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Short communication

A note on increased intake in lambs through diversity in food flavor

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Abstract

Because preferences for food flavor decline during and after a meal, intake could be increased by offering the same food in different flavors simultaneously. The objective of this study was to determine the effects of offering the same hay with different flavors on forage intake by lambs. Individually penned lambs were given *ad libitum* access to either alfalfa hay (Trial 1) or pasture (alfalfa-grass) hay (Trial 2). In both trials, lambs in the variety of flavors (VF) treatment were simultaneously fed the same amount of natural, garlic, oregano, and basil flavored hay, whereas lambs in the natural flavor (NF) treatment were fed natural hay. There was no difference ($P > 0.05$) between treatments in daily intake of alfalfa hay in Trial 1 (mean daily intake ± S.D. was 1620 ± 234 g for VF and 1583 ± 262 g for NF). In Trial 2 lambs in the VF treatment ingested 10% more ($P < 0.07$) pasture hay than lambs in the NF treatment (mean daily intake ± S.D. was 1446 ± 181 g for VF and 1320 ± 214 g for NF). Variety of flavor tended to increase consumption of pasture hay (middle quality hay), but did not increase consumption of alfalfa hay (high quality hay).

Keywords: Forage intake; Diet selection; Food flavor; Ingestive behavior

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1. Introduction

Why does an animal terminate a meal? This question has long been recognized as a problem of basic importance for the understanding of ingestive behavior (Swithers and Hall, 1994). Current evidence suggests that satiety is influenced by both post-ingestive feedback signals and food's sensory properties (Provenza, 1996; Sclafani, 2004). Excessive levels of nutrients or toxins, nutrient imbalances or nutrient deficiencies cause satiety (loss of interest or appetite) through the development of transient food aversions (Provenza, 1996). However, regardless of the post-ingestive consequences, during consumption of a food the pleasantness of its taste, smell, appearance, and texture decreases, which has been referred to as ''sensory-specific satiety'' (Rolls, 1986). The underlying mechanism appears to be oral habituation (Swithers and Hall, 1994). Oral habituation results from repeated exposure to oral stimulation, during which ingestive responsiveness declines, even in the absence of substantial post-ingestive signals.

Satiety appears to be specific to a food which has been eaten (Rolls et al., 1984). Feeding to satiety on one food decreases the response of gustatory, olfactory, and visual neurons to the taste, odor, and sight of that particular food, yet those neurons continue to respond to other foods (Critchley and Rolls, 1996). Varying just one sensory property of a food (e.g. its flavor) can enhance intake (Rolls et al., 1986). Feeding rats the same food in a variety of flavors resulted in increased intake and body weight gain (Naim et al., 1986). A similar response is expected to occur in ruminants, although it remains to be seen whether intake is stimulated when a primary component of the diet is offered in a variety of flavors (Provenza et al., 1996; Atwood et al., 2001a). Early and Provenza (1998) have shown that preference in sheep is influenced by changing flavor when the same food is offered, and that preference for alternative flavor is greater when the food is nutritionally inadequate. However, they did not compare offering a single feed flavor to multiple flavors of the same feed, as we did in the present study.

The objective of this study was to determine the effects of offering the same hay with different flavors on forage intake by lambs. Since sensory satiety becomes more pronounced when foods are nutritionally inadequate (Early and Provenza, 1998), we tested the variety of flavor hypothesis using both a high (alfalfa hay) and a moderate (alfalfa-grass hay, henceforth pasture hay) quality forage.

2. Materials and methods

We conducted two consecutive trials using sixteen 6-month-old female Corriedale lambs of 31 ± 1.5 kg of initial bodyweight (mean ± S.D.). Lambs were kept in individual pens under a shelter and had free access to fresh water and a mineral mix throughout the study. At the beginning of the study (i.e. before the trials), the daily *ad libitum* intake of alfalfa hay was assessed for 7 days. Lambs were then assigned to two experimental groups by stratified randomization on the basis of mean daily intake and initial liveweight.

Chopped (2–3 cm) hay either in its natural flavor (NF treatment) or in a variety of flavors (VF treatment; garlic, oregano, basil, and natural) was offered to the lambs in both trials for a 15-day period. In Trial 1 we offered the lambs a high quality alfalfa hay while in Trial 2 a lower quality pasture hay was offered. The total amount of hay offered to each animal was twice its voluntary intake as assessed during the 7-day pre-trial period. Thus, for the VF treatment, the amount of hay offered in each flavor (four flavors in total) represented 50% of the initial voluntary intake. Such amount was enough to ensure refusals of 10% or more for each flavor. Lambs were fed the hay into four buckets (10 L capacity) with either the same (natural) or four different flavors (natural, garlic, oregano, and basil). Flavored hay was prepared by carefully mixing 20 g of garlic powder, oregano leaves, or basil leaves per kg of hay. For the VF diet, the physical position of each flavor was randomly changed every day in order to prevent any selection bias. Lambs were fed at 08:00 h

daily after collecting refusals, which were individually weighed to calculate intake. Intake was expressed as g lamb^{-1} day^{-1}. We allowed 5 days of adaptation to the new diets so we present results for the last 10 days of each trial. Lambs were switched by treatment for Trial 2 in order to avoid any influence of past experience with the flavors.

Composite samples ($n = 10$) of hay offered during each trial were analyzed to determine neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP).

We conducted two independent mixed model analyses, one for each trial. The sequential nature of daily intake data was addressed by selecting a covariance structure which maximized Akaike's information criterion (Littell et al., 1996). For both trials that was an autoregressive structure. The mixed model included fixed effects for treatment, day, and the interaction of treatment by day; lamb within treatment was the random effect. Hay quality variables were analyzed by one-way ANOVA. The SAS System was used for calculations (Littell et al., 1996).

3. Results

The alfalfa hay used in Trial 1 was lower ($P < 0.0001$) in NDF (49.1% versus 56.9%) and ADF ($P = 0.0006$) (34.4% versus 39.1%), and higher ($P = 0.0729$) in CP (20.6% versus 19.1%), than the pasture hay used in Trial 2.

In Trial 1, lambs in the VF treatment consumed a similar amount ($P = 0.6615$) of alfalfa hay than lambs in the NF treatment (Fig. 1). Intake was 1620 ± 234 (S.D.) g lamb^{-1} day^{-1} and 1583 ± 262 (S.D.) g lamb^{-1} day^{-1} for the VF and NF treatments, respectively. There was day to day variation in intake ($P < 0.0001$) which was not homogeneous across treatments ($P = 0.0034$, day by treatment interaction). In the VF treatment daily consumption of alfalfa hay flavored with oregano, garlic, basil or natural was 368 ± 103, 447 ± 105, 426 ± 101, and 378 ± 111 (S.D.) g lamb^{-1} day^{-1}, respectively.

In Trial 2, lambs in the VF treatment consumed 10% more ($P = 0.0716$) pasture hay than lambs in the NF treatment (Fig. 2). Intake was 1446 ± 181 (S.D.) g lamb^{-1} day^{-1} and 1320 ± 214 (S.D.) g lamb^{-1} day^{-1} for VF and NF treatments, respectively. There was daily variation in intake ($P = 0.0005$) which was of a similar magnitude ($P = 0.7872$) in both treatments. In the VF treatment daily consumption of pasture hay flavored with oregano, garlic, basil or natural was 326 ± 133, 378 ± 135, 319 ± 179, and 423 ± 100 (S.D.) g lamb^{-1} day^{-1}, respectively.

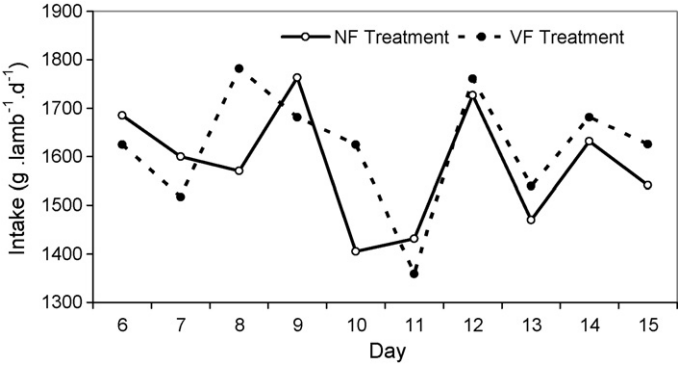

Fig. 1. Intake of alfalfa hay fed in its natural flavor (NF treatment) or in a variety of flavor (VF treatment) in Trial 1. Each value represents the mean of eight animals. Differences between treatments are not significant ($P > 0.05$). The S.E.M. is 58 g lamb^{-1} day^{-1}.

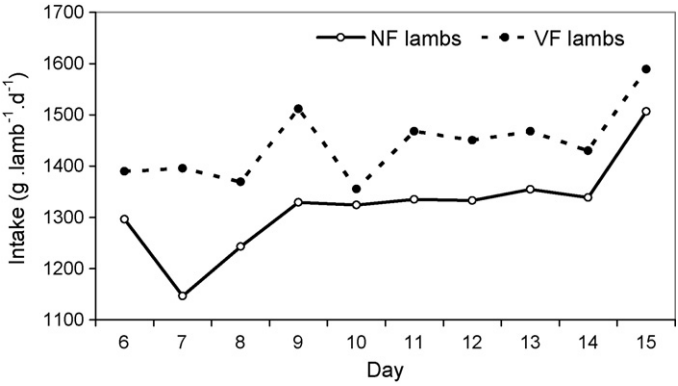

Fig. 2. Intake of pasture hay fed in its natural flavor (NF treatment) or in a variety of flavor (VF treatment) in Trial 2. Each value represents the mean of eight animals. Differences between treatments tend to be significant ($P < 0.07$). The S.E.M. is 44 g lamb^{-1} day^{-1}.

Table 1
Group (across individuals) and day (within individuals) coefficients of variation for intake of alfalfa hay (Trial 1) or pasture hay (Trial 2) in natural flavor (NF) vs. variety of flavor (VF)

Treatment	Trial 1				Trial 2			
	Group		Day		Group		Day	
	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)
NF	16.3	9.7–24.2	12.8	9.7–16.7	15.3	8.5–21.2	13.6	6.8–22.0
VF total	13.0	7.0–17.8	12.2	7.7–17.8	12.0	6.4–16.6	10.2	6.7–15.2
VF oregano	32.6	11.4–69.6	42.8	24.9–59.8	53.2	21.3–170.2	49.0	20.6–71.1
VF garlic	25.1	8.8–44.5	29.0	14.0–53.8	43.3	13.8–123.2	45.3	23.4–71.1
VF basil	34.0	8.4–133.5	41.5	18.7–60.6	58.1	21.8–87.6	55.6	17.8–124.4
VF natural	33.5	5.5–74.2	38.4	21.7–57.8	26.3	13.1–71.4	27.0	14.0–53.0

For both trials, coefficients of variation calculated across individuals (within groups) or across days (within animals) were one to several orders of magnitude higher for intake of each individual flavor in the VF treatment than for total intake in either the VF or the NF treatment (Table 1).

4. Discussion

The hypothesis that guided our study was that continuous oral experience with the same flavor decreases intake, and that the lower the nutritional quality of the food the greater the depression in consumption. Based on this notion, we predicted that offering the same hay in different flavors would stimulate consumption by lambs and that the lower the nutritional quality of the hay, the higher the effect would be. Variety of flavor did not increase intake in Trial 1, when lambs were fed a high quality alfalfa hay (Fig. 1), whereas it tended to increase intake in Trial 2, when lambs were fed pasture hay of a lower nutritional quality (Fig. 2). Our findings are thus partially consistent with the variety in flavor hypothesis.

The lack of influence of variety of flavor on intake when lambs were fed alfalfa hay in Trial 1 could have been due to the high palatability of alfalfa and the short duration of the trial (2 weeks). Studies of the effects of consumption of monotonous diets suggest that the initial palatability of foods determines how soon changes in the pleasantness of these foods do occur (Rolls, 1986). The higher the initial palatability of foods, the longer it takes for a decrease in pleasantness to occur, since the reward quality of food is determined both by food flavor and post-ingestive consequences of nutrients (Provenza, 1996; Myers and Hall, 1998; Sclafani, 2004). Thus, repeated presentation of alfalfa hay of initial high palatability may have not changed the pleasantness for that food along the 2 weeks of trial. The same argument can be submitted to explain the positive influence of variety of flavor on intake in Trial 2, since the pasture hay fed during this trial was of a lower nutritional quality than the alfalfa hay fed in Trial 1. Changes in palatability occur more rapidly for foods of initial low palatability than for foods of initial high palatability (Rolls et al., 1986; Early and Provenza, 1998). Variations in preference were stronger for heifers fed untreated straw (43% digestibility) in different flavors than for heifers fed ammoniated straw (58% digestibility) in different flavors (Atwood et al., 2001a).

Differences among individuals in morphology and physiology may explain group and day coefficients of variation observed in Trials 1 and 2 (Table 1). Individual uniqueness in morphology and physiology influence food intake and preference (Provenza et al., 2003). Both cattle (e.g. Atwood et al., 2001b) and sheep (e.g. Scott and Provenza, 1999) vary greatly among individuals in their preference for and intake of foods. The higher coefficients of variation for intake of each individual flavor in the VF treatment, compared to the coefficients of variation for total intake (Table 1), could be attributed to temporal decreases in flavor preference following food ingestion.

When a variety of foods are available, animals commonly tend to switch between foods because of the decrease in palatability in any one food after consumption (Rolls, 1986). Our results showed that the variation in just one sensory property of a food can elicit the switching behavior. However, the more different the foods, the more rewarding the behavior will be (Rolls et al., 1986). The adaptive significance of a varied diet may lie in the consumption of a more balanced diet, on avoiding over-ingestion of toxins and/or on attenuating metabolic disorders (Provenza et al., 2003).

Variety of flavor tended to increase consumption of pasture hay (middle quality hay), but did not increase consumption of alfalfa hay (high quality hay). These results suggest that when livestock are feed low quality forages in confinement, offering mixtures of forages or the same forage in different flavors may stimulate intake and enhance performance. Likewise, in pastures containing plant of limited nutritional value (typically rangelands), diversity of plant species should provide enhanced intake and greater animal performance.

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