Ensiling Complete Rations for Ruminants

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Complete or total mixed rations (TMR) are produced by mixing forages, byproducts, concentrates, minerals, vitamins, and additives. From this mix, animals consume the nutrients necessary to meet the requirements of maintenance and production. Alternatively to daily preparation, TMR can be ensiled

Several benefits have been associated with TMR silages, such as a reduced requirement for labor and machinery (if TMR silage is purchased), uniform composition during storage under farm conditions, the potential for incorporating unpalatable byproducts (if their flavors and odors are altered by fermentation), and high aerobic stability after feed out. Additionally, TMR silages, similar to other silages, have the potential for commercialization, especially if stored in smaller structures (e.g., bales, bags, and pouches).

In the industry, TMR ingredients are usually mixed in stationary mixer wagons and stored in big bags (e.g., 300 to 400 kg) or baled by agricultural compactors (e.g., 800 to 1,000 kg). When TMR silage is produced on-farm, it may be stored in different silo types. In small herds, however, structures such as ag-bags, pouches, drums, and bales are preferred over bunkers or piles, to reduce the risk of aerobic deterioration during feed out.

Keywords: aerobic stability ; fermentation ; proteolysis ; starch digestibility ; wet byproducts

Ensiling Sole or Mixed Ration Ingredients

Combining ingredients with different characteristics before ensiling would improve the conservation process. Mixing dry with wet ingredients may minimize the risk of effluent production and undesirable fermentation. Using ingredients rich in soluble sugars and homofermentative lactic acid bacteria would improve the fermentation, whereas ingredients that promote heterofermentation would improve the aerobic stability of TMR silages

Effects of Moisture Content on the Conservation of TMR Silages

Increasing moisture levels in TMR silages affects the fermentation pattern, leading to greater accumulation of fermentation end-products and proteolysis, accompanied by higher dry matter loss, but minor or no effects on the aerobic stability within the DM range adopted currently. The effect of moisture content on starch digestibility in TMR silages remains to be confirmed.

Nutrient Changes during TMR Silage Fermentation

Water Soluble Carbohydrates

After TMR ensiling, fermentation end-products accumulate at the expense of a decrease in soluble carbohydrates (e.g., sucrose, glucose, and fructose). Nonetheless, the final content of soluble carbohydrates in TMR silages will depend on their initial contents and the course of fermentation. One may argue that including silages already fermented as TMR silage ingredients would limit the content of soluble carbohydrates in TMR silages, but it contributes to acidify the mixture immediately at ensiling, sparing the number of soluble carbohydrates required for fermentation. In the industry, feedstuffs already fermented have been successfully used as ingredients for TMR ensiling.

Starch

Ensiling often increases starch digestibility, especially in cereals with a greater content of prolamins in their endosperm (e.g., flint corn and sorghum). Protease activity during ensiling reduces prolamin concentration (hydrophobic proteins that surround the starch granules impairing starch digestion) and increases starch availability. A similar pattern would be expected in TMR silages formulated with corn or sorghum grains, for instance. Such an increase in starch digestibility has been associated with higher feed efficiency in animals fed TMR silages. In TMR silage, the starch concentration tends to be similar to the fresh TMR.

Cell Wall

The plant cell wall is a complex matrix of polysaccharides, mainly consisting of cellulose, hemicellulose, and pectin. Although soluble carbohydrates from the cell content are the main fuel for microbes during ensiling, in a minor proportion, the constituents of the cell wall may also be cleaved and used as a substrate for silage fermentation. Such partial breakage of cell wall polymers is likely favored in silages with higher moisture content. Nevertheless, in TMR silage, the concentration of fiber tends to be similar to the fresh TMR.

Proteins

The partial transformation of true protein into nonprotein compounds due to ensiling is an inevitable process performed by vegetal and microbial enzymes. The extent of protein transformation during ensiling is determined by pH, moisture, temperature, and storage length. In general, a rapid pH drop (e.g. below 4) notably reduces protein breakdown. However, protein degradation may continue during storage. In TMR silages, ingredient sources may also affect proteolysis. The use of byproducts that have undergone washing and/or heating during food processing (at agroindustry) might also decrease protein fractions that are susceptible to proteolysis. Nonetheless, proteolysis extension seems to be lower in TMR silages than we usually see in high-CP forages (e.g., alfalfa and temperate grasses), mainly due to the higher DM content.

Lipids

Lipids are not usual fuels for fermentation. In this way, well-conserved silages will present similar content of total fat as in fresh material. However, an increase in free fatty acids and changes in the concentration of specific fatty acids, such as a decrease in unsaturated fatty acids, may occur, especially under suboptimal conditions of ensiling management. Lipases and lipoxygenases are associated with lipolytic activity during ensiling. Lipases can cleave ester bonds of triglycerides, thereby releasing glycerol and free fatty acids, whereas lipoxygenases can oxidize the free fatty acids. Lipase and lipoxygenase activities are elevated soon after harvesting, due to the presence of residual oxygen, as well as in higher pH conditions (neutral to basic) or in higher temperatures. In this way, management targeting to achieve the anaerobiosis as soon as possible, such as fast silo filling, adequate compaction, and sealing will curtail changes in lipids.

Vitamins

Carotenes (provitamin A) and tocopherols (vitamin E) are prone to oxidation after harvesting, in a process similarly described for lipids. Tocopherol is less degraded than carotene and this phenomenon has been attributed to a higher stability of tocopherol in anoxic conditions as well as a possible activity of tocopherol-producing bacteria. Nonetheless, the TMR silages often contain exogenous sources of vitamins which, in terms of stability, may differ from natural sources of vitamins (or provitamins) present in feeds. The fate of natural and synthetic vitamins in TMR silage remains to be described.

Minerals

Although there is a lack of information on the fate of minerals in ensiled TMR, one would expect minor changes in their concentrations but an increase in their availability, as previously reported for other silages. Some factors attributed to higher availability of minerals are the conversion of inorganic minerals into organic forms, the acidic conditions achieved during the ensiling process, and the breakage of phytates and oxalates during fermentation.

Feed additives

Even as discussed for nutrients in previous topics, feed additives may be altered during fermentation. In the meantime, the capacity of the additives to act in the rumen and host metabolism after undergoing fermentation warrants further investigation. Some studies have examined the effects of feed additives on silage conservation, but the fate of those additives is unknown. Ionophores, for instance, may be degraded during fermentation and impair fermentation and reduce aerobic stability. Similar results were already observed for condensed tannins.

Animal Performance

For dairy cows, no adverse effects of TMR silage use have been reported regarding milk yield, with animals presenting similar or higher milk yield when compared to fresh TMR. Ensiling a TMR increases ruminal protein degradability due to proteolysis during storage and may increase nitrogen excretion via urine, but also via milk due to the higher microbial synthesis in the rumen. An increase of feed efficiency by ruminants fed ensiled rations have been reported, due to the improved starch digestibility in TMR silages containing cereal grains. In addition, animals consuming TMR silages may emit less methane, due to the higher starch digestibility and the conversion of lactic acid (formed during silage fermentation) to propionic acid, an electron-consuming reaction in the rumen.

Final Remarks

Marketing TMR silages represents a promising business opportunity for agro-industry, whereas feeding TMR silages is an alternative to simplify nutritional management. Among nutritional changes during TMR storage, a decrease in true-protein content and an increase in starch digestibility (which often leads to higher feed efficiency) have been consistently reported. Further research is warranted to fine-tune the supply of metabolizable protein, vitamins, and additives via TMR silages.