Toxin-Nutrient Interactions Influence Diet Selection

Given a choice herbivores prefer foods that are high in nutrients and low in toxins. Nevertheless, plants high in toxins are common on rangelands. Understanding how toxins affect intake and how supplemental nutrients affect intake of toxic plants may allow managers to develop ways to enable their animals to safely consume plants high in toxins and to reduce the number of unpalatable plants on rangelands.

Intake of toxins affects nutrient selection. Toxin ingestion by herbivores affects their nutritional state. For example, after consuming a diet high in tannins, which bind to plant proteins and can deplete protein in the body, sheep and goats prefer diets with high protein/energy ratios. Likewise, following infusions of terpenes, nitrate, tannins or lithium chloride, lambs prefer foods with high protein/energy ratios. However, following infusions of cyanogenic glycosides, lambs prefer foods with high energy/protein ratios. Cyanide increases the demand for energy, while the other toxins either reduced the need for energy or increased the need for protein. Thus, ingesting plants high in toxins influences nutrient selection by herbivores.

Supplemental nutrients increase toxin ingestion. Supplementing ruminants with moderate amounts of protein and energy increases their intake of foods containing terpenes, menthol, lithium chloride or tannins. Sheep and goats receiving supplemental nutrients nearly doubled their intake of chopped sagebrush, a plant containing terpenes. In a grazing study, sheep receiving supplemental protein and energy for 15 min/day spent 12% more time feeding on sagebrush compared with sheep that did not receive supplement.

Herbivores must be provided with the proper mix of nutrients, not just more nutrients, to enable them to increase intake of toxin-containing foods. Sheep and goats fed a diet high in protein, or allowed to choose between foods high in energy or protein, eat more sagebrush and a high-tannin diet than when they received either no supplement or a supplement high in energy and low in protein. After eating a meal of sagebrush, sheep and goats selected a diet higher in protein than animals that had just eaten alfalfa pellets. Thus, when animals eat foods containing toxins, their subsequent selection of foods depends on the toxin consumed and the proportions of energy and protein in the foods offered.

Herbivores avoid foods containing nutrients that have adverse interactions with toxins. For instance, sagebrush contain a high proportion of plant fiber as well as terpenes. Some terpenes reduce fiber digestibility by inhibiting the rumen microbes that breakdown plant fiber. Foods high in energy such as grain, also inhibit the breakdown of fiber by microbes. Thus, a high-grain diet may actually worsen the effects of terpenes.

Why nutrients help. When animals eat foods high in toxins, their need for nutrients increases. Most toxins are lipophilic compounds (fat loving) that must be transformed into hydrophilic substances (water loving) before they can be eliminated from the body. This conversion requires additional energy and protein.

Furthermore, excretion of these compounds may disrupt the body's acid/base balance forcing the body to use additional protein and energy.

Thus, the ability to ingest toxins depends on an animal's nutrient status because the body must change the structure of a toxin before it can be excreted from the body. In short, as toxin ingestion increases the animal's nutritional requirements also increase.

Body Condition. It is generally believed that thin animals may be more likely to ingest foods with toxins when few alternatives are available. However, thin animals may be more likely to suffer from toxicosis than animals in average body condition. Studies show when animals in poor body condition ingest toxins, they accumulate higher concentrations of toxins in their blood compared with animals in average body condition. Conversely, animals in high body condition are less likely to suffer toxicosis but they also may be less likely to eat foods high in toxins.

Implications. Conventional wisdom suggests that the greater the level of hunger the more likely animals will eat unpalatable plants. However, in many instances this is simply untrue. Our research demonstrates that sheep eat more sagebrush when fed supplemental nutrients. In addition, a rancher in Montana was unsuccessful getting hungry sheep to eat spotted knapweed but they grazed it readily after eating a meal of nutritious forages, low in toxins. Likewise, hungry goats browsing in New Mexico refused to eat sagebrush for several days but ate it readily after grazing alfalfa-grass pasture prior to turnout on sagebrush range.

The ideas presented here suggest that maintaining herbivores in adequate body condition and providing them with supplemental nutrients will enable them to safely increase intake of toxic plants. Understanding the nutritional and physiological needs of herbivores that graze plants containing toxins can lead to more effective, efficient, and sustained control of unpalatable plants by livestock.

References:

Provenza, F.D., J.J. Villalba, L.E. Dziba, S.B. Atwood and R.E. Banner. 2003. Linking herbivore experience, varied diets, and plant biochemical diversity. Small Rum. Res. 49:257-274. http://www.behave.net

Funding provided by Utah Agricultural Experiment Station and USDA-IFAFS. Produced by Utah State University in collaboration with University of Idaho, University of Arizona, Montana State University and the National Wildlife Research Center with research conducted at Utah State University.

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