Small Ruminant Symposium: Novel Uses of Natural Bioactive Compounds in Small Ruminant Production and Future Directions

574 Bioactive compounds and their mode of action in forage-fed ruminants. T. N. Barry,* *Massey University, Palmerston North, New Zealand.*

Bioactive compounds are generally secondary compounds and include lignin (all forages), condensed tannins (lotus, sulla and sainfoin), sesquiterpene lactones (chicory), endophyte alkaloids (perennial ryegrass and fescue), S-methyl cysteine sulphoxide (SMCO) and glucosinolates (brassica plants). They have all evolved as part of the plant's defense mechanism, to protect against microbial attack and being eaten by insects and herbivores. Hence high concentrations of all these compounds are associated with reduced voluntary feed intake (VFI) by ruminants and with animal health effects for SMCO (anemia) and endophyte alkaloids (staggers). Condensed tannins (CT) react reversibly with forage proteins, reducing protein degradation in the rumen and for some forages increasing the absorption of essential amino acids (EAA) from the small intestine, depending on the concentration and structure of the CT. For CT such as *Lotus corniculatus* beneficial effects are seen at 20–40 g/kg DM with no depression in VFI. For CT in this range that increase EAA absorption beneficial effects are reduced bloat in cattle, increased wool growth, ovulation rate, lactation performance, reduced parasite problems in sheep and reduced methane production. Methodology has just been published to induce CT production in legumes containing only traces of CT (white clover). Chicory is a herb that disintegrates rapidly in the rumen, has rapid rumen clearance, high VFI and promotes good growth in grazing ruminants. Young sheep and deer grazing chicory have reduced need for oral anthelmintics and part of this anthelmintic effect is due to its content of sesquiterpene lactones and to low levels of CT. Forages containing bioactive compounds can be used in sustainable grazing systems.

Key Words: bioactive plant secondary compounds, chicory, condensed tannins

575 Consequences of plant secondary compounds on ruminant nutrition. B. R. Min* and S. Solaiman, *Department of Agricultural and Environmental Sciences, Tuskegee University, Tuskegee, AL.*

Plant secondary compounds are varied in nature but are characterized by hydroxylated aromatic rings (e.g., flavan-3-ols). They are considered as secondary metabolites, and their nutritional aspects in ruminants are often poorly understood. This paper mainly considers 2 classes of plant secondary compounds in this context, i.e., proanthocyanidins (condensed tannins; CT) and hydrolysable tannins (HT) and their effect on rumen environment and animal nutrition. The CT are prevalent in browse materials and are expressed in the foliage of some legumes, but rarely in grasses. The HT are present in oak (*Quercus* spp.), Acacia, Eucalyptus and a range of browse and tree leaves. Nutritionists and researchers continue to define dietary CT and HT in terms of concentration, as well as either beneficial or detrimental effects on ruminant animals. Beneficial effects are dependent on the chemical and physical structure, and concentration of the CT and HT in the diet. The HT may be toxic because products of their metabolism can cause liver damage and other metabolic disorders. However, the CT, when present in diet at a proper level (2 to 4% DM) can exert beneficial effects on protein, and minerals metabolism; blood parameters; rumen fermentation (VFA and ammonia production); rumen and fecal microbial populations; feed efficiency; and overall animal performance. Dietary CT may also contribute to animal health by preventing the risk of frothy bloat in cattle. In contrast, high dietary CT concentrations (>5% DM) depress feed intake, digestive efficiency, and animal productivity. From the biochemical standpoint, CT have a wide range of biological activities and enormous potential for uses in livestock industry which requires in-depth investigation and evaluation in the perspective ruminant production systems. Future research should identify optimum level and chemical structures for expression in the high-quality diets to be offered as extract or mixed with grasses or with legumes. Animal feeding systems will be empowered by the choice of variety and concentration of CT in the diet. The potential of novel secondary compound plant sources for use in animal production warrants further investigation.

Key Words: plant secondary compounds, ruminants, tannins

576 Bioactive compounds for control of internal parasites. T. H. Terrill,* *Fort Valley State University, Fort Valley, GA.*

Livestock producers have used nutraceutical plants to improve health and productivity of their animals for several millennia. A large number of bioactive secondary plant metabolites with activity against gastrointestinal nematodes (GIN) of livestock have been identified, including alkaloids, terpenes, and various phenolics, although relatively few plants have been validated scientifically as anti-parasitic. A class of phenolic bioactive compounds for which there is a growing body of evidence for anti-parasitic properties in the diet of ruminants is condensed tannins (CT). Recent work with tropical and temperate CT-containing forages and CT extracts in a series of in vitro and in vivo studies have greatly expanded the scientific knowledge base on use of these compounds to control GIN of livestock. Evidence for these effects has been both direct and indirect. Direct effects of CT on all phases of the GIN life cycle (eggs, larvae, adults) have been reported, although for the most part, determining the exact mechanism of action has remained an elusive target. There have also been reports of indirect effects of certain types and concentrations of CT in the diet improving host resilience and resistance to GIN infection by improving the animal′s nutritional status and immune function. The anti-parasitic efficacy of CT-containing forage/browse in animal diets is likely due to a combination of direct and indirect effects and can vary greatly, depending upon the form of feed (fresh versus dried), CT astringency and concentration in extractable and bound forms, previous exposure to CT-containing plants, seasonal effects, animal age, and the parasite and host species involved. Nevertheless, there appears to be great potential for increased use of bioactive compounds as anti-parasitic agents in livestock production systems in the future.

Key Words: bioactive compounds, condensed tannins, gastrointestinal nematodes

577 Emerging opportunities and challenges on exploitation of bioactive plant secondary compounds to mitigate environmental impacts by ruminants. J.-S. Eun*[1] and B. R. Min[2], [1]*Utah State University, Logan,* [2]*Tuskegee University, Tuskegee, AL.*

Greenhouse gas (GHG) emissions from livestock and their impacts on climate changes are a major concern worldwide. It has been reported that enteric methane is the most important GHG emitted (50 to 60%), at the farm scale, in ruminant production systems. Methane represents also a significant energy loss to the animal ranging from 2 to 12% of gross energy intake. Therefore, mitigating the production of enteric methane from ruminants without altering animal production is desirable both as a strategy to reduce global GHG emissions and as a means of improving feed efficiency. Some of plant secondary compounds (PSC) such as tannins and polyphenols play key roles in animal health, quality of animal products, mitigation of GHG emissions, and efficiency of N use by ruminants. However, the beneficial effects on methane production and N utilization efficiency have not been consistently observed. The discrepancies among different studies in response to feeding PSC-containing forages or supplementing PSC extracts are attributed to the different chemical structures and concentrations of PSC and type of diets. For example, reliable and distinguishable effects of tannins on methane reduction can be expected only from levels >20 g/kg DM, a threshold often not exceeded in current commercial feed supplementation with tannins. Hence, the challenge is to identify PSC sources that can be feasibly added to the diet in a cost effective manner that also result in a net reduction in GHG emissions. Measurements with in vitro culture systems could provide an inexpensive starting point for screening of potential PSC, whereas individual promising PSC need to be investigated in detail in vivo. Different PSC exert their characteristic effects on ruminal fermentation in association with the inhibition of methanogenesis; however, their ultimate impacts on environmental performance by ruminants should be assessed on the amount of emissions/kg of livestock product.

Key Words: greenhouse gas emissions, methane, bioactive plant secondary compounds

578 Bioactive plant compounds and food safety. R. C. Anderson,* *Southern Plains Agricultural Research Center, United States Department of Agriculture/Agricultural Research Service, College Station, TX.*

The gut of food-producing animals is a reservoir for human pathogens such as *Salmonella*, *Campylobacter*, *Clostridium*, *Listeria*, enterohemorrhagic *Escherichia coli* as well as other commensal and pathogenic bacteria expressing important antimicrobial resistance traits. Food producers recognize a need to continuously develop new technologies that effectively minimize contamination of foods and may be used as alternatives to antibiotics at risk from regulatory restrictions. In the search for new interventions, the use of functionally bioactive plant compounds may be viewed favorably as many of these are generally recognized as safe (GRAS). Essential oils extracted from several different plant species have been shown to exhibit broad spectrum bactericidal activity against gram-negative and gram-positive foodborne pathogens, purportedly by disrupting bacterial cell wall integrity. The antimicrobial activity of tannin-derived compounds against a variety of bacteria has also been demonstrated. In the case of hydrolysable tannins such as tannic acid, bacterial growth is inhibited by chelation of iron thus reducing its availability. The mechanisms by which condensed tannins inhibit bacterial growth are less clear and have been proposed to be due to cell wall disruption or binding of proteins, enzymes or amino acids. The antimicrobial activity of hop extracts rich in lupulones has also been demonstrated against certain amino acid-fermenting bacteria such as *Campylobacter*, presumably by exhibiting an ionophore-like effect. While most commonly associated with yeast cell wall products, oligosaccharides produced in certain forestry products are now being explored for their ability to prevent gut colonization mediated by mannose-specific binding by *Salmonella* and *E. coli*. Whereas results from in vitro studies have shown good efficacy, often yielding several log-fold reductions in bacterial numbers, results from animal studies have been less conclusive, possibly because of their absorption or degradation in the stomach or proximal small intestine. Clearly, more research is needed to better understand how to fully harness the biological activity of these compounds.

Key Words: antimicrobial resistance, bioactive plant compounds, foodborne pathogens