



Flavours in Ruminant Diet

Kalam et al.

## Flavoured Additives in Ruminant Nutrition: A Review

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### ABSTRACT

The Indian livestock population is growing exponentially and with limited available fodder for live-stock, it is becoming difficult to obtain optimum production from the animals. Constraints of fodder availability force to use unconventional feedstuffs. Palatability of certain feedstuff depends on the pre- and post-ingestive feedback which comprise of smell, taste, texture and flavour of feed and aversion and preference towards particular feed causes due to those factors. Unconventional feeds have low palatability which impacts its intake thus the production. Flavoured additives are substances which are added to those unconventional feedstuffs to improve its palatability by masking the unpleasant characteristics present in it and thus enhance its intake and production of animal. Preference of animal toward particular feed changes with the taste with sweet and umami taste shows positive preference whereas bitter tastes show negative preference. Flavoured additives increase dry matter intake, average daily gain, and weight gain in growing animals whereas in dairy animals it improves dry matter intake, milk yield, milk fat percentage, feed efficiency and reduces loss of body condition and improves energy balance in early lactating cow. There are few challenges for manufacturing livestock ration and raw material quality and availability is the major cause which impact the cost of production and those challenges can be overcome by the use of flavoured additives to produce economic ration.

**KEYWORDS:** Additive, Animal, Feedstuff, Flavour, Palatability

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### INTRODUCTION

High performing livestock demands a better nutrition for efficient production system. In India, currently we are facing feed and fodder shortage due to various reasons (Roy et al., 2019) and this situation compels us to use unconventional feedstuffs and crop residues which have low palatability and digestibility thus, affects the animal performance. The senses of taste are well developed in dairy cattle (Albright, 1993) so, the feeds that are pleasing to olfactory, gustatory and tactile senses are selected by animal and are avoided which are not. Animal behaviours in relation to taste are better described as evidence of preference, aversion or indifference (Kare, 1970). Aversion can affect the feed intake of the animal, thus the performance and health.

Voluntary feed intake is important for optimum animal performance (Journet and Remond, 1976) which is affected during stress condition (Grant and Albright, 1995). Hence, the palatability of the feed regulates animal performance. Over the past five decades, feed additives have received increasing attention from both nutritionists and producers (Hou et al., 2017). As feed additives are highly utilised to improve the efficiency of feed and ruminants are very sensitive to feed palatability, which is one of the main reasons palatant additives, like flavors had become very important in ruminant nutrition. Studies have been conducted on various flavours such as vanilla, sucrose, starch, molasses, oregano, ginger, fenugreek, fennel etc. to evaluate their preferences when added to unconventional or low-quality feedstuff and many

of the studies found significantly improved growth performance and production parameters. Altering just one sensory property of feed can enhance its intake (Rolls et al., 1986) hence several flavours and volatile compounds are applied to improve the feed palatability and preferences (Cannas et al., 2009). Preference towards a certain feed depends on pre-ingestion information and post-ingestion information. Pre-ingestion information supported by the sight and smell before feed intake and post-ingestive information arises after feed intake caused due to its texture and taste.

### **Palatability**

Palatability is seen as an inherent quality of the feed and is described as “dietary features or conditions that evoke a selection response in the animal”. It is determined by the feed’s taste, smell, temperature, and texture. However, palatability cannot be treated merely as a feed quality because it is dependent on the animal’s experience and present nutritional condition. The palatability of the feed is the outcome of the animal’s hunger, which is stimulated by the consumption of feed. Eating rate, particularly at the start of the meal, is an excellent indicator of the animal’s hunger, while palatability of the feed is defined as all physical and chemical properties of the feed that influence appetite. (Burritt and Provenza, 2002).

Palatability is obviously not a quantitative measure unless feed intake is measured per unit of time. Although preference gives information about differences among feeds, it may not affect intake when a single feed is offered. However, it is widely known that the positive or negative post-ingestive effects that these meals elicit in animals are modified by their past experiences. These experiences can occur early in life, such as during prenatal or early growth stages, or during the productive lives of the animals, and are modified by their needs, which are strictly related to the animal’s physiological condition, as well as by external stimuli.

They are memorized in specific areas of the brain cortex and when elicited by a sensorial perception

can induce aversion towards feeds, depending if previous experiences induced positive perceptions, i.e., feed reward, or negative ones (Baumont, 1996). Sensory perceptions differ even within the same meal. As the meal progresses, the first powerful sensory sensations elicited by the meal are dampened by a sequence of anorexic neuro-hormonal signals, which originate in the gastrointestinal tract and convey satiety signals to the brain’s nucleus tractus solitarius. Thus, it is more acceptable to describe palatability as the inter relationship between sensory and post-ingestive effects, which are impacted by feed chemical and physical properties, animal nutritional condition, and previous experience with feed (Provenza, 1995).

### **Odour**

The first sensory evaluation of feed without any direct contact in animals is supported by sight and smell/odour. It is the chemical properties of a substance due to volatile aroma and perceived by the sense of smell through the olfactory organs e.g., spicy, fruity, putrid, burnt etc. smell molecules are carried to the cells, which produce a series of chemical reactions and sensations transmitted to the brain. Both smell and taste are chemical senses which involve chemoreceptors. Olfaction involves the detection of volatile chemicals in solution.

### **Taste**

Taste is considered important as it is the last sense that can inform animals about a feed’s characteristics before it is swallowed (Valentin et al., 2006). Taste and smell are often mixed together resulting in a global stimulation of the oro-pharyngeal area, called flavor (Favreau-Peigné et al., 2013). Ruminants quickly learn to associate positive post-ingestive feedback with nutritious feeds, and negative PIF with feeds that contain toxins, excessive nutrients or inadequate nutrients (Provenza et al., 2003).

### **Basic tastes**

Bitter, sour, salty, sweet, and umami are the five categories into which taste experiences can be categorized. Toxins are frequently present in the feed if the flavour is unpleasant and bitter. Tastes that

are sour or bitter might also indicate rotten food. Although sodium salts are the primary source of salty taste stimuli and several non-sodium salts also have a salty flavour element. This implies that the presence of sodium or general minerals is indicated by a salty taste. Consummatory reactions to salty taste stimuli vary significantly between some species' sodium-replete and -depleted individuals. Concentrated salt solutions can be acceptable to animals with depletion even if they are repulsive to animals with sodium- or mineral-replete bodies. Sugars, a natural sweet taste stimulant that denotes the presence of carbohydrates in feed, are the most prevalent sweet taste stimulus. The most common umami taste stimulus is L-glutamate, which may indicate the presence of protein (Bachmanov and Beauchamp, 2007).

**Texture**

Perception of the physical constituents of a substance through lips (beak), palate, tongue and teeth. This involves touch sensation associated with the mouth and includes such physical attributes as granularity, density, pellet or particle hardness.

**Flavour**

According to the US Society of Flavor Chemists, the flavor is “the substance taken into the mouth which stimulates one or both senses of smell and taste and/or also the general pain, tactile and temperature receptors in the mouth. The functional use of flavours in the diet of animals is to increase a sensory response in animal’s appetite for feed intake. It improves the health, productivity as well as the reproductive performance of the animals and aid in farmer’s profitability.

**Flavoured additives**

The non-nutritive substance which improves the aroma or taste or both of any feedstuff and provokes a sensory response that will stimulate the animal’s appetite for feed, ultimately improving feed intake and performance. Flavors are often added to calf starters to stimulate the consumption of dry feed (Thomsen and Rindsig, 1980). Exposure to diverse flavors has the potential to induce a more consistent diurnal consumption of feed by reducing peaks and nadirs of intake compared with exposure to monotonous rations (Villalba et al., 2011).

Table 1. Classification of flavoured additives

Spices	Sweeteners	Flavour masks	Organic chemicals
Coriander, Clove Ginger, Turmeric Fenugreek Aniseed, Capsicum	Molasses Honey Sucram/ Cyclamates	Vanilla Lactovanilla flavour Banana flavour	Monosodium glutamate Benzoic acid Talin
Cinnamon Thyme	Glucose Saccharin	Red berry flavour Grass feed flavour	Ethyl acetate, Diacetyl Furfurol, Simax-100

**Uses and preferences**

**Use**

Flavours are used to mask the unpleasantness of low-quality feeds and unconventional feedstuff having less palatability which makes it appealing in the animals. They also increase the voluntary dry matter intake due to improved palatability of feeds which eventually improves the performance of the animal. Flavours can also be used during stress condition like transient stress, weaning stress, disease stress, heat stress etc. to improve the feed intake of

the animal during these conditions. Addition of certain flavours could be beneficial as ruminants have a large number of taste buds present on their tongue having preference for different flavours. As flavours are added in minor quantities in the feed, they are cost effective and help to overcome the high-cost feed in scarcity.

**Preferences**

It is possible that the bitter taste serves as a warning effect because it has a negative hedonic value. The salty taste may have a variable hedonic

value depend on physiological requirements and a signal value for the amount of minerals in feeds. The sweet taste seems to have a positive hedonic value in cattle. Since sour taste appears to be positive at low intensities but negative at larger intensities, it is challenging to determine its precise hedonic value. Many experiments showed the umami taste to be preferred to increase intake, including in the absence of a post-ingestive effect (Ginane et al., 2011).

### Hedonic value

The hedonic value of a feed's sensory properties needs to be considered as a potential determinant of feeding behaviour, as it can override normal satiety signals and regulatory mechanisms, and so lead to excessive feed intake in animals. It has also been shown that the neural systems underlying the hedonic and homeostatic regulations of eating are separate, involving distinct brain structures and neurochemicals. This separation means that homeostatic needs are not the sole force driving feeding behaviour, and that hedonism can influence feeding decisions as well. Within each species, often shown a broad variability in the hedonic responses of animals toward the tastes (Ginane et al., 2011). Hedonic scales are well tried and tested for capturing liking data (Stone and Sidel, 2004). In relation to evaluating eating and drinking experiences, hedonics

are often referred to as simply 'liking'. Liking is the immediate experience or anticipation of pleasure from the oro - sensory stimulation of eating a feed (Mela et al., 2006).

### Effects on growing ruminant

Consumption of solid feed by young ruminants is critical for rumen development, weaning transition, and postweaning growth (Khan et al., 2016). Restricted milk feeding and early weaning have been used as strategies to promote solid feed intake and reduce the rearing cost of calves (Yavuz et al., 2015). Adequate nutrition is essential to maintain the integrity of the immune system. Decreased feed intake may increase an animal's susceptibility to infection, particularly during stress conditions like weaning and transportation of young stock. In young ruminants, feed neophobia, a phenomenon that can decrease intake and animal performance, can be problematic in the transitional period from milk to solid feed (Costa, 2015). Identifying flavor preferences of young ruminants may be beneficial for overcoming feed neophobia, which may occur even in animals offered highly nutritious novel feeds (Catanese et al., 2012). Flavoring agents affect and increase the intake of poor-quality feeds (Cheeke, 1991) and also stimulate feed consumption by increasing palatability.

Table 2. Meta analysis of flavoured additives in growing animals

Additive	Experimental animal	Effects	Reference
Orange and Vanilla (In water)	Holstein calves	Increased feed intake in both flavoured water.	Thomas et al. (2007)
Mixture of garlic powder, oregano leaves, basil leaves 0.2 % vanilla	Corriedale lamb	Increased weight gain in orange flavoured water. Stimulates the consumption of low nutritive hay.	Distel et al. (2007)
Sucram (Sodium saccharin-based dietary sweetener)	Calves	Prewaning ADG was improved and met weaning criteria early. DMI and ADG were numerically increased.	Fathi et al. (2009)
Milk aroma flavour	Holstein calves	Increased feed intake and weight gain.	Ponce et al. (2014)
			WU et al. (2015)

<sup>1</sup>ADG – Average Daily Gain

<sup>2</sup>DMI -Dry Matter Intake

### Effects on dairy animals

Dry matter intake is the single most significant variable related to the performance of lactating dairy cows (Huhtanen et al., 2007). High-yielding dairy cows usually experience a negative energy balance during early lactation because the energy in milk exceeds the energy intake through feed (Reynolds,

2006). Reduction in the dry matter intake affects the animal's health and performance. Cows in early lactation or sick cows that are off feed, could be benefited from the highly preferred flavour, which may stimulate overall DMI. Elevation of feed intake with increasing dietary sugar has been observed in dairy cattle (Sutton et al., 2001).

Table 3. Meta-analysis of Flavoured additives in Dairy animals

Additives	Experimental Animal	Effects	References
Liquid flavour supplementation	Holstein cows	Increase in DMI from week 1 prepartum to week 4 postpartum. Loss of body condition 1-week prepartum and 2-week postpartum was reduced. Improves the energy balance of cows in early lactation.	Shah et al. (2004)
Replace dietary starch with sugar	Holstein cows	A linear increase in DMI and milk fat content with increasing dietary sugar.	Broderick et al. (2008)
Sucram Sweetener + Lactovanilla Flavour	Sahiwal cows	Numerically improved milk production.	Jongwe et al. (2014)
Anise, fenugreek, honey, orange, thyme, molasses, and vanilla	Holstein cows	The most consumed diet was fenugreek and vanilla added ration.	Harper et al. (2016)
Molasses-based liquid feed	Holstein cows	Increased DMI, milk yield, and 4% FCM in early lactation.	Havekes et al. (2020)
Fennel and Ginger	Egyptian buffalo	Improves feed efficiency and production of milk and fat concentration.	Fahim et al. (2022)

<sup>1</sup>DMI -Dry Matter Intake

### Challenges for manufacturer

The feed industry is growing rapidly as the demand for rapid animal performance, better health and reproductive performance is increasing. Feed manufacturing is challenging as the same raw material is not available throughout the season. It may be affected by the off-quality batches of raw material and such a situation forces to use of another ingredient for feed manufacturing because of the different compounds in different kinds of feed materials. Feed manufacturing can also be affected economically by minor changes and such situation may cause feed manufacturing expensive. By the addition of flavours to the feed, it can overcome such challenges and can be beneficial to the producer as well as the consumer.

### CONCLUSIONS

Feed choice is determined by complex factors that include previous experiences, feed sensory characteristics, post-ingestive feedback and the physiological condition of animals. Incorporation of familiar flavour in the diet increases acceptance of novel feed. The addition of flavour to diet, exerts a masking effect on unpleasantness and in turn results in increased intake of low-palatable feed. Flavour is a useful tool to deal with situations affecting feed intake like weaning, heat stress, transition period etc. The effect of flavour on dry matter intake may be determined by a variety of factors including the basal diet and amount of flavour supplementation. Flavoured additives show a promising effect on dry

matter intake and average daily gain in calves. However, flavoured water increases the feed intake in calves. It has the potential to increase feed intake in early lactating cows and also increase milk fat and milk production and the potential to reduce loss of body condition in cows during the transition.

## REFERENCES

- Albright, J.L. 1993. Feeding behaviour of dairy cattle. *Journal of Dairy Science*. 76: 485-498.
- Bachmanov, A.A. and Beauchamp, G.K. 2007. Taste receptor genes. *Annual Review of Nutrition*. 27: 389-414.
- Baumont, R. 1996. Palatability and feeding behaviour in ruminant. *Annales de Zootechnie*. 45(5): 385-400.
- Broderick, G.A., Luchini, N.D., Reynal, S.M., Varga, G.A. and Ishler, V.A. 2008. Effect on production of replacing dietary starch with sucrose in lactating dairy cows. *Journal of Dairy Science*. 91(12): 4801-4810.
- Burritt, E.A. and Provenza, F.D. 2002. What makes an animal choose a forage. In: *Proc. Western Alfalfa Conference*. University of California, Davis. pp. 129-136
- Cannas, A., Mereu, A., Decandia, M. and Molle, G. 2009. Role of sensorial perceptions in feed selection and intake by domestic herbivores. *Italian Journal of Animal Science*. 8(2): 243-251.
- Catanese, F., Distel, R.A., Provenza, F.D. and Villalba, J.J. 2012. Early experience with diverse foods increases intake of non-familiar flavors and feeds in sheep. *Journal of Animal Science*. 90(8): 2763-2773.
- Cheeke, P.R. 1991. *Applied Animal Nutrition: Feeds and Feeding*. Macmillan, New York.
- Costa, J.H.C. 2015. *Food Neophobia, Feeding and Sorting Behaviour in Dairy Calves*. Doctoral dissertation, University of British Columbia, Canada.
- Distel, R.A., Iglesias, R.M.R., Arroquy, J. and Merino, J. 2007. A note on increased intake in lambs through diversity in food flavor. *Applied Animal Behaviour Science*. 105(1-3): 232-237.
- Fahim, N.H., Kholif, A.E. and Azzaz, H.H. 2022. Fennel and ginger improved nutrient digestibility and milk yield and quality in early lactating Egyptian buffaloes. *Annals of Animal Science*. 22(1): 255-270.
- Fathi, M. H., Riasi, A. and Allahresani, A. 2009. The effect of vanilla flavoured calf starter on performance of Holstein calves. *Journal of Animal Feed Science*. 18(3): 412-419.
- Favreau-Peigné, A., Baumont, R. and Ginane, C. 2013. Food sensory characteristics: their unconsidered roles in the feeding behaviour of domestic ruminants. *Animal*. 7(5): 806-813.
- Ginane, C., Baumont, R. and Favreau-Peigné, A. 2011. Perception and hedonic value of basic tastes in domestic ruminants. *Physiology and Behaviour*. 104(5): 666-674.
- Grant, R.J. and Albright, J.L. 1995. Feeding behavior and management factors during the transition period in dairy cattle. *Journal of Animal Science*. 73(9): 2791-2803.
- Harper, M.T., Oh, J., Giallongo, F., Lopes, J.C., Weeks, H.L., Faugeron, J. and Hristov, A.N. 2016. Preference for flavored concentrate premixes by dairy cows. *Journal of Dairy Science*. 99(8): 6585-6589.
- Havekes, C.D., Duffield T.F., Carpenter A.J. and DeVries, T.J. 2020. Effects of molasses-based liquid feed supplementation to a high-straw dry cow diet on feed intake, health, and performance of dairy cows across the transition period. *Journal of Dairy Science*. 103(6): 5070-5089.
- Hou, Y., Wu, Z., Dai, Z., Wang, G., and Wu, G. 2017. Protein hydrolysates in animal nutrition: Industrial production, bioactive peptides, and functional significance. *Journal of Animal Science and Biotechnology*. 8(1): 1-13.
- Huhtanen, R., Rinne, M. and Nousiainen, J. 2007. Evaluation of the factors affecting silage intake of dairy cows: a revision of the relative

- silage dry-matter intake index. *Animal*. 1(5): 758-770.
- Jongwe, C., Thakur, S.S., Kaur, J. and Mahesh, M.S. 2014. Effect of replacing groundnut cake with guar meal (*Cyamopsis tetragonoloba*) in concentrate mixture with and without added sweetener and flavour on production performance of Sahiwal cows. *Indian Journal of Animal Nutrition*. 31(2): 138-142.
- Journet, M. and Remond, B. 1976. Physiological factors affecting the voluntary intake of feed by cows: a review. *Livestock Production Science*. 3(2): 129-146.
- Kare, M.R. 1970. Taste, Smell and Learning. *Duke's Physiology of Domestic Animals*. Comstock-Cornell University Press, Ithaca, NY.
- Khan, M.A., Bach, A., Weary, D.M. and Von Keyserlingk, M.A.G. 2016. Invited review: Transitioning from milk to solid feed in dairy heifers. *Journal of Dairy Science*. 99(2): 885-902.
- Mela, D.J. 2006. Eating for pleasure or just wanting to eat? Reconsidering sensory hedonic responses as a driver of obesity. *Appetite*. 47(1): 10-17.
- Ponce, C.H., Brown, M.S., Silva, J.S., Schlegel, P., Rounds, W. and Hallford, D.M. 2014. Effects of a dietary sweetener on growth performance and health of stressed beef calves and on diet digestibility and plasma and urinary metabolite concentrations of healthy calves. *Journal of Animal Science*. 92(4): 1630-1638.
- Provenza, F.D. 1995. Postingestive feedback as an elementary determinant of food preference and intake in ruminant source and food flavor on conditioned preference. *Journal of Range Management*. 48(1): 2-17.
- Provenza, F.D., Villalba, J.J., Dziba, L.E., Atwood, S.B., and Banner, R.E. 2003. Linking herbivore experience, varied diets, and plant biochemical diversity. *Small Ruminant Research*. 49(3): 257-274.
- Reynolds, C.K. 2006. Production and metabolic effects of site of starch digestion in dairy cattle. *Animal Feed Science and Technology*. 130(1-2): 78-94.
- Rolls, B.J. 1986. Sensory-specific satiety. *Nutrition Reviews*. 44(3): 93-101.
- Roy, A.K., Agrawal, R.K., Bhardwaj, N.R., Mishra, A.K. and Mahanta, S.K. 2019. Revisiting national forage demand and availability scenario. In: *Indian Fodder Scenario: Redefining State Wise Status* (Eds. A. K. Roy, R. K. Agrawal, N. R. Bhardwaj). ICAR- AICRP on Forage Crops and Utilization, Jhansi, India. pp. 1-21.
- Shah, M.A., Friedman, E.J., Bahaa, A.O. and Murphy, M.R. 2004. Effect of liquid flavor supplementation of the diet on dairy cows in the transition period. *Journal of Dairy Science*. 87(6): 1872-1877.
- Stone, H. and Sidel J.L. 2004. *Sensory Evaluation Practices*. 3rd Edn. Elsevier Academic Press, London.
- Sutton, J.D., Phipps, R.H., Cammell, S.B. and Humphries, D.J. 2001. Attempts to improve the utilization of urea-treated whole-crop wheat by lactating dairy cows. *Animal Science*. 73(1): 137-147.
- Thomas, L.C., Wright, T.C., Formusiak, A., Cant, J.P. and Osborne, V.R. 2007. Use of flavored drinking water in calves and lactating dairy cattle. *Journal of Dairy Science*. 90(8): 3831-3837.
- Thomsen, N.K. and Rindsig, R.B. 1980. Influence of similarly flavored milk replacers and starters on calf starter consumption and growth. *Journal of Dairy Science*. 63(11): 1864-1868.
- Valentin, D., Chrea, C. and Nguyen, D. H. 2006. *Taste-Odour Interactions in Sweet Taste Perception. Optimising Sweet Taste in Foods*. Woodhead Publishing Ltd, Cambridge, UK.
- Villalba, J.J., Bach, A. and Ipharraguerre, I.R. 2011. Feeding behaviour and performance of lambs are influenced by flavor diversity. *Journal of Animal Science*. 89(8): 2571-2581.

- Wu, Y., Bi, Y., Li, S., Wang, Y. and Cao, Z. 2015. Effect of milk aroma flavor on starter consumption, growth, and feed conversion in female Holstein calves. *Journal of Animal Science*. 93(3): 392.
- Yavuz, E., Todorov, N., Ganchev, G., and Nedelkov, K. 2015. The effect of feeding different milk programs on dairy calf growth, health and development. *Bulgarian Journal of Agricultural Science*. 21: 384-393.