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Palatability: More than a Matter of Taste

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Is it palatable or unpalatable? These terms are often used to describe forage plants or livestock feeds, but do we really understand the meaning of palatability? Webster defines palatable as agreeable to the palate or taste. Animal scientists explain palatability as the degree to which animals like a food based on its flavor. Plant scientists describe palatability as a plant's chemical composition, its structure and the availability of other plant species in a pasture or on rangeland. These definitions of palatability focus on either 1) a food's flavor or 2) its chemical and/or physical characteristics but none of these definitions link the two.

The purpose of this fact sheet is to explain the factors that influence palatability. Understanding palatability will enable managers to influence how readily livestock eat many plants, even plants thought to be unpalatable.

Understanding Palatability

For the past 30 years, researchers at Utah State University have focused on understanding diet selection of livestock. Their research demonstrates that palatability is based on much more than the flavor of a food. Palatability is the relationship between a food's flavor and its nutrient and toxin content. When an animal eats a food, it is digested releasing nutrients and in many cases toxins, because all plants contain some level of toxins. These nutrients and toxins are absorbed in the gut and travel to the cells and organs of the body. Signals are then sent back to the brain to tell it how well a food meets the animal's nutritional needs. The brain then pairs the food's flavor with its nutritional benefits and/or toxicity. The brain stores this information for future use. Scientists refer to this process as postingestive feedback (Provenza 1995).

Feedback is positive (increases palatability) if a food meets nutritional needs. Feedback is negative (decreases palatability) if a food is low in nutrients, has too many readily digestible nutrients, or contains high levels of toxins. Palatability is influenced by the nutrient and toxin content of the food, the nutritional needs of the animal, and the animal's past experience with the food. The senses (smell, taste, sight) enable animals to discriminate among foods and provide pleasant or unpleasant feelings associated with eating. Whether or not an animal readily eats a food is not determined by flavor alone, rather it is determined by the experiences associated with eating the food (Provenza 1995).

How Did We Figure this Out?

In order to determine that feedback from the food and not the flavor of the food alone influenced palatability, we had to separate flavor from feedback. Our first studies focused on food aversions; or why sheep and cattle avoid eating certain foods. Sheep were allowed to eat small amounts of new or novel foods. In this experiment, we used the shrub mountain mahogany. Sheep were then dosed with capsules of lithium chloride (LiCl), a compound known to cause nausea. The following day, animals ate less of the shrub if they received LiCl, but continued to eat it if they did not receive LiCl (Burritt and Provenza 1989; Lane et al. 1990). We continued this process for five days. At the end of five days, lambs receiving LiCl no longer ate mountain mahogany. Those lambs that did not receive LiCl continued to eat the shrub (Figure 1).

To separate the effect of nutrients from the flavor of foods high in nutrients, sheep were fed flavored straw, a food very low in nutrients. Immediately after eating straw, a stomach tube was briefly placed in the rumen of each sheep and a solution of nutrients (energy or protein) was poured directly into the animal. This process was repeated several times. Sheep that received nutrients (starch) after eating flavored straws preferred the flavor that was paired with nutrients (Figure 2, Villalba and Provenza 1997ab).

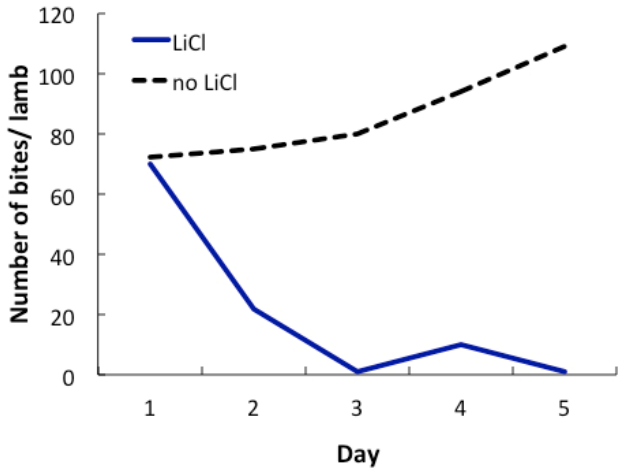

Figure 1. Number of bites of mountain mahogany by lambs dosed with LiCl and lambs that didn't receive LiCl.

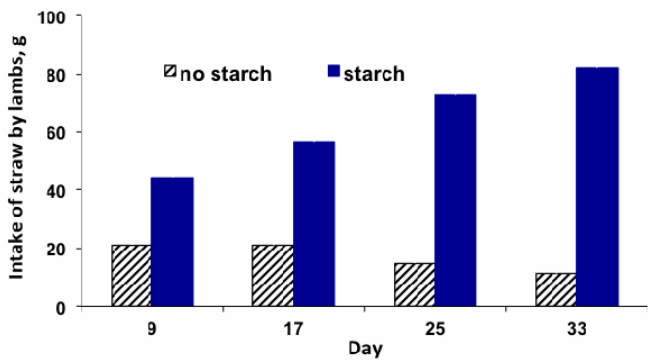

Figure 2. Preference for flavored straws by lambs receiving infusions of starch into their rumens and lambs that received no starch

Nutrients, Toxins and Novelty

Ruminants prefer foods with the correct mix of nutrients that best meet their nutritional needs. Ruminants show little preference for foods low in nutrients, and they generally eat limited amounts of foods very high in nutrients like energy, protein, or minerals. For example, protein is required in moderate amounts every day, but too much protein causes excess production of ammonia in the rumen, which is toxic in high amounts and reduces palatability. Energy is also a major nutrient, but too much energy from readily digestible sources of carbohydrates, like grain, can cause acidosis and reduce palatability. The ratio of protein to energy also has a strong influence on palatability (Villalba and Provenza 1999). Palatability declines if there is too much protein relative to energy or if protein and energy ferment at different rates (Kyriazakus and Oldham 1993).

Eating foods with toxins, such as terpenes, alkaloids, and cyanogenic glycosides, also causes palatability to decrease. When ruminants forage on pastures or rangelands, they rarely over-ingest toxins because rapid postingestive feedback from toxins tells them to limit the amount of toxic food eaten. Thus, the amount of toxin in a food sets a limit on the amount of a particular food an animal can eat (Burritt and Provenza 2000). If toxin levels in a plant decline over the growing season, palatability and intake of the plant increases. That's why, when given a choice, ruminants are able to select plants that are higher in nutrients and lower in toxins than the average of the plants available on pastures or rangelands.

These lambs have been trained to eat Russian olive (left) and avoid Carragena (right).

Positive feedback improves the palatability of new foods. Many people dislike certain foods the first time they eat them because foods, such as avocados, beer or coffee, have strong and different new flavors, but calories, alcohol and caffeine can all be positively re-enforcing. If they continue to eat a new food, often because of social pressures or lack of other familiar foods, they come to like the flavor because it meets nutritional needs or is positively re-enforcing. Thus, the flavor of the food has not changed, but the person's response has, due to positive feedback. How could you ever learn to like a food if palatability or preference was solely base on a food's flavor?

Animals react the same way. Initially, young animals learn what and what not to eat by eating with their mothers (Mirza and Provenza 1990). So when livestock encounter nutritious, new or novel foods, especially those with strong flavors, they are unlikely to try those foods. However, if they continue to eat them because they need additional nutrients or because others are eating them, they are likely to form preferences for those foods (Burritt and Provenza 1989).

Changes in Palatability Are Automatic

You may be thinking that animals cannot possibly be smart enough to figure all this out. Food preferences are not about conscious thought rather, changes in palatability occur automatically through flavor-feedback interactions. Animals don't need to think about or remember the feedback event. Even when animals are asleep, feedback still changes palatability. When sheep eat a food and then receive a dose of a toxin during deep anesthesia, they learn to avoid the food because the

negative feedback of the toxin (nausea) happens even when the animals are deeply asleep (Provenza et al. 1994). Thus, feedback operates automatically to change palatability. At times, changes in preferences are not rational. For example, people form strong aversions to foods eaten just before they become nauseated. Even if the person knows that the flu or seasickness, not the food, caused the nausea, they avoid the food in the future.

The body is typically subtle at instructing individuals what and what not to eat. People remember feedback events that were traumatic, such as getting violently ill from food poisoning. In those cases, the body clearly tells us through nausea and vomiting not to eat the food again. However, most of the time the body works subtly and at a subconscious level to indicate needs. If it didn't, animals would spend all their time just trying to figure out what to eat, how to digest it, and how to change preferences based on the body's changing needs. It is remarkable that so many complex interactions happen without a bit of thought.

Why Does It Matter?

Understanding why animal choose certain foods might enable us to train livestock to fit our rangelands rather than change our rangelands to fit our livestock, because palatability and preference for foods are flexible. If flavor alone dictated what animals ate, then it would be impossible to get animals to eat certain foods if they tasted bad, unless we changed the flavor of the food. Since palatability is based on feedback from foods, then whether or not an animal eats a food will depend on the animal's initial and follow-up experiences with the food. Understanding why animals eat certain foods can: 1) improve intake of new foods animals encounter in feedlots, 2) allow us to teach livestock to eat weeds provided they are nutritious and not toxic, 3) help animals make the transitions to new locations with novel plants, and 4) encourage livestock to eat less palatable forages, such as sagebrush, by understanding the chemistry of the plant and how it may affect feedback.

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