Making sense of taste & smell

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Ever wondered why horses have such big, long noses? Well, just like in the Little Red Riding Hood tale: All the better to smell with! But, how important are smell and taste when it comes to preferences and food choices? And, do you think horses use their senses of smell and taste in the same way we do?

In this two-part series, nutritionist Mariette van den Berg investigates the influence smell and taste have in a horse’s diet selection. This first part reviews the science behind how these senses work, and examines the anatomy of the nasal and oral cavities in horses.

Part two will cover how animals learn to like or dislike certain foods and how this knowledge can help you manage your horse’s diet, including tips on working with fussy eaters.

Considering the vast variety of horse feeds on the market, you would assume that the equine senses of olfaction (smell) and gustation (taste) would have been extensively studied by feed companies. The reality, however, is that research into the mechanisms that influence your horse’s diet selection and food preferences is very limited.

Nevertheless, a better understanding of what is currently known could be relevant to your own horse and feeding management, so let’s review some introductory questions and highlight some of the relevant research findings.

Insight into the ‘chemical senses’

The chemical senses of taste and smell are considered to be one of the oldest adaptations in animals. They are essential because they help us to identify whether something is good to eat or bad for you. An example of this is that sweet foods often signal a simple source of energy, while bitterness can be an indication that something is poisonous. This helps to highlight that an animal’s food intake and preferences are the direct result of the interrelationship between a food’s flavour and its postigestive feedback - the feedback from the gut to the brain that allows animals to sense the nutritional (e.g. energy) or toxic (e.g. nausea, colic) effects of the food they have eaten.

The flavour of food is not limited to how it tastes, but rather a combination of its odour, taste and texture.

The postigestive effect results from feedback from cells and organs (in the gut) to the brain, and this feedback is termed ‘positive’ (i.e. it increases the food’s palatability) if the food meets the animal’s nutritional needs, and ‘negative’ (decreases palatability) if the food is either inadequate or excessive relative to the nutritional needs, or it contains high levels of toxins.

Your sense of smell allows you to detect chemicals at a distance and it draws in the finer characteristics of foods, but it isn’t very useful for detecting the ions that give the salty, sweet or sour tastes. In order to detect them, these ions need to be dissolved in water or saliva. Taste, therefore, allows you get up close and personal with the food.

All animals have chemical senses of some sort. We know that organisms as small as single-cell amoebas can sense specific chemicals. Invertebrates, such as insects, use cells dedicated to chemical senses, which are the direct evolutionary equivalents of mammal taste buds. Flies, for example, taste through their feet and probosces (elongated, sucking mouthparts). Vertebtrates, on the other hand, have tongues and all tongues have taste buds. Despite this, it appears that not all animals can taste similar things. Research has found that different species have different taste buds specialised to detect the things they are most adapted for.

Senses and feedback mechanisms that link nutrition and feeding behaviour

Smell and taste belong to the chemical sensing system we call ‘chemosensation’. Smelling and tasting is a complicated process that starts when molecules released by the substances around us stimulate special nerve cells in the nose, mouth or throat, and these cells then transmit messages to the brain.

Olfactory (smell) nerve cells are stimulated by the odours around us - for example, the fragrance from a flower. These nerve cells are found in a patch of tissue high up in the nose and they connect directly to the brain.

Gustatory (taste) nerve cells are clustered in the taste buds of the mouth and throat. They react to food or drink mixed with saliva. Many of the small bumps that can be seen on the tongue contain taste buds. These surface cells send taste information to nearby nerve fibres, which send the messages to the brain.

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In humans, our ability to taste bitterness is the most highly developed. We can detect the presence of a bitter taste as little as 1 part per 200,000. In comparison, we detect sweetness in about 1 part per 200. Researchers say this may be a built-in safety mechanism for detecting poisonous plants; that is, we can detect the bitter poisonous alkaloids in plants without having to eat enough to get sick from them.

Horses have been shown to respond at least 4 of the 5 taste sensations: sweet, salty, sour and bitter solutions. Although there is a large individual variability among horses, they prefer or avoid foods according to their taste. Researchers say that this is important to consider when feeding horses for performance or health.

Above: Feedback from the gut to the brain stem and limbic system causes changes in the preference for particular foods, which are involuntary (non-cognitive) and depend on the food’s effect on the internal systems. On that basis, higher cortical centres involved with declarative memory (the memory which can be consciously recalled) interact with the limbic system to facilitate changes in food selection behaviour. (Adapted from Provenza, 1995.)

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Salty, which permits modulating the autonomic nervous system (visceral nerves), the brain stem, limbic system (thalamus, hypothalamus, amygdala and hippocampus) and higher cortical centres of the brain, interact through neural fibres that can facilitate or inhibit behaviours (see Figure 1).

Taste plays an important role in the processes that cause animals to change their preference or food intake. The affective or involuntary process (an automatic process that can even happen when the animal is asleep) links the taste of food with its post-ingestive consequences to alter the preference or intake of food (depending if it had a positive or aversive effect internally).

The cognitive or voluntary process (a learned behaviour) involves the use of the senses of smell, sight and sound to discriminate amongst foods that cause satisfaction, and foods that make the animal feel unwell or sick. The affective and cognitive processes are mediated by different brain systems (see Figure 1), but they operate in parallel to regulate the internal environment.

It is through these processes that animals acquire food preferences and aversions (they learn to like or dislike certain foods).

Flavours

In humans, the sense of taste comes from taste receptor cells, which are bundled together in clusters of up to 150 (i.e. taste buds). Taste buds are usually the most widespread on tiny pegs of the surface of the tongue called papillae. In humans, we know there are five primary taste sensations:

- Salty, which permits modulating the diet for electrolyte balance.
- Sour, which typically indicates acids.
- Sweet, which indicates energy-rich nutrients.
- Bitter, which can indicate toxins.
- Umami, which is the taste of amino acids, such as meats and cheese.

Certain tastes join with texture, temperature and odour to produce a flavour that allows us to detect what we are eating. Many flavours are recognised through the sense of smell. If you hold your nose while drinking coffee, for example, you will have trouble identifying the coffee flavour, even though you can distinguish the food's sweetness or bitterness. This is because the familiar flavour of coffee is sensed largely by odour.

Interestingly, taste and smell cells appear to be the only cells in the nervous system that are replaced by the body, when they become old or damaged. Scientists are examining this phenomenon while studying ways to replace other damaged nerve cells.

Humans versus animals

Do you think that foods taste identical to us as they do to other animals? The molecular mechanisms in humans and animals does appear to be comparable - what is sweet to us, also tastes sweet to a rat - however, there are some exceptions. For example, cats can't taste sweet things (it's an evolutionary trait that all members of the cat family have lost and some species of monkey can't taste artificial sweeteners, but do taste natural sugars.

It has been estimated that humans have 8,000-10,000 taste buds on their tongue that are typically replaced every 10 to 14 days. Other mammals, however, have many more taste buds, predominantly on their tongue and palate. Herbivores, like cows and horses, have around 25,000, omnivores, like pigs, have around 13,000 and carnivores generally have the least number of taste buds. Researchers suggest that the reason why herbivores have so many taste buds is that they need to be able to differentiate if plants contain toxic substances. Conversely, a carnivore's diet is usually fairly consistent and safe (it comes in packages). Birds have far fewer taste buds than mammals and, for example, chickens only have around 30.

Fish have lots of taste buds, both in their mouths and on their skin, mainly along their lateral lines. Several reptiles, such as snakes and lizards, use their tongues to detect both taste and smell chemicals, and they do so by transporting molecules to a pit in the roof of the mouth called the Jacobson's organ, the famous organ that is responsible for the flehmen response in horses (See Figure 2 opposite).

The equine senses

The truth is that we know very little about the role of smell, taste and post-ingestive feedback mechanisms in horses. Industry has assumed that most of these processes work in a similar way as observed in other herbivores, such as cows and sheep - both species that have been the subjects of some research.

There are, however, some distinct differences that we have to consider between horses and ruminants. Most notably the difference in post-ingestive gut-brain feedback of the horse - a hindgut fermenter that cannot vomit - with that of a ruminant with a very different anatomy.

So, next month, we will delve more deeply into the theory and research to date that relates to the food preferences and aversions in ruminants, and what current research is available on horses.