Implement Compact TMR to increase productivity, feed efficiency and health in dairy herds

By

Dr. Niels Bastian Kristensen, cand. agro., Ph.D.
SEGES P/S, Dairy & Beef Research Centre, Agro Food Park 15, DK-8200 Aarhus N, Denmark
nbk@seges.dk

Optimizing ruminal fermentation and health are priority challenges for all dairy nutritionists. Fermentation of fibrous plant materials is a relatively slow process and due to the limited capacity of the rumen it follows that high producing cows fed slowly degradable feedstuffs will meet limitations in nutrient supply. On the other hand excessive ingestion of rapidly fermentable feedstuffs or feedstuffs providing unbalanced fermentation products for the metabolism of the cows can upset rumen function or the nutrient efficiency.

With high genetic merit dairy cows both under- and over-nutrition can have dire consequences for productivity, efficiency, and health implying that high precision in feeding the rumen is the number one priority.

Classically dairy nutrition research has focused on predicting the composition of the optimum ration and evaluating feedstuffs for the optimization of this ideal ration. Most often research has been done in confined environments with limited disturbance from "practical farming" feed bunk dynamics. Under practical conditions many factors contribute to the complexity of relating nutrition to production results and health. One factor of major importance is the behavior and interactions between cows at the feed bunk.

From Danish experience it appears that introduction of feed mixers in the dairy industry have been accompanied by relatively little systematic research into the mixing process and impacts of mixing on feed bunk dynamics. It has most often been taken for granted that the concerns that predominated in the area of separate feed allocation would also be the primary concerns in the TMR area. With the Compact TMR perspective on dairy feeding and nutrition we have experienced a new potential for optimizing TMR feeding for dairy cows.

Essentials of the Compact TMR concept

Compact TMR is a mixing concept that targets nutrition and behavior of dairy cows with the aim to simultaneously benefit productivity, efficiency, and health. The basic principle is that all cows in a feeding group/herd shall have unlimited access to a feed mix that cannot be sorted and therefore guaranties constant composition of the substrate supply of the rumen and minimizes the struggle between cows for access to the feed. Nothing but the best feed is available to all cows - all day.

In practice the concept relies on:

1. Securing orts / left overs equivalent to minimum 2% of amount fed (approx. 1 kg/cow per day)
2. Providing the mix as Compact TMR

Orts / left overs:
Maintaining 2% orts (left overs) it critical to ensure that all cows, including low ranking cows, have access to sufficient feed. Access to a TMR/PMR with a constant composition at all times is important to reduce stress on cows in the herd/group. Orts are a critical control point to test if the ration is sorted by the cows. Orts and feed mix fed have to be indistinguishable, if this is not the case, cows have sorted the ration and first and last cow feeding at the feed bunk have been offered different rations.

Always test orts for aerobic deterioration, if orts tends to warm the feed mix is not stable and unstable ingredients has to be replaced or the mix has to be preserved with acids (e.g. propionic acid).

Maintaining a sufficient amount of orts is critical for controlling the behavior of cows, if cows rush to the feed bunk at feed out or push up of the feed, they are either under-fed (i.e. orts too small) or the feed mix can be sorted.

Mixing process:
The mixing process is divided into three phases in standard vertical- and horizontal auger mixers

1. Soaking phase
2. Structuring phase (middle-mix)
3. Finishing phase (final-mix)

Soaking phase:
Pelleted concentrate and dry feed components are sources of 'noise' and can induce extensive sorting in TMR and PMR mixes. To avoid these problems dry components have to been soaked in water or other feedstuffs with high moisture content to ensure that these components are retained in the TMR/PMR.

The amount of water required depend on the ration and on the DM of silages added to the mix. A good starting point is to use equal amounts of water and dry feedstuffs. Most pellets will burst when soaked for 1 h, but more resistant pellets like pellets of sugar beet pulp require multiple hours (8 – 12 h). Adding too little water is a much more common problem than adding too much water.

Weigh dry ingredients into mixer without mixing to increase weighing precision. Start the mixer and then add water, this ensures good contact between water and dry ingredients and avoid too much of the dry ingredients residing on the augers.

IMPORTANT: When adding water to TMR/PMR the water should be added to dry ingredients that absorb the water. Avoid adding water to silages as this will reduce stability. Be aware of risk for decreased stability of feed mixes when adding water.

Optimum dry matter concentration of TMR/PMR:
Addition of water can be necessary not only to dissolve pellets and help small components adhere to the mix, but also to ensure that the final mix will have a high density. The overall aim is to ensure that small concentrate particles adhere to larger fiber particles and cannot be sorted out by the cows. It is recommended to plan for 36 to 38% DM in Compact TMR mixed using vertical auger mixers. With horizontal auger mixers at higher dry matter concentration, 39 to 40% DM, are often prefered to prevent the mixers from squeezing water out of the mix in the final phase.

Feedstuffs like molasses, sugar beets, wet pulp, distiller's grain etc. can also provide humidity and decrease or replace addition of water.

Structuring phase:
In the structuring phase the most fibrous components are loading and the mixer is operated for 15 to 20 min after loading. The purpose of the structuring phase is threefold: stepwise mixing, adherence of concentrates to the skeleton of the mix and shredding of fibers. The structuring phase ensures a stepwise mixing process that allow concentrates to mix well into the most fibrous components of the mix. The fibers are the skeleton of the mix and are supposed to carry all nutrients to the cow.

To ensure sufficient mixing and adherence of small particles the standard mixing time in the structuring phase is 15 to 20 min (typical 26-32 rpm in vertical auger mixers). The mixing impact of different mixers varies with fabric and geometry as well as the botanical composition of silages.

Final mix:
The last ingredient to be added to the mixer is corn silage. The heavy mix of the structuring phase is "dissolved" by addition of corn silage. Many mixers are challenged by the physical properties of the mix in the finishing phase (especially vertical auger mixers). It is very important to monitor the mixer when starting a Compact TMR protocol and often mixers need to be modified with auger shares / other devices mounted on the augers to be able to mix a Compact TMR. The final mixing time is again 15 – 20 min with 26 – 32 rpm of augers (vertical augers).

Don't stop the mixer:
When mixing Danish-type rations it is strongly recommended not to stop the mixer between the structuring phase and the finishing phase, if possible also unload without stopping the mixer. The mix from the structuring phase is very heavy and compact. Pull the mixer into the barn with the PTO running and start unloading without stopping PTO.

Multiple mixes per day:
In larger herds with multiple mixes per day the number of soaking events and/or structuring mixes should be minimized by producing a large soaking-mix and/or structuring mix and use these as premixes in several final mixes.

Inspection of flow during mixing is of critical importance:
When implementing the Compact TMR protocol it is of critical importance to ensure that the mixer can move the compact feed mix during the whole mixing process. It is of paramount importance to monitor the flow of feed in the mixer – if not all feed in the mixer is mowing it can be very harmful to the cows. Adjustments are typically made at the base of the auger close the sides of the mixing chamber. Also adjustments of position and length of knives/blades and/or adjustment of secondary arm at the base of the auger (if present on the particular mixer) are measures that can be involved in optimizing the mixer for Compact TMR.

Mixers of several makes failed to mix Compact TMR without adjustments, but it has been possible to modify all mixers (except for some totally worn out mixers) for Compact TMR.

Eating behavior:
To evaluate the success of the Compact TMR protocol there are at least 3 important control points:

- Evaluate the mix fed to the cows
- Evaluate the flow of the mix in the feed mixer
- Monitoring the behavior of cows feeding on the mix

When cows eat from the top you have mixed the ration well. If cows are searching deep into the mix or feeding on the floor they are sorting and the ration is improperly mixed. If cows eat feed only from the top of the pile and don't push around with the feed you have come close to provide them a Compact TMR.

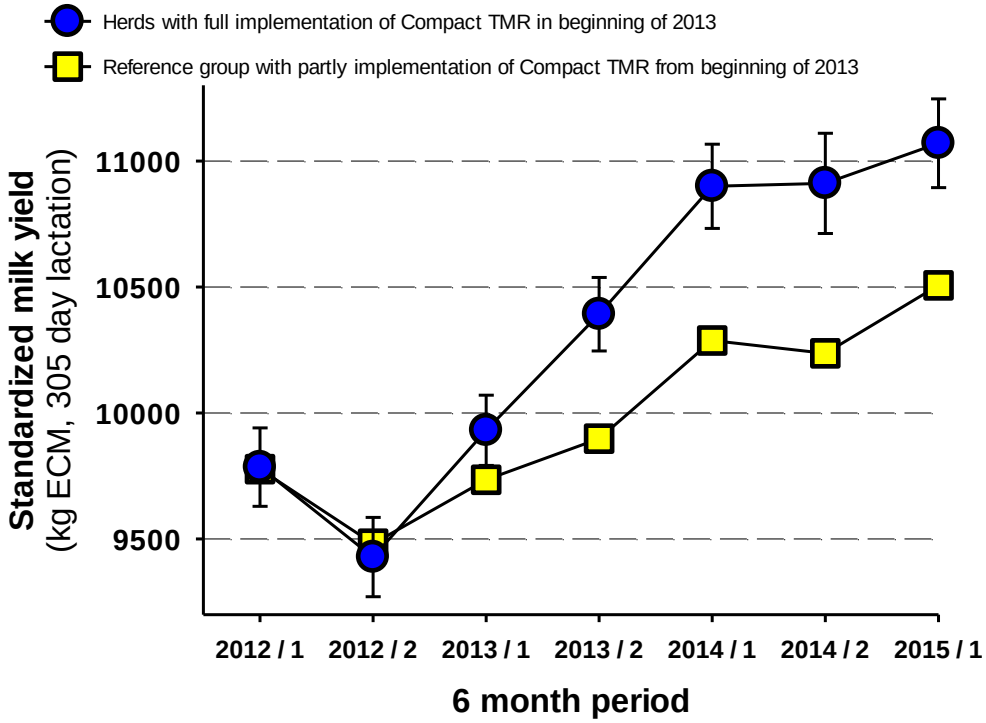

Cows eating the TMR from the top of the pile. Photo Niels Bastian Kristensen, SEGES

Production responses to Compact TMR:
Introduction of the Compact TMR concept at Danish dairy farms started experimentally in 2012 and it was more systematically introduced early in 2013. The short term responses in milk production have been in the range from no effect to a maximum increase of approx. 4 kg ECM/cow per day during the first month after introduction.

The single most apparent change in cow behavior after introduction of Compact TMR is less cows at the feed bunk, less reaction from cows during feed out and more resting time. However, the impact on resting time apparently depends on the stalls / cubicles. If the stalls are fitted with hard or worn out mattresses it appears that the cows benefit less because they will stand in the stalls or at the floor in the barn instead of resting.

In trials where introduction of Compact TMR have been linked with recording of feed conversion is has repeatedly been observed that the feed efficiency (energy in milk / NorFor energy allowance for milk) increased 3 to 5 % units in response to introduction of Compact TMR. It has though been observed that herds with a very restrictive feed allocation before introduction of Compact TMR have experienced a period of 2 to 3 weeks where feed efficiency have dropped in association with introduction of Compact TMR. My interpretation is that the restively fed herds have experienced a depression of normal gain, especially for the young cows, before introduction of Compact TMR that then is compensated when cows are allowed more feed. There are no indications for any over-eating effects associated with Compact TMR feeding of dairy cows.

The figure below shows development in milk yield for a group of farms that introduced Compact TMR early in 2013 in association with SEGES projects and have continued to apply this concept since (circles with blue filling). The reference group is a larger group of herds (more than 200; squares with yellow filling) that are assumed to represent a less systematic implementation of Compact TMR. Some farms in the reference group will have adapted the Compact TMR, other to less or no extent. Both groups have had a significant increase in milk production – in line with the total population of dairy cows in Denmark during the last 2 years, however, the group with full implementation of Compact TMR have had an increase in milk yield of 500 kg ECM / 305 days lactation more than the reference group.



The figure shows development in milk yield for a group of farms that introduced Compact TMR early in 2013 in association with SEGES projects and have continued to apply this concept since (circles with blue filling) relative to a reference group (more than 200; squares with yellow filling) that are assumed to represent a less systematic implementation of Compact TMR.

Value of Compact TMR

The economic value of Compact TMR will be very herd specific and strongly influenced by e.g. milk price. However a rough estimate of the minimum effect can be estimated from an example:

- Herd with 250 dairy cows
- Ration is mixed and fed once daily
- 36m^3 vertical auger mixer
- 65% of the costs of the mixer allocated to the milking cows (rest is divided between dry cows and replacement heifers)
- Production response to Compact TMR = 500 kg ECM / 305 day lactation
- Increased feed consumption = 250 kg DM/year per cow
- Labor cost not included

Based on these assumptions it has been estimated that the costs of mixing increases from 0.72 ¢/kg DM to 1.12 ¢/kg DM when changing from low impact mixing to Compact TMR. Even with a pessimistic estimate for positive side effects (i.e. assumption of no gain in feed efficiency, positive health effects, and less labor use to take of lame cows) there is still approx. 70 € / cow per year to gain from implementing Compact TMR. In reality the gain is likely much higher, but the effects will be dependent on local factor for individual herds.

Overview mixing protocol for Compact TMR

MIX Phase	Feedstuffs	Treatment time	Effect	Caution – be aware!
Soaking phase	Commodities, concentrate, and premixes. In combination with water or other humidifying feedstuffs. Common starting level is 1:1 (dry feedstuff:water).	1 - 12 h (overnight) Depends on feedstuffs. Canola meal, SBM, and concentrate pellets are fast absorbing water. Sugar beet pulp pellets slowly absorbs water.	Ensures that dry feedstuffs can adhere to fibers and the water needed to increase density of mix is applied to the dry components.	Important to add enough water so that commodities and pellets don't end as dough that survives the later mixing. It is far more dangerous to add too little water than to add too much water.
Structuring phase (middle-mix)	Mineral premix, grass silage and other fibrous silages*	15-20 min.	The structuring phase ensures a step vise mixing protocol and ensures that the concentrate components are attached to the fibers (skeleton of the mix).	Important to allow the mixer time to do the job. Be aware that the mix can be very heavy after completing the structuring phase and the mixer should not be stopped.
Finishing-phase (final-mix)	Corn silage*	15-20 min.	In the final phase 2 large components are mixed and this is an important feature of the stepwise protocol.	It is often in the final phase of the mixing process that the vertical auger mixers fail to keep the mixing flow. This is a critical problem for the quality of the TMR. Mount auger shares/shoes etc. as necessary to ensure flow in the mixer. Maintain focus on the function of the feed mixer and replace parts as they wear. Use tractor with enough power to run the augers at target speed.

*Example based on ration containing both grass and corn silage. For ration with the majority of silage from either grass or corn loading of this same silage is split between structuring and final mixing phase.