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Effect of maize processing on diet selection in cows

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Abstract

The effect of maize, processed by three different methods, on the diet selection process was studied in 12 fistulated dry cows in a randomized block design. The experimental period lasted 20 days and was repeated twice (eight animals/treatment). Treatments allowed selection of different processed maize grains by the animals: sugar cane and coarsely ground maize (CG), sugar cane and finely ground maize (FG) and sugar cane and steam-flaked maize (SF). Urea was used with sugar cane in all treatments in the same proportion, ensuring 10% of crude protein in the ingredients and avoiding the influence of nitrogen (crude protein) on the selection process. The selection process was evaluated by comparing (1) the chemical composition (total digestible nutrients, neutral-detergent fibre) of the diets selected by the animals and (2) ruminal fermentation variables (pH, volatile fatty acids-VFA, and ammoniacal nitrogen). Maize intake by cows in the SF treatment was 45.08 and 42.08% lower than the CG and FG treatments, respectively. This resulted in a 24.52 and 22.58% lower total dry matter intake (DMI), a 29.83 and 27.59% lower total digestible nutrient (TDN) intake in kg, a 9.29 and 8.62% lower TDN intake in % and a 45.70 and 47.19% higher neutral detergent fibre (NDF) intake in % by cows fed SF compared to CG and FG, respectively. However, degradable dry matter intake (kg) and degradable starch intake (kg and %) did not differ among treatments. These data suggest that maize-processing influenced diet selection, probably due to different energy content and availability in processed grains used, and that animals were able to recognize differences among maize degradabilities, which are not determinable by usual chemical analyses. Regarding ruminal parameters, total VFA, acetate and butyrate concentration, pH and ammonia nitrogen did not differ among treatments, indicating that animals made practical choices with the objective of maintaining an optimum ruminal environment. However, differences in propionate concentration and acetate:propionate ratio were observed, probably due to lower intake of steam-flaked maize in the SF treatment.

Keywords: Bovine; Corn; Diet selection; Energy; Intake; Steam-flaking

1. Introduction

Forbes (1995) reviewed many studies on the hypothesis that animals are capable of distinguishing differences among feedstuffs and choosing the most suitable diet according to their physiological status.

Such choices are based not only on sensorial perceptions, but also on foods' chemical characteristics (Provenza, 1996). Lactating cows, submitted to a choice between grass and maize silages, ate more maize as the quality of grass silage became poorer (Weller and Phipps, 1985). Kyriazakis and Oldham (1993) demonstrated that

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sheep were able to select a diet that met their crude protein (CP) requirements and thereby avoid feeding excess protein. Lawson et al. (2000) suggested that protein demand might guide lactating cows' diet selection, although Tolkamp et al. (1998) observed that diet selection by lactating cows did not differ from a random choice among diets with different metabolizable protein content.

Rumen environment may also influence voluntary choice. Sheep preferred foods with $NaHCO_3$ when offered a choice between a high energy source with or without $NaHCO_3$ (Cooper et al., 1996). Grain-fed lambs preferred foods and solutions containing $NaHCO_3$ and lasalocid, compounds that attenuate acidosis (Phy and Provenza, 1998).

Due to grain-processing methods, an increase in ruminal degradability of starch may be expected, with a greater magnitude for steam-flaked than for ground maize. (Huntington, 1997). If altering the availability of ruminal starch by grain-processing leads to a raise in ruminal fermentable starch, then changes in the ruminal environment should be expected. The aim of the present study was to relate nutritional differences between various processed grain to the hypothesis that animals could perceive such differences given a choice between high-fibre (sugar cane) and high-energy feed (maize grain) with differing ruminal availability of starch due to the processing method.

2. Materials and methods

2.1. Housing and animals

Trial was carried out at the experimental facilities of College of Veterinary Medicine and Animal Science (University of Sao Paulo, Brazil). Animals were housed in individual stalls equipped with one feed bunk, subdivided into two feeders: one offering sugar cane (high-fibre feed) and the other maize (high-energy feed), thus allowing separate measurement of each feed intake.

Twelve non-pregnant and non-lactating Holstein cows (live-weight range: 582.1–714.5 kg), fitted with ruminal cannulae, were used.

2.2. Experimental design and treatments

A randomized block design was used (Snedecor and Cochran, 1989). Blocks were formed at the beginning of the experiment according to cows' live weight, so that three blocks with four animals each were formed: heavy, medium and lean cows. This experimental design facilitated the same chance of animals from different live-weight ranges receiving the proposed treatments equally.

Trial was divided in two periods of 20 days each with a 1-week interval between periods. In the first period, cows from the same block were allocated randomly to one of the three treatments, *i.e.* different methods of maize grain processing, whereby animals could manifest their preferences: (CG) urea-corrected sugar cane and coarsely ground maize, (FG) urea-corrected sugar cane and finely ground maize and (SF) urea-corrected sugar cane and steam-flaked maize. During the second period, treatments were changed among cows within each block. Each cow was considered an experimental unit and each treatment had eight experimental units.

2.3. Routine, feedstuffs and feeding scheme

Each 20-day period was divided in two: an adaptation phase (from day −5 up to day −1) and a data collection phase (day 0 to day 14). During the adaptation phase, only sugar cane (high-fibre feed), supplemented with urea mixture, was offered to all animals. Sugar cane plant were picked in the early morning and chopped completely (chopper Nogueira®, model EM-9F3B, Brazil), so that a homogeneous material was offered to cows. The chopper had an 8-mm space between knives, which produced a theoretical average particle size of 1.29 cm, according to methodology proposed by Lammers et al. (1996) and modified by Heinrichs and Kononoff (2002). At the time of feeding, urea–ammonium sulphate mixture (9 parts urea and 1 part sulphate) was added to the sugar cane (5.2 g of mixture/kg of original matter of sugar cane) to promote nitrogen supplementation and balance crude protein (CP) roughage content, thereby avoiding choices being made by differences in CP content of treatments. Starting from day 0 up to day 14, both urea-supplemented sugar cane and maize grain were offered to cows. Maize grains used in all treatments were flint-type (hard texture grain due to the starch granules-protein array) with similar chemical composition (Table 1).

Steam-flaked corn was processed at a commercial feedlot (Ração Total®, Brazil), with an exposure time to steam of ~30 min at 90 °C and then a drying temperature of 46.7 °C. At the end of the process, flakes had an average density of 270 g/L and average particle size of 8.25 mm. To obtain coarsely ground maize, approximately 95% of the kernels were dry-cracked in a hammer mill into thirds; the end product had an average particle size of 1.6 mm. Finely ground maize was produced by dry-grinding in hammer mill to produce a particle of 0.8 mm average size. Average particle size of grains was determined by shaking granulometry (sieves from Bertel®, Brazil, screen size: 2.36–0.25 mm; shaker from Marconi®, Brazil) for 15 min. After shaking,