ENSILING TOTAL MIXED RATION: A METHOD OF PRESERVING WET BY-PRODUCTS WITH ENHANCED AEROBIC STABILITY

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Abstract
In Japan, high-moisture by-products are commonly stored with dry feeds as total mixed ration (TMR) silage. Food and beverage by-products have an unbalanced composition of nutrients, and thus mixing prior to feeding a ration is necessary, even when suitable preservation is achieved by storing wet by-products alone. Brewers grains and soybean curd residue are representative by-products; various dry feeds such as hay, corn grains, wheat bran, cotton seed cake, soybean meal, and beet pulp are combined with the by-products to create a TMR mixture. Typical concentrations of dry matter (DM), crude protein (N×6.25), and total digestible nutrients are 500–600 g/kg, 160–180 g/kgDM, and 720–740 g/kgDM, respectively, and thus without other supplements dairy cows can perform a high level of milk production. Because small particles of by-products enable high packing density, lactic acid fermentation often dominates the ensiling process In addition, aerobic spoilage would not take place, and thus feed intake can be kept at a high level even in hot seasons. A number of TMR manufacturers thus exist in various regions, commercializing TMR silage for local farmers. From an aerobically stable TMR silage, we detected a small amount of 1,2-propanediol and isolated Lactobacillus buchneri as a predominant lactic acid bacterium. Subsequent experiments have shown that addition of L. buchneri inhibits aerobic deterioration of corn and grass silages; hence, the resistance to aerobic deterioration can be accounted for by the activity of L. buchneri. The fact that L. buchneri became prevalent during the ensiling process of TMR silage was also demonstrated by bacterial community analysis. To explore bacteria associated with aerobic stability of the TMR silage, we collected commercial TMR silage from different factories at various seasons. Acetic acid and 1-propanol contents were different between factories and indicated seasonal changes, with increases in warm seasons compared to cool seasons. L. buchneri was found in the products from 3 of 4 factories. Likewise, various sourdough lactic acid bacteria (LAB) were identified in TMR silage; L. pontis, L. hammesii, L. mindensis, L. frumenti and L. farciminis were detected in many products. Changes owing to product season were distinctive, and L. pontis and L. frumenti became detectable in summer products. Manufacturers have started to use locally produced silage as a forage source of TMR ingredients; therefore, we determined bacterial transfer from crop silage to TMR silage as well. Bacteria grown in the first round of crop ensiling could serve as a bacterial additive for the second round of TMR ensiling. L. acetotolerans, L. brevis, L. buchneri, L. delbrueckii, Pediococcus ethanolidurans, Weissella cibaria, Enterococcus mundtii

were the LAB species identified in both ingredient silage and TMR silage. Non-LAB species identified in ingredient silage, e.g. Enterobacter amnigenus, Bacillus coagulans, and Bacillus smithii, were undetectable or replaced by LAB species in TMR silage. Moreover, there were newly appeared LAB species in TMR silage such as L. parafarraginis, L. fructivorans, L. suebicus, W. paramesenteroides, and L. casei. Cluster analysis indicated that the bacterial community of TMR silage was not closely related with those of ingredient silage. Through this series of research our L. buchneri isolate has been commercialized as a bacterial inoculant. Several other LAB species are now evaluated as candidates of revised inoculants.

Key words: aerobic stability, dairy cow, fermentation, lactic acid bacteria, total mixed ration