The trailer type has a lower initial cost and allows the tractor power unit to be used for jobs other than feeding. But as herd size and the amount of time spent feeding increases, the truck mounted mixer may be more advantageous. For this analysis, the trailer type mixer is used for all herd sizes, with the power unit cost charged only for the amount of time used in the feeding operation.

Mixers should be sized according to the ration fed, the number of cows in each feeding group and the frequency of feeding. Since these factors will vary for each producer, mixer size selection should be done individually. Two farms with the same herd size may require significantly different mixer capacities due to differences in feeding programs or herd groupings.

Mixers are rated in terms of volume, either cubic feet or bushels. It is usually more convenient to use cubic feet. Mixer manufacturers will typically list a struck capacity and a mixing capacity. The struck capacity is the volume when the feed is level with the top of the sides. The mixing capacity is the volume at or near the top of the mixing devices (augers, paddles, etc.) and is 75-80 percent of the struck capacity. Mixers should be sized based on mixing capacity rather than struck capacity. Filling the mixer beyond its mixing capacity will increase mixing time, decrease mixing uniformity and may even increase feed wastage.

TMR density in the mixer is between 15 and 20 pounds per cubic foot, depending on the ingredients. A TMR with silage and/or haylage, but little or no dry hay, will weigh approximately 20 pounds per cubic foot. A TMR containing 8 to 10 percent hay in addition to wet roughages will have a density of about 15-16 pounds per cubic foot after mixing. Using these figures, a mixer rated at 200 cubic feet of mixing capacity will hold about 2 tons of TMR without hay, but only about 1.5 tons of TMR containing hay.

Example

Determine an appropriate mixer size for a 200-cow dairy herd fed the ration in Table 6 of the Appendix. Assume two feedings per day and three production groups for lactating cows.

From Appendix Table 6, each lactating cow is fed 76 pounds of ration, and there are 160 lactating cows in three equal groups. Each group has approximately 53 cows. Although the actual ration and amount fed may vary by group, assume 76 pounds x 53 cows = 4028 pounds fed daily per group. This ration requires 4028 pounds ÷ 16 pounds per cubic foot = 250 cubic feet of volume. Since feeding occurs twice daily, only half this volume or 125 cubic feet is required per feeding. This is the minimum mixing capacity needed for the mixer. The minimum struck level capacity would be 25 percent larger or 150 cubic feet. The mixer chosen should be as close to these specifications as possible. A slightly larger mixer capacity would allow for more cows per group if group sizes were not equal. For example, a 200 cubic foot mixer (struck capacity) would mix the ration for about 70 cows (200 cubic feet x .8 x 16 pounds per cubic feet ÷ 38 pounds per cow per feeding = 67 cows).

Table 10 provides mixer capacity guidelines for different herd sizes and feeding groups. The capacities are based on a twice per day feeding frequency and the labor requirements are based on time to load ingredients into mixer, mix and distribute to bunks.

Table 10. Mixer Capacity and Labor Guidelines for Total Mixed Ration Feeding

	Herd size (no. cows)[1]					
	100	200	300	500	750	1000
Mixer capacity (cu. ft.)	100[2] (125)[3]	125[2] (150)[3]	150[2] (200)[3]	200[2] (250)[3]	250[2] (300)[3]	250[2] (300)[3]
No. feeding groups	2	3	4	5	6	8
Loads/group	2	2	2	2	2	2
Loads/day	4	6	8	10	12	16
Labor/day[4]	3.0	4.5	6	10	12	16

[1]Total number cows in herd. Total cows fed TMR equals 80 percent of herd size. Number of cows fed per mixer batch is herd size times .8 divided by number of feeding groups.
[2]Mixing capacity.
[3]Struck capacity.
[4]Hours. Assumes 45 minutes per load for mixing and delivery to bunk for herd sizes of 300 cows or less and one hour per load for herd sizes greater than 300 cows.

Using hay in the TMR

Most TMR mixers currently on the market are designed to work best with rations that are approximately 50 percent silage and/or haylage. As mentioned earlier, some mixers are designed to handle small amounts (up to 10 percent of the ration) of dry long-stemmed hay. But adding too much dry hay in these mixers results in poor mixing and ingredient separation during transporting and unloading.

As the amount of hay in the ration increases, it is important that the hay be chopped, cut or somehow processed to reduce stem length for better mixing and increased palatability. There are two ways to process hay: One is to use a mixer designed to cut hay, and the other way is to process hay using specialized equipment before it is placed in the mixer.

Where it is not feasible to feed good quality silage or haylage, balancing the TMR by feeding dry alfalfa hay as the only roughage is certainly possible. When all of the TMR ingredients are dry, adding water is a good way to get the ingredients to stick together and at the same time improve ration palatability.

Another problem with the hay based TMR is the bulkiness of the dry hay. A typical hay TMR would be about one-third hay, one-third water and one-third concentrate. With this much hay, the mixer capacity needs to be one-third larger than for rations containing silage and haylage. For instance, a hay TMR for the 200-cow herd in the previous example would require a mixer capacity of 207 cubic feet .

Also additional labor and capital investment for equipment is required in handling a hay-based TMR. Mixers designed to chop large amounts of hay are about 50 percent more expensive than conventional TMR mixers of similar capacity. If a conventional TMR mixer is used, special equipment, facilities and power are necessary to process and store the hay before mixing. And in either case, a system for adding water to the TMR is required. Additional labor will likely be needed for handling water and hay. But the additional costs associated with a hay-based TMR are often offset by the elimination of investments for facilities in storing silage and haylage.

Table 11. Feeding System Components and Estimated Initial Costs (continued on page 14.)

	Size	Capacity	Estimated dollar investment
100-cow herd			
1. Horizontal Silo (corn silage)	8'x21'x120'	410 tons	$10,250
2. Horizontal Silo (haylage)	8'x18'x150'	320 tons	10,600
3. Hay Storage	17'x40'x80'	3200 sq. ft.	16,000[1]
4. Grain Storage (1 bin)	18' dia. x 16'	3,000 bu.	5,000
5. Commodity Storage (4 bays)	40'x48'	1,920 sq. ft.	16,000[2]
6. Roller Mill	3 hp	225 bu./hr.	3,500
7. Mix wagon w/scales	100 cu. ft.[3]	——	7,200
8. Front-end loader	5' wide	——	3,600
200-cow herd			
1. Horizontal Silo (corn silage)	12'x30'x120'	850 tons	$21,250
2. Horizontal Silo (haylage)	12'x24'x150'	630 ton	20,800
3. Hay Storage	17'x48'x120'	5760 sq. ft.	28,800[1]
4. Grain Storage (2 bins)	18' dia. x 16'	6,000 bu	10,000
5. Commodity Storage (4 bays)	40'x48'	1,920 sq. ft.	16,000[2]
6. Roller Mill	3 hp	225 bu./hr.	3,500
7. Mix wagon w/scales	125 cu. ft.[3]	——	7,700
8. Front-end loader	6' wide	——	3,900
300-cow herd			
1. Horizontal Silo (corn silage)	12'x43'x120'	1240 tons	$24,800
2. Horizontal Silo (Haylage)	12'x36'x150'	1000 tons	27,000
3. Hay Storage	17'x48'x144'	6912 sq. ft	34,560[1]
4. Grain Storage (2 bins)	21' dia. x 16'	9,000 bu.	12,600
5. Commodity Storage (4 bays)	40'x48'	1,920 sq. ft.	16,000[2]
6. Roller Mill	5 hp	335 bu./hr.	4,000
7. Mix wagon w/scales	150 cu. ft.[3]	——	8,100
8. Front-end loader	6' wide	——	3,900

[1]Hay storage costs based on an estimated initial investment of $5 per square foot of building space.

[2]Commodity storage costs based on an estimated initial investment of $4,000 per 12 x 40 foot bay, or $8.33 per square foot of floor area.

[3]Mixing capacity of TMR mixer.

Table 11. Feeding System Components and Estimated Initial Costs (con.)

	Size	Capacity	Estimated dollar investment
500-cow herd			
1. Horizontal Silo (corn silage)	16'x54'x120'	2,070 tons	$31,000
2. Horizontal Silo (Haylage)	14'x50'x150'	1,580 tons	31,000
3. Hay Storage	17'x48'x240'	11,520 sq. ft.	57,600[1]
4. Grain Storage (2 bins)	21' dia. x 18'	10,000 bu.	13,600
5. Commodity Storage (5 bays)	40'x60'	2,400 sq. ft.	20,000[2]
6. Roller Mill	7.5 hp	550 bu./hr.	4,500
7. Mix wagon w/scales	200 cu. ft.[3]	———	11,500
8. Front-end loader	6' wide	———	3,900
750-cow herd			
1. Horizontal Silo (corn silage)	16'x80'x120'	3,070 tons	$38,000
2. Horizontal Silo (Haylage)	16'x66'x150'	2,380 tons	40,000
3. Hay Storage	17'x48'x360'	17,280 sq. ft.	86,400[1]
4. Grain Storage (2 bins)	24' dia. x 20'	14,000 bu.	17,200
5. Commodity Storage (6 bays)	40'x72'	2,880 sq. ft.	24,000[2]
6. Roller Mill	7.5 hp	550 bu/hr	4,500
7. Mix wagon w/scales	250 cu. ft.[3]	———	13,000
8. Front-end loader	7' wide	———	4,300
1,000-cow herd			
1. Horizontal Silo (corn silage)	16'x54'x240'	4,140 tons	$62,000
2. Horizontal Silo (Haylage)	14'x50'x300'	3,360 tons	62,000
3. Hay Storage	17'x48'x480'	23,040 sq. ft.	115,200[1]
4. Grain Storage (2 bins)	30' dia. x 18'	20,000 bu.	21,400
5. Commodity Storage (6 bays)	40'x72'	2,880 sq. ft.	24,000[2]
6. Roller Mill	15 hp	850 bu/hr	5,750
7. Mix wagon w/scales	250 cu. ft.[3]	———	13,000
8. Front-end loader	8' wide	———	4,800

[1]Hay storage costs based on an estimated initial investment of $5 per square foot of building space.

[2]Commodity storage costs based on an estimated initial investment of $4,000 per 12 x 40 foot bay, or $8.33 per square foot of floor area.

[3]Mixing capacity of TMR mixer.

Section 3

Economic Analyses

Myron Bennett
Professor Emeritus and Agricultural Economist
and
Donald D. Osburn
Professor of Agricultural Economics

Section 3 is divided into two major parts. The first part emphasizes the cost of feeds coming out of storage, equipment requirements, and costs to prepare, mix and distribute feed to the herd. The latter section provides an economic analysis of TMR as to the expected benefits and costs for various levels of milk production and potential profit per cow based on different herd sizes. Appendix tables are extensively referenced for details.

Methodology and Procedure

Section 2, entitled "Facilities and Equipment," provided the basic investment information by herd size for this economic analysis. Section 2 is available to help producers size their equipment and facilities as they develop expansion plans. The size of horizontal silos needed for the year-around feeding of haylage and silage, hay storage structures (to store 50 percent of the needs for herds up to and including 200 cows and 25 percent of storage requirements of hay for herds of 300 to 1,000 cows) and grain storage for an 8-month supply of corn are discussed. Sizes of storage buildings for commodity byproducts are suggested. Roller mills, mixer wagons and electric motor horsepower requirements are also included. Costs of these buildings and machinery are based upon 1990 cost estimates. These costs were used to prepare the the analytical data reported in the appendix tables.

Cost of forage feeds and corn out of storage

Feeds vary in value depending on their average annual value at harvest, storage losses and the cost of storage facilities. The objective in producing Appendix Tables 1 through 5 is to illustrate how feeds can be priced out of storage, standing in the field or harvested and placed in storage. This provides comparable data necessary to appropriately analyze costs associated with ration formulation and feeding alternatives.

An alfalfa crop is a good example (Appendix Table 1). Approximately $20 per ton is added to the harvest time price for storage losses and building storage costs. For producers who own storage, purchasing hay to be delivered during harvest time at $73 per ton or less can be a profitable advantage. If storage is not available and hay can be purchased as needed for an average price of $93 per ton or less, purchasing as needed can be more economical. The $10.96 per ton building storage costs for alfalfa hay assumes all hay is stored. Actually, all hay fed is not stored during the full season because it is either fed during the harvest season or, as with larger herds, purchased and fed over a period of months. Based on the assumption that only 50 percent of the alfalfa hay required is stored during the full season (i.e. the hay turns two times per year), the building storage cost would be $5.48 per ton or less for the total tonnage fed. The actual storage cost would be $2.74 per ton for herds of 300 cows or more, assuming only 25 percent of the hay is stored. These price calculations illustrate that each producer will have to adjust the price based upon length of storage, quantity stored and the average market price for purchased hay. This same type of adjustment can be applied to mixed hay in Appendix Table 2.

In comparison, alfalfa haylage [45 percent dry matter (DM)] is worth 45 to 50 percent of alfalfa hay value from storage (see Appendix Table 4, line 12). The standing alfalfa crop is worth $22 to $23 per ton (45 percent DM basis). These example costs are based on an average yield of 8 tons of 45 percent DM haylage per acre and a market price of $73 per ton for alfalfa hay at harvest (80 percent DM).

And does it pay to store corn in Southwest Missouri? The answer to this often asked question is yes; if the cost of corn increases more than 70 cents per bushel from harvest to mid-winter. Dairies in North and Southeast Missouri do not have the 30 cents per bushel trucking charge because they are not in grain deficit areas. (See Appendix Table 5 for an itemized list of costs.) If the average price of corn does not advance 60 to 70 cents per bushel, buying as needed, with minimum storage, may be the most profitable. Also, buying as needed would ensure high quality grain. Keeping stored grain in top condition is one problem of storing grain at harvest.

Estimated quantities of forage and concentrates by herd size

These quantities were calculated so storage facilities, machinery and equipment needed for feed preparation and distribution could be sized according to volume (see Section 2, "Facilities and Equipment"). Also, based on these quantities, feed costs per cow and per ton were calculated and reported in Appendix Table 13 for each herd size.

Facilities and equipment requirements for TMR

Section 2 discusses procedures for sizing feed storage, processing and delivery equipment. Total units of feed per cow and by herd size are reported in Appendix Table 6. The list of machinery, equipment and storage facilities needed to prepare, mix and distribute these feeds for each herd size are reported in Appendix Table 9. The listed items and their costs were transferred from the information provided in Section 2, Table 11. Capital invested in new facilities results in annual fixed costs such as cost recovery (depreciation), interest, taxes, insurance and repairs. These costs were calculated and also reported in Appendix Table 9. In addition, Table 9 includes a calculation of added dollars for cash flow (line 9) when capital is borrowed.

Cost of each ingredient per ton as fed

The objective of Appendix Table 10 was to develop a cost per ton for each feed ingredient as it is fed to the dairy herd. All costs per ton including delivery cost, building storage costs, handling losses, insurance and interest (12 percent annual percentage rate was assumed) to cover holding periods that are reported on line 9. These costs provide an opportunity to compare ingredients on an as-fed basis. Alternative feeds can also be compared to these costs. For example, the cost of a complete 16 percent crude protein dairy concentrate (Brand X) costing $145 can be compared to the cost of the farm grain mix costing $132 per ton (Appendix Table 11). This comparison illustrates that the on-farm mixed ration costs $13 less per ton. These costs do not address the possibility of a volume discount with byproduct feeds that may be possible with larger herds. For example, least-cost rations formulated at the farm have shown as much as a $50 per ton savings by using byproduct feeds compared with a complete commercial dairy grain ration. Also it is difficult to determine the added value (fiber, fat and oils) of using byproduct feeds in the total mixed ration.

Labor costs

Estimated total hours required to load, mix and distribute the daily ration are reported in Table 10 of Section 2. These hours are based on two daily feedings and the number of feeding groups assumed for each herd size. The number of hours assumes 45 minutes per load in mixing and delivery to the bunk for herd sizes up to 300 cows and one hour per load for herd sizes greater than 300 cows. Larger herds require more time per load because of distances to the lots and the number of gates to open, etc. Also, a larger mixer requires more time to load and unload.

The average cost of labor was calculated at $5.50 per hour. Labor costs will vary depending on availability of off-farm jobs within the community. The $5.50 per hour includes the employer's share of social security taxes but does not include housing costs, meals, utilities, etc., that may provided in addition to the hourly wage.

Marginal power and labor costs for the TMR system

Tractor power costs were calculated by multiplying the total (fixed and variable) costs per hour of operating the tractor based upon horsepower times the estimated hours required to load, mix and distribute the feed to each size herd. (See Appendix Table 12.)

The estimated total power and labor costs to prepare and deliver the daily ration are shown on lines 8 and 9 of Appendix Table 13. The marginal (added) cost estimates of power and labor are approximately 50 percent of total costs. Any feeding system will require power and labor to distribute feed, so 50 percent was used for the following reasons:

1. Milking time efficiency. Cows are not fed concentrates in the parlor, which reduces the total time they are in the parlor. (In a 1988 Northern U.S. dairy survey, over 72 percent of Missouri farms reported feeding cows in the parlor.)
2. Parlor clean-up time reduced. Less parlor time reduces animal waste and feed wastage. So less labor is required to clean up the parlor.

Items 1 and 2 reduce labor costs, not power costs.

3. The added power costs associated with the TMR should not be more than 50 percent of total costs due to loading and distributing all feed.

In summary, we assumed that only 50 percent of the reported total labor and power costs should be charged to the TMR system. Each individual operator can compare the feeding time to the time reported in Section 2, Table 10, page 12. Furthermore, the marginal analysis that follows is based on these assumptions. (See Table 6, page 21.)

Milk price

The average (projected) price of $11.50 per cwt. (conservative estimate) for milk testing 3.5 percent was used. One ratio greatly influencing investment profitability in dairying is the milk-feed price ratio (pounds of 16 percent crude protein dairy ration equal in value to one pound of milk). Nationally, this ratio averaged 1.73 for the period 1980-89. The ratio used in our analysis is 1.59 ($11.50 per cwt. milk ÷ $7.25 per cwt. for 16 percent commercial dairy feed). This recent history indicates that the relationship between producer milk price and concentrate has been more favorable than the relationship projected in this analysis.

Expected added returns and added costs associated with the TMR system

As was discussed in Section 1, "Application of Total Mixed Dairy Rations," the TMR system has the potential of enhancing the profitability of the dairy operation. For details, see Appendix Table 14. The following reported advantages were used to calculate potential added income.

1. Increased milk production per cow. As reported in Section 1, potential increase in milk production varies from 1,000 to 2,000 pounds per cow. We used three levels of increased production (5 percent, 8 percent and 10 percent). For an annual production of 18,000 pounds, the 5 percent level increased production per cow by 900 pounds, 8 percent by 1400 pounds and 10 percent by 1800 pounds.

2. Improved milkfat test. Due to improved rumen fermentation and fewer large swings in rumen pH, the milkfat test can be expected to increase .1 to .2 percent. To stay on the conservative side, we used .1 percent, which was assumed to be worth 10¢ per hundred weight of milk produced. This added value for milkfat is likely to decrease further due to surplus milkfat.

3. Reduced feed wastage. Research has shown that feeding TMR has reduced forage losses by 3 percent and concentrate feed wastage up to 5 percent (Coppock, 1977 J. Dairy Sci., 60:1327-1336). Three percent of the average feed cost per cow was credited to the TMR system.

4. Other advantages not given monetary credit. Feeding a TMR eliminates feeding concentrates in the milking parlor. This can reduce milking labor and time required to clean up the parlor due to reduced feed and animal waste.

Also improved health through less slug feeding of grain has been apparent. And the number of animals going off-feed is reduced. These factors can lower veterinary and medicine expenses along with associated management time.

Other added costs associated with TMR

Added milk production has additional costs associated with it. These costs consist of added concentrate feed (one pound of concentrate feed per 2.5 pounds of milk) and milk marketing costs (hauling, assessments and capital retained, etc.) of 75 cents per cwt. of additional milk. For details, see Appendix Table 14.

A service fee of $1.50 per cow per month is charged against the system to cover the cost of balancing rations through the use of consultants and/or computer programs, feed analysis, etc.

In summary, the results of the calculations are reported in the following Appendix Tables:

1.Table 9. New Investments Needed To Process Total Mixed Rations. Fixed costs are also provided by herd size.

2.Table 13. Summary of Ration Costs by Herd Size.

3.Table 14. Economic Advantage of TMR for Three Different Levels of Improved Milk Production (Present Milk Production 18,000 Pounds/Cow).

Results of Analyses

Relationship between herd size and costs

The added capital investment needed per cow to prepare, mix and deliver TMR is $337 per cow for a 100-cow herd, dropping to $78 for a 1,000-cow herd. This illustrates the usual change in investments, fixed costs and cash flow (principal, interest, repairs, insurance and taxes), as number and volume increase — a continued downward sloping cost curve which reflects advantages for larger operations. Table 1 highlights cost-size relationships and shows that economies of size exist.

Table 1. New Investments, Fixed Costs and Cash Flow Obligations Per Cow[1]

	Herd size (no. cows)					
	100	200	300	500	750	1,000
	(per cow)					
New investments	$337.00	$186.00	$137.00	$115.00	$93.00	$78.00
Fixed costs	$60.10	$32.75	$23.77	$19.84	$15.71	$13.19
Cash flow obligations	$85.29	$46.85	$34.25	$28.76	$23.10	$19.61

[1]Details reported in Table 9 of Appendix.

The largest marginal drop in investment per cow occurs from 100 to 200 cows — $151 per cow ($337 to $186); 200 to 300 cows — $49 per cow ($186 to 137); and 300 to 500 cows — $22 per cow ($137 to $115).

Table 2. Total Costs of Feed Per Unit[1]

	Herd size (no. cows)					
	100	200	300	500	750	1,000
Economic Costs Per Unit[2]						
Per ton	$83.37	$79.78	$83.32	$83.51	$83.02	$83.44
Per cow	$1,359	$1,300	$1,357	$1,360	$1,352	$1,360

[1]Details reported in Table 13 of Appendix.
[2]Includes cost of feed and ownership costs of equipment.

The quick change from 100 to 200 cows suggests that new investment fixed costs of $60 and $85 cash flow per cow are likely to be too high to be economically feasible for 100-cow herds. For herds of 200 to 300 cows, the investment per cow drops from $186 per cow for 200 cows to $137 per cow for 300 cows. The fixed costs are $33 per cow for 200 cows and $24 for 300. The cash flow obligation also drops from $47 to $34 per cow for a 300-cow herd. (Cash flow obligations are based on 100 percent financing over a payback period of 7 years. Fixed costs, however, are based on expected economic life that exceeds 7 years. This explains why cash flow obligations exceed fixed cost estimates.)

In summary, from a new investment perspective regarding fixed costs and cash flow obligations per cow, the 100-cow unit is too small to spread overhead costs over units of production. But smaller herds can reduce fixed costs and cash flow obligations associated with new capital by (1) using existing equipment and facilities, and (2) changing to a TMR system when major repairs or renovations are necessary anyway. The 300-cow unit has captured a large portion of the monetary advantage of size (economies of size). Herds of 200 to 300 cows are large enough to take advantage of economies of size associated with TMR. Herds consisting of more than 300 cows can gain additional cost savings from TMR if their financial position will justify the added obligations associated with borrowed capital.

Adding the operating costs (labor, power and total feed costs) to the fixed costs yields the total cost per ton of feed as fed and feed cost per cow for each size unit.

Ration costs by herd size

The total cost of feed on an as-fed basis includes the cost of feed ingredients, labor and power costs, fixed costs of machinery and cash flow obligations resulting from borrowed money. A reminder — all these costs are not added costs associated directly with a TMR system. The cost of each feed ingredient includes storage costs, handling losses, transportation, interest and insurance. These costs, especially for corn and forages, would be the same even if they were not blended into a total mixed ration.

To visualize more easily the economies of size advantages, the total cost of feed as distributed to each herd size is tabulated in Tables 2 and 3. The component parts of the total cost of feed are reported in Table 4.

Feed costs per ton and per cow are lowest for the 200-cow herd. Even the 100-cow herd size has costs similar to the larger herds. A major reason for these lower costs is the assumption that the smaller herds would have pasture available for dry cows and replacement heifers on the farm or could rent it within the community. The market price for pasture is $7 per mature animal month (1,000-pound cow grazing one month) which is a low return for pasture produced on owned land. Thus, the pasture hay equivalent is priced at $21 per ton compared to $59 for mixed hay coming out of storage. In contrast, herds consisting of 300 cows or more were assumed to be strictly on drylot or exercising pasture (having no pasture for grazing). Pasture was not assumed as an alternative for larger herds because (1) there are logistics problems in moving large numbers of dry cows and replacement heifers to and from pasture and (2) large acreages of pasture are not likely available in most communities. All producers will not fit the assumptions of having no pasture because some of the larger herds may continue to have

Table 3. Economic Cost per Ton As Fed without Mixed Hay and Pasture[1]

	Herd size (no. cows)					
	100	200	300	500	750	1,000
1. Cost per ton	$97.96	$93.17	$91.83	$92.09	$91.44	$91.99
2. Cost per cow	$1,195	$1,136	$1,119	$1,122	$1,114	$1,122

[1]Method of calculation: Table 13 Appendix — line 11 total costs and tons of feed minus (line 7 pasture tons and dollars plus line 6 mixed hay tons and dollars) = net dollars ÷ net tons = feed costs per ton; net dollars ÷ no. cows = feed costs/cow.

pasture for replacement heifers.

The result of the pasture assumption is that the smaller herds have cheaper feed. But to confirm this as the major reason, the tons and costs of mixed hay and corresponding pasture and its cost (feed fed to dry cows and heifers which may or may not be fed as TMR) was deducted from the total cost of feed and the residual divided by the remaining tons. As a result, the economic cost per ton of feed fed by herd size is reported in Table 3.

Removing dry cows and replacement heifers' forages from total feed fed cost estimates identifies the 750-cow herd size as having the lowest cost feed per ton of $91.44 and feed per cow of $1,114. The 300-cow herd had the next lowest feed cost of $91.83 per ton and $1,119 per cow. This data supports our contention that the primary reason for substantial cost increases for herd sizes in excess of 200 cows was the lack of pasture for forage (see Table 2). Renting pasture valued at $7 per AUM is cheaper than buying land for the purpose of raising pasture.

Findings concerning economies of size

Table 4 itemizes each cost component going into the total cost of feed fed per cow.

Line 5 in Table 4 shows the annual total cost of feed as fed per cow. The 200-cow herd with the pasture cost advantage has the lowest cost. Therefore, dairies of 200 to 300 cows can use TMR economically (process and distribute feed) if their equipment and storage facilities are sized appropriately.

Of the herds in total confinement, the 750 cow size can utilize the TMR system more economically than any other size. But the dollar advantage beyond the 300-cow herd is relatively small, indicating that larger herds have very little advantage over the smaller herds in confinement.

Labor costs drop but tend to level out as the herd gets larger, indicating size/time efficiency. Labor costs also tend to be lumpy because the assumed feeding labor per cow is the same for the 750- and thousand-cow units at .96 minutes per cow. The assumed labor for 300- and 500-cow units is 1.2 minutes per cow and 1.35 minutes for 200 cows compared to 1.8 minutes for the hundred-cow unit.

Power costs drop from $77 for 100 cows to $58 for 300 cows and then increase as the herd gets larger. For example, power costs are $79 per cow for the thousand-cow unit. The major reason for this is the size of equipment needed to mix and deliver the feed. Herds larger than 500 cows need larger equipment which requires more horsepower, thus increasing tractor operating costs (see power section of Appendix Table 12).

Table 4. Component Cost of Total Feed Costs Per Cow[1]

	Herd size (no. cows)					
	100	200	300	500	750	1,000
1. Labor	$60.23	$45.19	$40.15	$40.15	$32.12	$32.12
2. Power costs	76.71	61.26	58.46	65.76	70.13	78.90
3. Fixed costs	60.10	32.75	23.77	19.84	15.71	13.19
4. Total feed	1162.00	1160.40	1234.83	1234.46	1234.05	1235.48
5. Total costs	$1359	$1300	$1357	$1360	$1352	$1360

[1]Details in Appendix Table 13.

Economic advantage of TMR for different levels of increased milk production

Based on research findings and producer experience discussed in Section 1, three monetary credits (advantages) can be applied to TMR: (1) 3 to 10 percent increased milk production per cow; (2) improved butterfat test, average of .1 percent; and (3) 3 to 5 percent reduction in feed wastage. As per these credits, the following gross economic advantage per cow was calculated based on an average base price of $11.50 per cwt. for 3.5 percent milk. The value of a .1 percent increase in butterfat which was projected to be 10¢ was added to the $11.50 per cwt. price — giving an average price of $11.60 per cwt. for milk testing 3.6 percent butterfat.

Three different levels of improved milk production were assumed (900, 1400, and 1800 pounds) for a cow now producing 18,000 pounds of milk annually. These three levels provide an opportunity to compare marginal economic returns to the marginal costs associated with TMR in Table 5.

Reduced feed wastage was also included as an added credit to production on line 2 of Table 5. Research has shown that feed wastage can be reduced 3 to 5 percent by using TMR compared to free choice forages and parlor feeding concentrates. An average feed wastage credit of $40.44 per cow was given, which was 3 percent of the average feed cost per cow of $1,348 reported in Table 4, line 5. The increased milk production, butterfat price credit of .1 percent, and feed wastage reduction credits are combined on line 2 of Table 5, Adjusted Gross Economic Advantage of TMR.

The costs on line 3 include additional concentrate feed cost (conversion rate of 2.5 pounds milk per 1 pound of feed), milk marketing costs ($.75 per cwt.) and service fees for testing and formulating feeds to prepare TMR ($1.50 per cow per month). (See Appendix Table 14 for details.)

The results (returns to overhead costs) in Table 5 suggest the possibility of increased income of $114 to $188 per cow through the TMR use. The increase amount expected in milk production actually received (3 to 10 percent) depends on the level of nutrition available at the present time. For cows producing 18,000 pounds of milk, nutrition can't be too limiting. Herds that are using computer feeders effectively (providing concentrates throughout the day according to production) may see less improvement in production than those who are still feeding in the parlor and may not have cows grouped according to production. In short, the extent to which these benefits are realized will be influenced by the present situation of the operation.

Table 5. Adjusted Gross Economic Value of TMR Per Cow (Present Milk Production of 18,000 Lbs./Cow)

	Increase in milk production level		
	5%	8%	10%
1. Possible increased production from TMR	900#	1400#	1800#
2. Total gross economic advantage of TMR per cow (Appendix Table 14, ln 6)	$162.84	$225.48	$267.24
3. Total marginal costs (Appendix Table 14, ln 11)	$48.51	$66.82	$79.02
4. Marginal net return (gross profit) to overhead costs per cow from TMR (ln 2 minus ln 3)	$114.33	$158.66	$188.22

Marginal returns versus marginal costs

The net overall economic advantage derived from TMR can be easily evaluated when added returns are compared to added costs associated with processing, mixing and distributing total mixed rations. This comparison is summarized in Table 6.

Comparing net profits per cow on line 5 shows the use of TMR is profitable for all herd sizes except the hundred-cow unit – if milk production increases 900 pounds per cow annually (5 percent for cows producing 18,000 pounds of milk annually). With an average milk price of $11.50 per cwt., the 100-cow unit requires approximately 1150 pounds more milk rather than 900 pounds to break even if new feed processing equipment and storage facilities are purchased (see discussion on page 18 for additional thoughts in regard to smaller herds). As was stated in Section 1,milk increases of 1,000 to 2,000 pounds by users of TMR is a possibility.

Larger size herds have lower marginal costs per cow due to lower costs. The 750-cow unit has the highest net profit per cow with $47, for an annual increase in milk production of 900 pounds, $92 for 1440 pounds more milk, and $121 for 1800 pounds or a 10 percent increase in production for a cow producing 18,000 pounds of milk annually. Herds larger than 200 cows should be able to use the TMR system profitably if cows are grouped and fed according to their level of milk production.

Here are some additional thoughts that can favor a change to a TMR system even for smaller herds:

(1) Tractor costs include operating and fixed costs per hour of operation. Most operations will have older tractors that are capable of operating the feeding equipment. Fixed costs calculated in this study reflect new costs rather than costs incurred with the TMR system when operating dairies expand and can use tractors and equipment already available.

(2) The smaller herds of 100 to 200 cows can often lower their costs of investments used in these analyses by buying used machinery. Also, for example, many dairies may already own front-end loaders. Present buildings and facilities remodeled and/or rearranged can replace the new commodity building, division lot fences and expensive feed bunks. Planning and financial analysis can make TMR workable for the smaller herds, especially those of a 100 cows or more.

(3) Change to a TMR system when current facilities need to be remodeled or replaced.

Missouri can become more competitive by reducing costs and increasing milk production per cow. Producers should consider production practices and technology that large dairies in the West and Southwest are using, among which is the use of TMR. These dairies are using total mixed rations or a modification of TMR; therefore, TMR offers a profit potential to Missouri producers.

Table 6. Marginal Returns Versus Marginal Costs for Different Levels of Increased Milk Production by Herd Size and Per Cow

	Herd size (no. cows)					
	100	200	300	500	750	1,000
900 Lbs. (5%) Increased Milk Production Per Cow						
1. Marginal returns[1]	$16,280	$32,568	$48,852	$81,420	$122,130	$162,840
2. Marginal variable costs[2]	4,851	9,702	14,553	24,255	36,383	48,510
3. Marginal overhead costs:						
*Labor[3]	3,012	4,519	6,023	10,038	12,045	16,060
*Fixed costs[4]	6,010	6,549	7,132	9,918	11,784	13,192
*Power costs[5]	3,836	6,126	8,770	16,439	26,297	39,448
*Total	12,858	17,194	21,925	36,395	50,126	68,700
4. Total marginal costs (add lines 2 and 3)	$17,709	$26,896	$36,478	$60,650	$86,509	$117,210
5. Net return: herd	-$1,429	$5,672	$12,374	$20,770	$35,621	$45,630
per cow	-$14	$28	$41	$42	$47	$47
1400 Lbs. (8%) Increased Milk Production Per Cow						
1. Marginal returns[1]	$22,548	$45,096	$67,644	$112,740	$169,110	$225,480
2. Marginal variable costs[2]	6,682	13,364	20,046	33,410	50,115	66,820
3. Marginal overhead costs[6]	12,858	17,194	21,925	36,395	50,126	68,700
4. Total marginal costs (add lines 2 and 3)	$19,540	$30,558	$41,971	$69,805	$100,241	$135,520
5. Net return: herd	$3,008	$14,538	$25,673	$42,935	$68,869	$89,960
per cow	$30	$73	$86	$86	$92	$90
1800 Lbs. (10%) Increased Milk Production Per Cow						
1. Marginal returns[1]	$26,724	$53,448	$80,172	$133,620	$200,430	$267,240
2. Marginal variable costs[2]	7,902	15,804	23,706	39,510	59,265	79,020
3. Marginal overhead costs[6]	12,858	17,194	21,925	36,395	50,126	68,700
4. Total marginal costs (add lines 2 and 3)	$20,760	$32,998	$45,631	$75,905	$109,391	$147,720
5. Net return: herd	$5,960	$20,450	$34,541	$57,715	$91,039	$119,520
per cow	$60	$102	$115	$115	$121	$120

[1]Gross advantage of TMR/cow by added milk/cow (Appendix Table 14, line 6) x number of cows in herd.
[2]Marginal costs/cow (Appendix Table 14, line 11) x number of cows in herd.
[3]Marginal labor for mixing and distributing TMR was estimated to be 50 percent of total labor costs reported in Appendix Table 12, line 5.
[4]From Appendix Table 9, col. 3, line 7.
[5]Assumed marginal power costs to allocate to TMR to be 50 percent of total costs reported in Appendix Table 12, line 17.
[6]Transferred from 900 pounds increased milk production section, line 3. Marginal overhead costs are the same regardless of increased milk production.

Conclusions

Total mixed rations offer an opportunity to improve business profits through improved animal performance and health, decreased feed wastage, improved labor efficiency and improved butterfat test. The installation of a TMR system normally requires added investments in storage facilities, feed mixing and distribution equipment. Research suggests the TMR program can lead to a healthier herd due to feeding a balanced diet according to level of milk production. Through improved labor efficiency, the substitution of equipment and facilities can be done economically. The application of TMR centers around key management questions: (1) What size cow herds can profitably use the TMR system? (2) What herd size(s) captures the greatest advantage of economies of scale? (3) What production levels resulting from the use of the TMR system more than pay the added costs of the system?

The 100-cow unit and smaller will have more difficulty using the TMR system profitably based on the assumptions and costs used in this study. Fixed costs associated with the added investments, labor and power costs are too high to spread over limited production. Milk production should increase by 1150 pounds per cow annually to break even. However, fixed costs can often be reduced through the remodeling of buildings, purchase of used equipment and the use of high quality alfalfa hay rather than haylage and silage.

Surprisingly, the 200-cow unit had the lowest total feed costs (delivered to bunk) of any size at $1300 per cow. A pasture program for dry cows and heifers in lieu of mixed hay fed in total confinement was the major reason for the low total feed cost per cow. Pasture priced at the customary rental charge of $7 per AUM is cheaper than $59 per ton mixed hay fed in confinement. In summary, herds of 100 to 200 cows have a unique cost advantage from pasture in the use of a TMR system. Larger herds (300 cows or more) may also have this cost advantage if pasture is available for dry cows and replacement heifers.

Dairy herds kept in total confinement (assumed 300 cows or more) can find their total feed costs per cow increasing because of rising power costs and the leveling out of labor costs per cow. Power and labor costs offset the decline of fixed costs per cow as herd size increases (see Table 4). The 750-cow herd had the lowest total feed costs per cow of the herds in total confinement with $1352. But this was only $5 higher per cow than the 300-cow unit. In summary, if the labor, power, fixed costs and feed costs per cow are realistic, any size herd above 200-cow units can keep costs low enough to use the TMR system. This, however, requires management to size and construct the system in a cost-effective manner.

From a management point of view, the acid test is whether the added returns will more than offset the added costs of the TMR system (see Table 6). To stay on the conservative side, we would suggest that it will take a 900-pound (5 percent) increase in milk production to break even with perhaps a slight possibility of a management return of $25 to $45 per cow for herds larger than 200 cows. A 1400-pound or 8 percent increase in annual production should pay all costs and offer a return to management of $70 to $90 per cow. The hundred-cow unit has a potential of producing a $30 per cow return to management at this level of production. Annual net return for the herd can range from $3,000 for 100 cows to almost $90,000 for 1,000 cows.

The 10 percent or 1800 pounds of milk production is an extreme level of improvement and could be very profitable if achieved. The 900 to 1500 pound improvement levels are more likely. Benefits achieved will be influenced by the present feeding system used. For example, those with a computer system may see a smaller improvement than an individual feeding system via milking parlor. Actually, the TMR system may obtain gains associated with other production efficiencies. Well managed dairies can expect a smaller economic gain than those with nutritional problems and inefficiencies in the preparation and delivery of feed.

Appendix

Table 1. Establishing the Cost per Ton of Alfalfa Hay from Storage

1.	Assumed market price of alfalfa hay/ton at harvest, 80% DM		$73.00
2.	Storage losses/ton:		
	Moisture	6%	
	Storage	2%	
	Handling	3%	
	Digestibility	1%	
	Total	12% x ln 1	$ 8.76
3.	Building storage costs:		
	* New storage costs/ton of space is $80/ton		
	* Fixed costs as percent are 13.7% (Appendix Table 7, ln 6)		
	* Storage costs/ton are $80 x 13.7% =		$10.96*
4.	Value of alfalfa hay/ton farm storage, 88% DM		$92.72

*May be reduced depending on storage time and percent of total consumption stored. See page 15 for further explanation.

Table 2. Establishing the Cost per Ton of Mixed Hay from Storage

1.	Assumed market price of mixed hay/ton at harvest, 80% DM		$40.00
2.	Storage losses/ton:		
	Moisture	6%	
	Storage	2%	
	Handling	2%	
	Digestibility	1%	
	Total	11% x ln 1	$4.40
3.	Building storage costs:		
	* New storage costs/ton of space, $85/ton		
	* Fixed costs as percent are 13.7% (Appendix Table 7, ln 6)		
	* Storage costs/ton are $85 x 13.7% =		$11.65*
4.	Value of mixed hay/ton out of storage, 88% DM		$56.05

*May be reduced depending on storage time and percent of total consumption stored. See page 15 for further explanation.

Table 3. Establishing the Cost per Ton of 40% DM Silage Stored in Horizontal Concrete Trench

1. Estimated yield of corn (bus./ac.)		80
2. Estimated harvest time yield (tons/ac.)		14
3. Bushels of corn/ton of silage (ln 1 ÷ ln 2)		5.7
4. Value of corn on corn plant:		
a. Harvest time price of corn/bu. in field		$ 2.60 [1]
b. Less harvesting cost/bu.[2]	$.25	
c. Less cost of drying/bu.	$.10	
d. Equals net value of corn/bu.		$ 2.25
5. Base value of grain/ton in silage (ln 3 x ln 4d)		$12.83
6. Cost of custom harvesting and storing silage/ton[2]		$ 5.00
7. Cost of silage/ton in storage (ln 5 + ln 6)		$17.83
8. Storage costs/ton (annual fixed costs as percent 13% (Table 7, ln 7) x $20/ton cost[3] of horizontal silo)		$ 2.60
9. Storage losses/ton (ln 7 + ln 8) x 15% losses	$20.43	$ 3.06
10. Total cost/ton silage as removed from storage (add lns 7, 8 and 9)		$23.49

[1]Projected average value of corn in Missouri for 1990-95 by FAPRI is $2.10/bu.; 50¢/bu. for transportation and handling to dairy farms.
[2]"1987 Missouri Farm Service Custom Rates," MU Guide 302.
[3]Cost varies. Wide, shallow silos are cheaper than deep, narrow silos. Small herds will have higher investment costs than large herds.

Table 4. Establishing the Cost per Ton of 45% DM Alfalfa Haylage per Ton Farm Storage in Horizontal Concrete Trench

A. Establishing value of standing hay/acre	
1. Average yield/acre, 45% DM (tons)	8.0
2. Market value of alfalfa hay at harvest, 80% DM	$ 73.00
3. Value of hay standing/ton:	
a. Cost of harvesting — cutting, baling square bales, hauling and storing ($1/bale[1] x 33 bales/ton)	$ 33.00
b. Base value standing hay/ton (ln 2 minus ln 3a)	$ 40.00
4. Value of haylage/ton (ln 3b ÷ 80% = $50/ton DM x 45%)	$ 22.50
5. Value of standing haylage/acre (ln 4 x ln 1)	$180.00
B. Harvesting costs — cutting to storage	
6. Mowing, conditioning and windrowing ($7/acre1 x 3.5 cuttings)	$ 24.50
7. Harvesting and storage ($25/cutting1 x 3.5 cuttings)	$ 87.50
8. Value of haylage in storage (add ls 5, 6 and 7)	$292.00
9. Storage losses (ln 8 x 15%)	$ 43.80
10. Silo fixed costs ($20/ton[2] x 13% (Table 7, ln 7) x 8 tons)	$ 20.80
11. Total value/acre (add lns 8, 9 and 10)	$356.60
12. Total cost/ton of haylage out of storage (ln 11 ÷ ln 1)	$ 44.57

[1]"1987 Missouri Farm Service Custom Rates," MU Guide 302.
[2]Cost varies. Wide, shallow silos are cheaper than deep, narrow silos. Small herds will have higher investment cost than large herds.

Table 5. Grain Storage Cost Worksheet

Crop: Corn   Harvest-time price: $2.10/bu. (Mid-Missouri)

Initial Investment Cost

Building (bin) 5,000 bu. capacity			
Purchase price of building	$ ________ (A)		
Erection costs (15% of A)	________ (B)		
Concrete floor (17% of A)	________ (C)		
Total building investment (A+B+C)	________	$ 4,760 (D)	
Equipment			
Aeration ducts and pad	$ ________ (E)		
Aeration fan and motor	________ (F)		
Grain speader	________ (G)		
Unloading tube and well	________ (H)		
Bin sweep auger	________ (I)		
Unloading auger and motor	________ (J)		
Total equipment investment (E+F+G+H+I+J)		$ 2,040 (K)*	
Total investment (D+K)		$ 6,800 (L)	
Capacity of bin (bushels)			5,000 (M)

Annual Storage Costs

	Annual		Per Bushel
Fixed Costs[1]			
Depreciation: Building (D ÷ 20 yr.)	$ 238 (N)		
Equipment (K ÷ 10 yr.)	204 (O)		
Interest on investment (1/2 L x 12 %)	408 (P)		
Building repairs (D x 1%)	48 (Q)		
Insurance (L x .5%)	34 (R)		
Annual Fixed Costs (N+O+P+Q+R)	932 (M)		$ .186 (S)
Variable Costs			
Electricity, aeration and augers ($ .06 /kwh x .10 to .25 kwh/bu.)		$ .009 (T)	
Equipment repairs (K x 5% ÷ M)		.020 (U)	
Shrink ($ 2.10 /bu. x 1%)		.021 (V)	
Insurance on grain ($ 2.10 /bu. x .4%)		.008 (W)	
Management of stored grain		.010 (X)	
Subtotal[2] (T+U+V+W+X)		$ .068 (Y)	
Labor and trucking (in and out of storage)		.300 (Z)	
Interest on grain ($ 2.10 /bu. x 6 %)[3](12% APR x 6 months)		.126 (Z_1)	
Annual Variable Costs ($Y+Z+Z_1$)			$ .494 (Z_2)
TOTAL ANNUAL STORAGE COSTS ($S+Z_2$)			$ .680 (Z_3)

[1]Principal and interest payments may be substituted for depreciation (N and O) and interest (P) to reflect costs on a cash flow basis.

[2]This amount may be compared to commercial storage rates.

[3]Interest on grain is shown on an annual basis. Prorate if less than 12 months are used.

*Bin equipment estimated to be 30% of total cost. Total cost of corn/bu. coming out of storage $2.78 or $99.29/ton.

Table 6. Quantity of Feeds Prepared and Distributed by Herd Size — 18,000 lbs. Production

Feed ingredient	PER COW Daily ration	Total per year	TOTAL TONS PER HERD Number of cows in herd: 100	200	300	500	750	1,000
	—— lbs. ——		—— tons ——					
Lactating Cows (305 days)								
1. Alfalfa hay	9	2,745	137	275	412	686	1,029	1,373
2. Silage	23	7,015	351	702	1,052	1,754	2,631	3,508
3. Alfalfa haylage	18	5,490	275	549	824	1,373	2,059	2,745
4. Concentrates	26	7,930	397	793	1,190	1,983	2,974	3,975
Dry Cows (60 days)								
5. Mixed hay	20	1,200	60	120	180	300	450	600
6. Concentrates	4	240	12	24	36	60	90	120
Heifers — equivalent/cow								
7. Mixed hay		3,000	150	300	450	750	1,125	1,500
8. Concentrates		950	48	95	143	238	356	475
Dry Cows and Heifers — hay substitution for 6 AUM pasture for herds of 300 cows or more								
9. Mixed hay		4,000			600	1,000	1,500	2,000
SUMMARY OF FEEDS FED TO DAIRY HERD								
10. Alfalfa hay (ln 1)			137	275	412	686	1,029	1,373
11. Silage (ln 2)			351	702	1,052	1,754	2,631	3,508
12. Alfalfa haylage (ln 3)			275	549	824	1,373	2,059	2,745
13. Mixed hay (add lns 5, 7 and 9)			210	420	1,230	2,050	3,075	4,100
14. Concentrates for heifers (ln 8)			48	95	143	238	356	475
15. Concentrates for milk herd (lns 4 + 6)			409	817	1,226	2,043	3,064	4,085
Concentrate Breakdown for Milking Herd								
16. Whole cottonseed (ln 15 x 18%)		1,471	73	147	220	368	551	736
17. Corn (ln 15 x 20%)		1,634	82	163	245	409	613	817
18. Corn gluten feed (ln 15 x 26%)		2,124	106	212	319	531	797	1,062
19. Soy hulls (ln 15 x 18%)		1,470	74	147	221	368	551	735
20. Distillers grains (ln 15 x 18%)		1,471	74	148	221	367	552	735

Table 7. Fixed Costs Expressed as Percent of Initial Costs for New Investments

Item	Years useful life	Depre-ciation	Inter-est[1]	Taxes, insurance, housing	Repairs	Total fixed costs
		—— percent ——				
1. Roller mill	10	8.5[2]	6.0	1.5	4.0	20.0
2. Front-end loader	10	8.5[2]	6.0	1.5	2.5	18.5
3. Mixer wagon with scales and hay processor	7	12.9[3]	6.0	1.5	5.0	25.4
4. Commodity shed	20	5.0	6.0	1.2	2.5	14.7
5. Concrete bunks	20	5.0	6.0	.5	1.0	12.5
6. Hay storage	20	5.0	6.0	1.2	1.5	13.7
7. Concrete trench silo	20	5.0	6.0	1.0	1.0	13.0
8. Feedlot division fence	15	6.7	6.0	.5	2.0	15.2

[1]Annual interest charge is 6% of original investment (equivalent to 12% APR).
[2]Allows for 15% salvage.
[3]Allows for 10% salvage.

Table 8. Cash Flow Expressed as Percent for 7-year Loan, 12% Annual Interest and 100% Financing

Item	Annual amortized payment per $100	Insurance, taxes, housing	Repairs[1]	Total cash flow
		percent		
1. Roller mill	$21.91	1.5	3.0	26.41
2. Front end loader	21.91	1.5	2.0	25.41
3. Mixer wagon with scales and hay processor	21.91	1.5	5.0	28.41
4. Commodity shed	21.91	1.2	1.0	24.11
5. Concrete bunks	21.91	.5	.5	22.91
6. Hay storage	21.91	1.2	1.0	24.11
7. Concrete trench silo	21.91	1.0	.5	23.41
8. Feedlot diversion fence	21.91	.5	1.0	23.41

[1]Average repairs estimated as 7-year loan not years of useful life.

Table 9. New Investments Needed To Process Total Mixed Rations (Fixed Costs and Cash Flow Calculations)(continued on page 30.)

Item Column Number:	(1) Cost	(2) Percent fixed costs (Table 7)	(3) Annual fixed costs (col 1x2)	(4) Percent cash flow obligations (Table 8)	(5) Annual cash obligations (col 1x4)
100-cow herd					
1. Roller mill (3 hp)	$ 3,500	20.0	$ 700	26.41	$ 924
2. Front-end loader (5 ft. wide)	3,600	18.5	666	25.41	915
3. Mixer wagon with scales and hay processor (100 cu.ft.)	7,200	25.4	1,829	28.41	2,046
4. Commodity shed (4 bays)	16,000	14.7	2,352	24.11	3,858
5. Additional bunk space[1]	2,000	12.5	250	22.91	458
6. Feedlot division metal panels[2]	1,400	15.2	213	23.41	328
7. Total	$33,700		$6,010		$8,529
8. Total costs, fixed costs and cash obligations/hd.	$337		$60.10		$85.29
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$2,519
200-cow herd					
1. Roller mill (3 hp)	$ 3,500	20.0	$ 700	26.41	$ 924
2. Front-end loader (6 ft. wide)	3,900	18.5	722	25.41	991
3. Mixer wagon with scales and hay processor (125 cu.ft.)	7,700	25.4	1,956	28.41	2,188
4. Commodity shed (4 bays)	16,000	14.7	2,352	24.11	3,858
5. Additional bunk space[1]	4,000	12.5	500	22.91	916
6. Feedlot division metal panels[2]	2,100	15.2	319	23.41	492
7. Total	$37,200		$6,549		$ 9,369
8. Total costs, fixed costs and cash obligations/hd.	$186		$32.75		$46.85
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$2,820
300-cow herd					
1. Roller mill (5 hp)	$ 4,050	20.0	$ 810	26.41	$ 1,070
2. Front-end loader (6 ft. wide)	3,900	18.5	722	25.41	991
3. Mixer wagon with scales and hay processor (150 cu.ft.)	8,100	25.4	2,057	28.41	2,301
4. Commodity shed (4 bays)	16,000	14.7	2,352	24.11	3,858
5. Additional bunk space[1]	6,000	12.5	750	22.91	1,375
6. Feedlot division metal panels[2]	2,900	15.2	441	23.41	679
7. Total	$40,950		$7,132		$10,274
8. Total cost, fixed costs and cash obligations/hd.	$137		$23.77		$34.25
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$3,142

[1]Bunk space will vary depending on its location — outside or inside free-stall housing.
[2]Panels for additional grouping of cows.

Table 9. New Investments Needed To Process Total Mixed Rations (con.)

Item	Cost	Percent fixed costs (Table 7)	Annual fixed costs (col 1x2)	Percent cash flow obligations (Table 8)	Annual cash obligations (col 1x4)
Column Number:	(1)	(2)	(3)	(4)	(5)
500-cow herd					
1. Roller mill (7.5 hp)	$ 4,575	20.0	$ 915	26.41	$ 1,208
2. Front-end loader (6 ft. wide)	3,900	18.5	722	25.41	991
3. Mixer wagon with scales and hay processor (200 cu.ft.)	11,500	25.4	2,921	28.41	3,267
4. Commodity shed (5 bays)	20,000	14.7	2,940	24.11	4,822
5. Additional bunk space[1]	10,000	12.5	1,250	22.91	2,291
6. Feedlot division metal panels[2]	7,700	15.2	1,170	23.41	1,803
7. Total	$57,675		$9,918		$14,382
8. Total costs, fixed costs and cash obligations/hd.	$115		$19.84		$28.76
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$ 4,464
750-cow herd					
1. Roller mill (7.5 hp)	$ 4,575	20.0	$ 915	26.41	$ 1,208
2. Front-end loader (7 ft. wide)	4,300	18.5	796	25.41	1,093
3. Mixer wagon with scales and hay processor (250 cu.ft.)	13,000	25.4	3,302	28.41	3,693
4. Commodity shed (6 bays)	24,000	14.7	3,528	24.11	5,786
5. Additional bunk space[1]	15,000	12.5	1,875	22.91	3,437
6. Feedlot division metal panels[2]	9,000	15.2	1,368	23.41	2,107
7. Total	$69,875		$11,784		$17,324
8. Total cost, fixed costs and cash obligations/hd.	$93		$15.71		$23.10
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$ 5,540
1,000-cow herd					
1. Roller mill (15 hp)	$ 5,750	20.0	$ 1,150	26.41	$ 1,519
2. Front-end loader (8 ft. wide)	4,800	18.5	888	25.41	1,220
3. Mixer wagon with scales and hay processor (250 cu.ft.)	13,000	25.4	3,302	28.41	3,693
4. Commodity shed (6 bays)	24,000	14.7	3,528	24.11	5,786
5. Additional bunk space1	20,000	12.5	2,500	22.91	4,582
6. Feedlot division metal panels[2]	12,000	15.2	1,824	23.41	2,809
7. Total	$79,550		$13,192		$19,609
8. Total cost, fixed costs and cash obligations/hd.	$80		$13.19		$19.61
9. Added dollars for cash flow (ln 7, col 5 minus col 3)					$ 6,417

[1]Bunk space will vary depending on its location - outside or inside free-stall housing.
[2]Panels for additional grouping of cows.

Table 10. Cost of Feeds per Ton as Fed[1]

Item	Commercial feed 16% CP Brand X	Whole cotton seed	Corn	Corn gluten feed	Soy hulls	Dis-tillers grains	Silage	Alfalfa hay-lage	Hay: Alfalfa	Hay: Mixed
1. Market price/ton	$144.00	$133.00		$ 95.00	$ 76.00	$122.00				
2. Delivery		25.00		25.00	25.00	25.00				
3. Avg. annual cost delivered	144.00	158.00		120.00	101.00	147.00				
4. Cost out of storage[2]			$ 99.29				$23.49	$44.57	$92.72	$56.05
5. Handling loss (1% of ln 4)	1.44	1.58	.99	1.20	1.01	1.47	.23	.45	.93	.57
6. Insurance (.4% of lns 3 or 4)[3]		.16		.12	.10	.15	.05	.09	.19	.11
7. Interest (__% of lns 3 or 4)[4]		3.16		2.40	2.02	2.94	1.40	2.67	2.78	1.68
8. Total cost/ton	$145.44	$162.90	$100.28	$123.72	$104.13	$151.56	$25.17	$47.78	$96.62	$58.41
9. Price/unit used	$145	$163	$100	$124	$104	$152	$25	$48	$97	$58

[1]Average market price of corn was $2.10/bu. harvest time price central Missouri. By-product feed prices were based on 1989 prices adjusted downward by 10% because of projected lower prices for base feeds — corn and soybean oil meal.
[2]Calculated cost out of storage is in the following tables in appendix: corn, Table 5; silage, Table 3; alfalfa haylage, Table 4; alfalfa hay, Table 1; and mixed hay, Table 2.
[3]Insurance — by-product feeds, .4% rate x 25% (turn over 4 times); forage crops, .4% rate x 50%.
[4]Interest — APR 12% on corn calculated in storage cost, by-product feeds 2% for 2 mos., silage and haylage 6% for 6 mos., hay 3% for 3 months.

Table 11. Cost of Farm Mixed Ration per Ton

Feed ingredient	Lbs./ton	Cost/lb.	Total cost/ton
1. Whole cottonseed	360	$.0815	$ 29.34
2. Corn	400	.05	20.00
3. Corn gluten feed	520	.062	32.24
4. Soy hulls	360	.052	18.72
5. Distillers grain	360	.076	27.36
Total	2,000		$127.66
6. Plus cost of salt, minerals, vitamins/ton			4.75
7. Total cost per ton processed by-product feed			$132.41

Table 12. Labor and Power Costs for Total Mixed Rations by Herd Size

	Herd size (no. cows)					
	100	200	300	500	750	1,000
LABOR[1]						
1. Loading forages and commodities in wagon (hrs.)	493	739	986	1,825	2,190	2,920
2. Moving and processing hay	219	329	438	657	788	1,051
3. Distributing feed to animals (hrs.)	383	575	766	1,168	1,402	1,869
4. Total labor hours (add ls 1-3)	1,095	1,643	2,190	3,650	4,380	5,840
5. Total labor costs (ln 4 x $5.50/hr.)	$6,023	$9,037	$12,045	$20,075	$24,090	$32,120
POWER COSTS						
Tractor						
Loading forages and commodities in wagon						
6. Tractor size (hp)	50	60	60	60	90	100
7. Total cost/hr. operation	$7	$8	$8	$8	$12	$15
8. Tractor costs for loading (ln 1 x ln 7)	$3,451	$5,912	$7,888	$14,600	$26,280	$43,800
Processing and distribution						
9. Tractor size (hp)	50	50	60	75	90	90
10. Cost/hr. operation[3]	$7	$ 7	$ 8	$10	$12	$12
11. Tractor costs for processing and distribution (ln 2 + ln 3 x ln 10)	$4,214	$6,328	$ 9,632	$18,250	$26,280	$35,040
12. Total tractor costs (ln 8 + ln 11)	$7,665	$12,240	$17,520	$32,850	$52,560	$78,840
Roller mill, processing corn[2]						
13. Electric motor (hp)	3	3	5	7.5	7.5	15
14. Processing hours	26	52	52	52	62.4	52
15. Cost/hr. (1.2 x hp x 6¢/kw)	$.22	$.22	$.36	$.54	$.54	$1.08
16. Total electricity costs (ln 14 x ln 15)	$6	$11	$19	$28	$34	$56
17. Total power costs (ln 12 + ln 16)	$7,671	$12,251	$17,539	$32,878	$52,594	$78,896

[1]Labor and power cost estimates are based on Table 10, page 12, Section 2, Facilities and Equipment. The amount of labor is heavily dependent on number of groups the herd is divided into.
[2]Reference Table 9, page 11, roller mills for cracking shelled corn of Section 2, Facilities and Equipment.
[3]Tractor costs per hour of operation includes both variable and fixed costs — "Doane's Agriculture Report," 3-30-90, page 305, Vol. 53, No. 13-5. Cost per hour is 10 to 20% less because tractors are used more than 550 hours annually.

Table 13. Summary of Ration Costs by Herd Size (continued on page 33.)

		Size herd					
		100 cows		200 cows		300 cows	
	Cost per ton	Tons fed[5]	Total costs	Tons fed[5]	Total costs	Tons fed[5]	Total costs
1. Concentrates - cow herd	$132[1]	409	$53,988	817	$107,844	1,226	$161,832
2. Concentrates - heifers	220[2]	48	10,560	95	20,900	143	31,460
3. Alfalfa hay	97[3]	137	13,289	275	26,675	412	39,964
4. Silage	25[3]	351	8,775	702	17,550	1,052	26,300
5. Alfalfa haylage	48[3]	275	13,200	549	26,352	824	39,552
6. Mixed hay	58[3]	210	12,180	420	24,360	1,230	71,340
7. Pasture H.E.[4]		200	4,200	400	8,400		
8. Labor costs (Table 12, ln 5)			6,023		9,037		12,045
9. Total power costs (Table 12, ln 17)			7,671		12,251		17,539
10. Total fixed costs (Table 9, ln 7 for each herd size)		____	6,010	____	6,549	____	7,132
11. Total		1,630	$135,896	3,258	$259,918	4,887	$407,164
Economic costs per unit							
12. Feed costs/ton as fed (ln 11 ÷ tons)			$83.37		$79.78		$83.32
13. Feed costs as fed per cow (ln 11 ÷ no. cows)			$1,359		$1,300		$1,357
Debt servicing obligations per unit[6]							
14. Added dollars for cash flow (Table 9, ln 8 by herd size)			$2,519		$2,820		$3,142
15. Total cash flow obligations (ln 11 + ln 14)			$138,415		$262,738		$410,306
16. Obligations/ton as fed (ln 15 ÷ tons)			$84.92		$80.64		$83.96
17. Obligations as fed/cow (ln 15 ÷ no. cows)			$1,384		$1,314		$1,368

[1]From Table 11, ln 7.
[2]Dairy budgets, Missouri Farm Planning Handbook, Man. 75.
[3]From Table 10, ln 9.
[4]Assumed pasture is available for herds up to 300 cows — $7/mo./AUM or $21/ton H.E.
[5]From Table 6, lns 10-15.
[6]Cash flow obligations are based on 100% financing. Fixed costs are based on expected economic life that exceeds 7 years. This explains why cash flow exceeds fixed cost estimates.

Table 13. Summary of Ration Costs by Herd Size (con.)

		Size herd					
		500 cows		750 cows		1,000 cows	
	Cost per ton	Tons fed[5]	Total costs	Tons fed[5]	Total costs	Tons fed[5]	Total costs
1. Concentrates - cow herd	$132[1]	2,043	$269,676	3,064	$ 404,448	4,085	$ 539,220
2. Concentrates - heifers	220[2]	238	52,360	356	78,320	475	104,500
3. Alfalfa hay	97[3]	686	66,542	1,029	99,813	1,373	133,181
4. Silage	25[3]	1,754	43,850	2,631	65,775	3,508	87,700
5. Alfalfa haylage	48[3]	1,373	65,904	2,059	98,832	2,745	131,760
6. Mixed hay	58[3]	2,050	118,900	3,075	178,350	4,100	237,800
7. Pasture H.E.[4]							
8. Labor costs (Table 12, ln 5)			20,075		24,090		32,120
9. Total power costs (Table 12, ln 17)			32,878		52,594		78,896
10. Total fixed costs (Table 9, ln 7 for each herd size)			9,918		11,784		13,192
11. Total		8,144	$680,103	12,214	$1,014,006	16,286	$1,358,369
Economic costs per unit							
12. Feed costs/ton as fed (ln 11 ÷ tons)			$83.51		$83.02		$83.41
13. Feed costs as fed per cow (ln 11 ÷ no. cows)			$1,360		$1,352		$1,358
Debt servicing obligations per unit[6]							
14. Added dollars for cash flow (Table 9, ln 8 by herd size)			$4,464		$5,540		$6,417
15. Total cash flow obligations (ln 11 + ln 14)			$684,567		$1,019,546		$1,364,786
16. Obligations/ton as fed (ln 15 ÷ tons)			84.06		$83.47		$83.80
17. Obligations as fed/cow (ln 15 ÷ no. cows)			$1,369		$1,359		$1,365

[1]From Table 11, ln 7.
[2]Dairy budgets, Missouri Farm Planning Handbook, Man. 75.
[3]From Table 10, ln 9.
[4]Assumed pasture is available for herds up to 300 cows — $7/mo./AUM or $21/ton H.E.
[5]From Table 6, lns 10-15.
[6]Cash flow obligations are based on 100% financing. Fixed costs are based on expected economic life that exceeds 7 years. This explains why cash flow exceeds fixed cost estimates.

Table 14. Economic Advantage of TMR Per Cow for Three Levels of Improved Milk Production (Present Milk Production 18,000 Lbs./Cow)

	Increase in milk production/cow		
	5%	8%	10%
Economic advantages of TMR			
1. Increase in milk production (lbs.) (% increase x 18,000 lbs.)	900	1,440	1,800
2. Milk price/cwt., 3.5% butterfat	$ 11.50	$ 11.50	$ 11.50
3. Value of added butterfat[1]			
*Increased milk production x 10¢/cwt.	$ .90	$ 1.44	$ 1.80
*Present production 18,000 lbs. x 10¢/cwt.	$ 18.00	$ 18.00	$ 18.00
4. Reduced feed wastage (3% x avg. feed costs/cow $1,348 from Table 13, ln 13)	$ 40.44	$ 40.44	$ 40.44
5. Gross value of added milk production (ln 1 x ln 2)	$103.50	$165.60	$207.00
6. Total marginal advantage of TMR (add lns 3, 4 and 5)	$162.84	$225.48	$267.24
Marginal variable costs associated with added milk production			
7. Added concentrate feed[2] (lbs.)	360	576	720
8. Added cost of concentrate feed (ln 7 x .066/lb.)	$ 23.76	$ 38.02	$ 47.52
9. Milk marketing costs ($.75/cwt.[3] x ln 1)	6.75	10.80	13.50
10. Service fees ($1.50/cow/mo.[4])	18.00	18.00	18.00
11. Total marginal costs	$ 48.51	$ 66.82	$ 79.02
12. Adjusted gross economic value from TMR (ln 6 minus ln 11)	$114.33	$158.66	$188.22

[1]Value of .1% increase in butterfat per cwt. milk production = 10¢/cwt.
[2]Assumed 1 lb. of concentrate feed required to produce 2.5 lbs. of milk. Concentrate costs $132/ton (Table 11, ln 7). Assumes forage consumption doesn't change.
[3]Hauling, assessments, etc.
[4]Computer ration formulation costs, consultants, feed analysis, etc.

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