CHAIRS' SUMMARY PAPER: Forage Quality

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BACKGROUND

The goal of most livestock producers is to maintain forage quality at a level that supports a desired level of animal performance. Forage quality can be considered as the combination of quantity and quality (i.e., digestibility, degradability) of nutrients, most importantly, energy and protein. Energy and protein are described separately, but the two are interrelated. An increase in metabolizable energy intake also results in a increase in metabolizable protein intake, since microbial protein synthesis increases with additional intake of ruminally fermentable organic matter. Desirable characteristics of forages with high feeding value addressed in this theme include: high intake potential, high digestibility, easy comminution, high palatability, high non-structural carbohydrate concentrations, high crude protein levels, low protein degradability, and adequate mineral content.

STRATEGIES FOR IMPROVING FORAGE QUALITY

Forage quality can be improved using numerous strategies. Some of these include sward management (i.e., incorporation of legumes, fertilization, grazing management), post-harvest management, plant breeding, and feed supplementation to animals. Poppi et al., in their invited paper, indicate that the relative effectiveness of these strategies differ for tropical and temperate forage systems. They give the example of increasing the protein supply: reducing protein degradability within the plant is best suited for temperate plants, whereas increasing microbial protein synthesis is more effective for tropical plants.

Some of the issues addressed in this theme related to improving forage quality are:

Increased intake. Most participants agreed that increasing voluntary intake has the greatest potential for improving animal performance. Despite the relative importance of high intake potential, no effective breeding program has been implemented specifically to develop new forage varieties with increased intake potential. Plant breeding programs designed to increase forage intake have focused on ease of plant comminution. The greatest improvements to date have been achieved by identifying and incorporating plant species with inherently high intake potential.

Increased digestibility. Forage digestibility is determined primarily by the proportion of cell wall content and the digestibility of the cell wall fraction. Several posters examined histochemical properties (tissue types, cell types, lignin distribution) of plants as a means of understanding the factors limiting digestibility. Successful forage breeding programs for improved digestibility were described in the invited paper by Casler et al. for warm- and cool-season grasses, and for legumes. Breeding programs to increase forage digestibility are based on selections for increased *in vitro* dry matter digestibility (IVDMD) or reduced cell wall concentrations. Increased IVDMD was shown to reduce lignin concentration (e.g., smooth bromegrass) or increase ratios of ferulic to *p*-coumaric acid (e.g., switchgrass). The association of such trait modification with improved animal performance remains to be substantiated.

Protein content. Correcting for protein inadequacy in diets is expensive and retention of plant protein in animal products is relatively inefficient. Presently, breeding and management efforts to increase plant protein concentrations may not be as effective as strategies that enhance ruminal microbial protein synthesis, decrease feed protein degradation within the rumen, or supplement the specific amino acid needs of the animal.

Efficiency of microbial protein synthesis. Microbial protein synthesis contributes a significant portion of the protein reaching the small intestine. Growth of ruminal microbes depends upon the supply of ruminal fermentable organic matter. Low efficiency of microbial protein synthesis, particularly characteristic of C_4 grasses, can be overcome by increasing the rumen supply of fermentable energy. Increasing the water soluble carbohydrate or non-structural carbohydrate concentration of plants increases microbial protein synthesis. Plant breeding programs aimed at increasing digestibility of cell walls or increasing the proportion of cell solubles, including water soluble carbohydrates will improve the supply of rumen fermentable organic matter and enhance microbial protein efficiency. Alternative approaches that increase the supply of rumen fermentable energy include forage management and direct supplementation of the diet.

Protein degradability. Forage proteins are relatively highly degradable within the rumen. Degradable intake protein can be utilized for ruminal microbial protein synthesis, but the excess is converted to ammonia and excreted in the form of urea. Decreasing protein degradability is an important strategy for temperate forages and this can be achieved by using tannin-containing legumes, inclusion of condensed tannins, albumin fractions, or specific peptides.

FUTURE CONSIDERATIONS

- Posters were presented describing the benefits and limitations to currently available techniques for assessing forage quality. The consensus of this theme was that development of improved methods of predicting intake, digestibility, and rumen degradability of forages remains a priority. Casler et al. emphasized the need for rapid, low-cost, accurate methods to allow aspects of forage quality to be incorporated into plant breeding programs that must screen thousands of genotypes to identify superior candidates.

- Proven methods of enhancing forage quality presented in numerous posters are:
  i. Plant breeding techniques,
  ii. Forage agronomy and management (e.g. sward structure and composition, legume inclusion, nitrogen fertilization, mineral supplementation, timing of harvest),
  iii. Grazing management,
  iv. Post-harvest management, and
  v. Animal supplementation.

Although these methods are conventional, they still offer significant potential to achieve the goal of improved forage quality. Continued research using these proven methods is warranted.

- Significant improvements in forage quality can be made by selecting plants for increased digestibility. However, efforts must focus on overcoming the potential negative effects of these selections on forage yield and pest resistance.

- Molecular genetics and plant transformations offer new and promising methods of enhancing forage quality (eg. insertion of tannin genes, down-regulation of lignin synthesis, alteration of protein fractions to decrease ruminal degradation, enhancement of non-structural carbohydrate accumulation). However, there are a number of critical limitations to genetic manipulation of plants that need to be addressed. These include determining the most effective plant traits to be altered, maintaining high biomass yields for genetically manipulated plants, ensuring inherent defence mechanisms of plants are maintained (resistance to insects and disease), ensuring ecological safety, and sociological aspects.

- The economic benefits of developing plant populations with improved forage quality must be clearly demonstrated if significant resources and efforts are to be invested in these research programs in the future.

- Further understanding of the factors limiting intake, digestion, and utilization of forages will enhance abilities to improve forage quality.

- A multidisciplinary team of plant breeders, biotechnologists, agronomists, plant pathologists, animal scientists, and computer modelling specialists is likely to be the most successful approach to improving forage quality in a sustainable manner.