Forages and Pastures Symposium: Multidimensional Functions of Forages and Pastures for Dairy Production

229  The role of nutrition in dairy cow health and welfare in grazing systems. J. Roche 1, G. Zobel 2, J. Huzzey 3, and J. Loor 4,
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Animal welfare measures must consider a cow’s health and production (i.e., functional state), how she feels about her situation (i.e., affective state), and whether her management allows for “natural” behaviors. Although there are accepted, quantitative measures of functional state, affective state and naturalness are typically only assessed using indirect, behavior-based measures. The most unique factors likely to affect welfare differentiating cows in grazing systems from their housed counterparts fed TMR are climatic variation, a lack of shade and shelter, and the relatively low DMI of grazing cows. Both access to and quality of feed is also less consistent and predictable in grazing cows. From a functional state perspective, fluctuating DMI is associated with risk of disease, particularly in early lactation; when affective state is considered, hunger becomes a concern as well. Although grazing cows eat less, they also produce less milk; the lack of a considerable difference in negative energy balance between unsupplemented and supplemented grazing cows in early lactation likely indicates that output is reduced to match nutrient intake. The risk of disease is minimized by ensuring that animals are adequately managed in late lactation and the dry period, are not too fat at calving, and that pre-calving energy intake is controlled. Hunger is more difficult to assess and, is often, emotively anthropomorphized. Measurements of the neuro-endocrine factors that respond to nutrient intake and expenditure have been established; however, these should be paired with behavioral measures, such as vocalizations, changes in activity and motivation to access feed. As measures are further developed for assessing general animal affective state (e.g., cognitive bias, anticipatory behavior) these should be included when assessing welfare. Although its role in the functional state of cows has been extensively investigated, further research is required to better understand the role of nutrition in cows’ quality of life in grazing systems.

Key Words: forage, corn silage, alfalfa

230  The impact of forages and their quality on the efficiency of dairy production. R. D. Shaver 1, 2, 3, University of Wisconsin, Madison, WI.

Average 2016 production efficiency in USA exceeded 10,000 kg milk per cow (USDA-NASS); about 5% of WI dairy herds on DHI test exceeded 13,500 kg milk per cow. Some projections suggest that average production efficiency in USA dairy herds will reach this level within 20 yr. In a survey of feeding programs from selected WI high-producing (≥13,500 kg milk per cow) herds, 63% of milk production, on average, was attributed to dietary forages. Estimated percentages of dietary nutrients provided by forages, on average, were as follows: fiber (≥75%), protein (45%), energy (50%) and starch (40%). The foregoing points denote the importance of improved forage quality. Key forage quality indicators are reduced NDF content and greater NDF digestibility (ivNDFD) for decreased fill limitation of DMI to allow for production gains from forages or the feeding of higher forage diets. In a multi-commercial lab, multi-year survey of corn silage analyses, NDF% (DM basis) and ivNDFD (30 h; % of NDF) were 41 to 36% (mean = 1 SD) and 54 to 60% (mean + 1 SD), respectively. Starch, influenced by grain yield, contributes greatly to the energy value of corn silage. In the lab survey, starch was 32 to 39% (DM basis; mean + 1 SD). The digestibility of starch in corn silage is influenced by harvest maturity, kernel processing, time in storage before feeding, and kernel endosperm properties. The ivNDFD in corn silage is influenced primarily by hybrid type and growing environment. High cutting can decrease NDF% and increase ivNDFD and starch%. Optimal chop length questions have increased in concert with the feeding of higher corn silage diets. Key forage quality indicators for legume forages also include greater CP% for reducing supplemental protein. In the lab survey, legume forage NDF, ivNDFD and CP were 42 to 37% (mean = 1 SD), 46 to 57% of NDF and 21 to 24% CP (mean + 1 SD), respectively. Reduced-lignin alfalfa varieties are now available commercially for either increased ivNDFD or extended harvest windows for increased yield. New questions involve harvest and feeding strategies when combining reduced-lignin alfalfa silage and brown midrib corn silage.

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231  The filling effect of forages and its effect on feed intake of lactating cows. M. Allen 1, 2, Michigan State University, East Lansing, MI.

Forages provide physically effective fiber, which is required for proper rumen function. However, forage neutral detergent fiber (NDF) is filling and can limit dry matter intake (DMI) by distention from undigested feed residues within the gastrointestinal tract. The rumen is generally regarded as the site within the gastrointestinal tract at which distention limits DMI. A signal from distention is integrated in brain feeding centers and increasingly limits DMI as milk yield increases. Therefore, less filling rations should be fed to cows with high milk yield. Forage NDF has a longer ruminal retention time than NDF from other sources because of longer initial particle size. While grinding and pelleting forages generally increases DMI, decreasing particle size of chopped forages generally has less effect unless chopped very finely. Digestibility of NDF varies among forage type (e.g., grasses vs. legumes) and generally decreases as forages mature and become more lignified. Greater in vitro or in situ NDF digestibility of forages has been related positively to DMI and milk yield of lactating cows. Within a forage type, NDF that is more fermentable clears from the rumen faster and is less filling, allowing greater DMI when limited by distention. However, this applies only within forage type; NDF from perennial grasses is generally much more digestible than NDF from legumes but is also more filling and more likely to limit DMI. This is because grasses are more resistant to particle size reduction by chewing during eating and ruminating. Faster particle size reduction will increase the mass of particles below the threshold size to pass from the rumen as well as decrease the ability of the rumen to selectively retain those particles by decreasing the size of the rumen mat. Therefore, in vitro NDF digestibility should be used to compared within forage type only. The overall filling effect of diets is determined primarily by forage NDF content, forage particle size, fragility of forage NDF, and NDF digestibility within a forage family.

Key Words: rumen distention, forage NDF, forage fragility

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The influence of forage feeding on the ruminal microbiome of dairy cattle and its implications for dairy production. P. J. Weimer*1,2, 1USDA-ARS, Madison, WI, 2University of Wisconsin-Madison, Madison, WI.

Forage utilization is the key distinguishing feature of ruminant agriculture, and the ruminal microbiome is the agent by which these forages are converted to VFA and microbial cell protein that nourish the ruminant host. Culture-independent studies, based on phylogenetic classification of sequences of small-subunit ribosomal RNA molecules, have shown an impressive diversity in species composition of the ruminal microbiome. Because forages are compositionally and structurally more diverse and more complex than are grains and other concentrates, they have the potential to support a greater diversity of microbes within the rumen, and this diversity is extended further when forages are combined with concentrates in a TMR. Although microbiome composition varies across individual animals fed the same diet, certain forage-specific patterns in community composition have emerged. High-forage diets generally increase the relative abundance of phylum *Firmicutes* relative to phylum *Bacteroidetes*, consistent with higher ruminal ratios of acetate/propionate expected from known differences in the physiologies of cultured members of these phyla. Worldwide ruminal microbiome census studies have shown that forage-fed ruminants also host elevated populations of uncultured *Bacteroidales*, *Clostridiales* and *Ruminococcaceae*. Subtle differences in forage form may also affect microbiome composition. For example, orchardgrass fed as pasture selectively increases the abundance of genus *Butyrivibrio* compared with feeding the same forage as hay, and the parallel observed increase in butyrate production may enhance development of ruminal papillae essential for efficient VFA absorption. Bacterial species differ in their affinities for particular plant tissue types, further adding to the complexity of microbial interactions during forage degradation. Several recent studies with cows on mixed rations have shown associations between specific bacterial taxa and important production metrics such as feed efficiency and milk composition, but such studies have not yet been carried out on all-forage diets.

**Key Words:** forage, microbiome, rumen