Journal of Animal and Feed Sciences, 16, Suppl. 2, 2007, 454–459

Are sheep able to develop preferences or aversions in response to an increase of rumen fill?

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ABSTRACT

We conducted two conditioning experiments to investigate whether sheep are able to develop preferences of aversions in response to an increase of rumen fill performed with 300 or 600 g chopped straw introduced through the rumen fistula. When sheep where fed a basal diet of hay (Experiment 1) they developed aversions against the feeds associated with the increase of rumen fill without a dose effect. When they were fed a diet of pellets of beet pulp (Experiment 2) they developed neither preferences nor aversions. These results indicate that physical consequences of feed intake are integrated by the animals and that they can contribute to diet choice *via* diet learning.

KEY WORDS: diet learning, rumen fill, straw, sheep

INTRODUCTION

Learned feed aversions and preferences have been recognized as a major process in the control of diet selection and intake in ruminants like other mammals (Provenza, 1995). Because of prior learning, the senses that are stimulated in the presence of feed enable the animal to anticipate toxic or positive nutritional postingestive effects of feed and to make adequate diet choices. Increase of rumen fill has been recognized as one of the factor that control forage intake (e.g., Baumont et al., 1990), but it remains a matter of debate as there are many situations in which ruminants stop eating forages before the rumen is physically full (Forbes, 1995; Kyriazakis, 2003).

The aim of this work was to investigate whether sheep perceive an increase of rumen fill with fibrous material as a postingestive signal and develop either preferences or aversions for the associated feed depending on whether it should be

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seen as negative when animals were fed a fibrous diet or positive when they were fed a more concentrate diet.

MATERIAL AND METHODS

Two consecutive experiments were conducted indoors at the INRA Clermont-Ferrand/Theix experimental farm in central France in 2004.

Animals and feeds

Six rumen fistulated 3-year-old Texel wethers (61.1 kg, SEM 2.3) were housed in individual crates with free access to water and salt block. Basal diet consisted of mixed grass hay (1600 g/day) in Experiment 1, and dehydrated beet pulp (1400 g) plus mixed grass hay (200 g) in Experiment 2, distributed in two equal meals at 08.30 and 16.30.

Test feeds used for conditioning and choice measurements were either three hays (cocksfoot, perennial rye-grass and Italian rye-grass) or three cereals (barley, maize and wheat), respectively, in Experiments 1 and 2.

Experimental procedure and design

Each experiment ran the same design with one pre-experimental week (W0) for testing the preferences between hays or cereals before conditioning, followed by three (Experiment 1) or four (Experiment 2) identical periods lasting for one week. Each experimental week was composed of three conditioning days, two choice test days and two rest days before starting the next cycle.

In both experiments, three conditioning treatments were tested. They were applied during conditioning and consisted of introducing into the rumen either 300 g (Straw 1) or 600 g (Straw 2) of finely chopped straw (about 1 to 2 cm) mixed with artificial saliva. The third treatment, named Control, consisted of only opening and manipulating the rumen fistula. These treatments were associated with the consumption by animals of either hays (Experiment 1) or cereals (Experiment 2). Effect of conditioning treatments were then compared during choice tests between the associated feeds. Both conditionings and choice tests were performed at 13.30, between the morning and the evening meal.

On each conditioning day, animals received 500 g of one of the three test hays (Experiment 1) or 600 g of one of the three cereals (Experiment 2). Treatments were then applied on three occasions during the meal, every 10 min for hays and every 2 min for cereals. In treatments Straw 1 and Straw 2, one third of the total amount of straw indicated above was introduced at each occasion. For each animal, each

conditioning treatment (Control, Straw 1 and Straw 2) was allocated to one of the hays (cocksfoot, perennial rye-grass and Italian rye-grass) in Experiment 1 and to one of the cereals (barley, maize and wheat) in Experiment 2. Each animal received the three conditioning treatments during the three consecutive conditioning days. The allocation of the three hays or cereals to animals, treatments (Control, Straw 1, Straw 2) and conditioning days was balanced over the period.

On the two days following conditioning, preferences between experimental feeds (hays or cereals) were tested. For each animal the choice was always between the feed associated to the Control treatment and the feed associated to one of the two other treatments, over the two successive days. For hays, tests durations were 10 min with 200 g of both hays offered, and for cereals tests durations were 3 min with 400 g of both cereals offered. The same procedure was followed in W0 where all binary feed combinations were tested in order to obtain the initial preferences of all individuals.

Statistical analysis

We used the mixed procedure of SAS software package (1999) with the repeated statement to account for period effect. We analysed the choice for the hay (Experiment 1) or cereal (Experiment 2) associated with the intra-ruminal introductions of straw. Choice ratios were transformed (root square) to satisfy normality in Experiment 1, but not in Experiment 2 because of normal distribution of data. Individual sheep were considered as statistical units and we tested the effects of conditioning weeks (including W0 which corresponded to sheep preferences before conditionings began), treatments (i.e. amount of straw introduced into the rumen) and their interaction.

RESULTS

Experiment 1

When sheep were fed a basal diet of hay, conditioning with straw made the choice for the hay associated with straw hardly decrease ($P<0.0001$). Compared to the preference before conditioning (W0), this result was evident from the first week of conditioning ($P<0.001$) (Figure 1). Repeating the conditioning procedure slightly but continuously reinforced the decrease in preference for the hay associated with straw as preferences in W3 were significantly lower from those in W1 ($P<0.05$).

However, modifying the amount of straw introduced into the rumen (comparison Straw 1 and Straw 2) did not have any significant effect on the choice for the hay associated with these introductions.

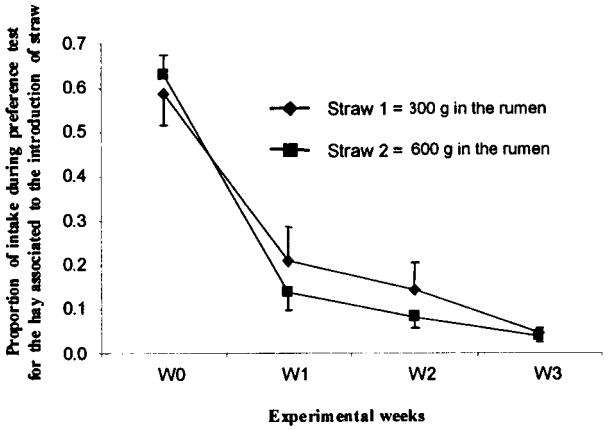

Figure 1. Effect of conditioning sheep, fed a basal diet of hay, with straw in the rumen on the preference (mean ± SEM) for the hay associated with the introduction of straw (n=6)

Experiment 2

When sheep were fed a concentrate basal diet and were offered cereals as experimental feeds, the preference for the cereal associated with the introduction of straw in the rumen was not affected either by the repetition of the conditioning procedure over four weeks, nor by the amount of straw introduced in the rumen (Figure 2).

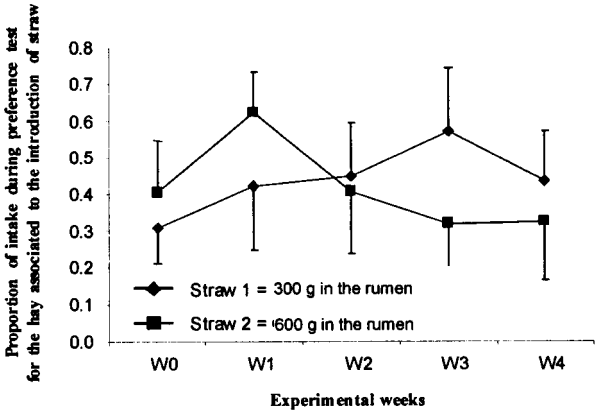

Figure 2. Effect of conditioning sheep, fed a basal concentrate diet, with straw in the rumen on the preference (mean ± SEM) for the hay associated with the introduction of straw (n=6)

DISCUSSION

These two experiments were aimed to test if sheep are able to perceive an increase in rumen fill with fibrous particles and if they would interpret it as a positive or a negative stimulus according to their basal diet and nature of experimental feeds. We choose to introduce in the rumen chopped particles of straw (0.8 g/g neutral detergent fibre (NDF) content) mixed with artificial saliva to simulate the physical consequences of the intake of a coarse forage on rumen digestive content.

Our results indicate that sheep are able to consider the increase in rumen fill as a negative postingestive consequence when they were fed as basal diet mixed grass hay and ate about 1000 g NDF per day that is close to the maximum they can eat (Baumont et al., 1997). In this situation rumen fill is important, and our results are consistent with the negative effect on intake of artificially increasing rumen fill (review by Faverdin et al., 1995) and with the concept that minimizing discomfort may explain dietary choice and feed intake (Forbes and Provenza, 2000). While diet learning was mainly focussed until now on nutritional or metabolic consequences (Villalba and Provenza, 1999; Ginane et al., 2005), these results show that a physical consequence as rumen load can also be quickly associated to the ingestion of a given experimental hay and makes the choice for this hay sharply decrease.

In contrast, when sheep where fed a more concentrate diet and ate only about 700 g NDF per day mainly in pellets they did not learn the increase in rumen fill either as a positive or a negative postingestive consequence. Straw has however been shown to prevent rumen disorders and to be consumed when sheep have choice with a concentrate feed (Cooper et al., 1995). The absence of learning in this second experiment may indicate that animals had difficulties to associate the physical consequences of straw in the rumen with concentrate feeds like cereals. It may show that animal's knowledge makes them conceive associations only in a delimited range.

A future prospect should be to combine the increase of rumen fill with different nutrient rewards to investigate the trade-off between physical and nutritive postingestive consequences.

CONCLUSIONS

Sheep learned the increase of rumen fill by the introduction of particles of straw in the rumen as a negative postingestive consequence when they were fed hay basal diet and when straw was associated with a fibrous feed (hay). In contrast, diet learning was not effective when they were fed pellets of sugar beet pulp as basal diet and when straw was associated with a concentrate feed (cereal). These

results indicate that physical consequences of feed intake are integrated by the animals and that they contribute to diet choice *via* diet learning.

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