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The importance of diet choice on stress-related responses by lambs

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ABSTRACT

Farm animals are commonly restricted to a reduced array of foods, like total mixed rations or pastures with low species diversity. Under these conditions, animals are less likely to satisfy their specific and changing nutrient requirements. In addition, foods and flavors eaten too frequently or in excess induce sensory-specific satiety and can cause aversions. Thus, sensory and postingestive monotony may reduce animal welfare. We hypothesized that exposure to monotonous diets, even if they are considered to be nutritionally balanced, is stressful for sheep. Twenty-four 2-month-old male Corriedale lambs were randomly assigned to two experimental groups. One group (diversity treatment, DIV) received a free choice of four-way combinations of two foods with low and two foods with high protein/energy ratios from an array of seven foods (three foods high in protein/energy ratio: soybean meal, sunflower meal, and alfalfa pellets, and four foods low in protein/energy ratio: barley grain, oat grain, milo grain, and corn grain). The other group (monotony treatment, MON) was fed a balanced ration containing all foods offered to lambs in DIV. Foods were offered in four individual buckets and exposure lasted 55 days. During exposure, feeding behavior was assessed, and blood samples were taken for a complete blood cell count and to determine serum cortisol concentration. Lambs in MON showed greater cortisol levels (31.44 vs. 19.90 ± 3.30 nmol/L [means ± SEM]; $P = 0.025$) and a greater neutrophil to lymphocyte ratio (0.37 vs. 0.26 ± 0.05; $P = 0.044$) than lambs in DIV. Lambs in DIV spent a lower proportion of time eating (0.38 vs. 0.49 ± 0.02; $P < 0.001$) and showed a greater intake rate (17.73 vs. 14.09 ± 1.26 g/min, $P < 0.044$) than lambs in MON. They also showed a greater proportion of time lying (0.44 vs. 0.36 ± 0.03; $P = 0.049$) and greater activity (0.047 vs. 0.035 ± 0.003; $P = 0.003$) than lambs in MON. However, final body weight and the average daily weight gain were not affected by treatment ($P > 0.05$). Our results showed that restricting lambs' dietary breadth produced changes in blood and behavioral parameters previously shown to be indicative of stress in sheep. The importance of incorporating food choice as an alternative practice to overcome stress associated to the traditional livestock feeding management is discussed.

1. Introduction

Animal welfare has gained relevance as an essential component of livestock production systems (Rushen et al., 2011). Management practices involving procedures meant to minimize stressful events in different phases of animal

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production are being increasingly required (Fitzpatrick et al., 2006). Among the different stressors affecting ruminants, fear (e.g. Boissy et al., 2005), heat (e.g. Silanikove, 2000), and transportation (e.g. Broom, 2003) have received the most attention. Paradoxically, less importance has been given to the feeding practices that impact nutrition and welfare in ruminant production systems (but see Catanese et al., 2012; González et al., 2009; Manteca et al., 2008).

Nutrition is considered to influence animal welfare because animals must be provided with all the nutrients needed for proper growth and development (Kyriazakis and Savory, 1997). This is usually attempted by offering animals a high quality forage or a complete mixed ration formulated to satisfy the average nutrient requirements of a given group of animals. Nevertheless, individuals within a herd vary substantially in their intake and preferences for foods, and tolerance for excesses and deficits of nutrient in their diets (Manteca et al., 2008). Differences in food intake depend on an animal's past experiences with foods as well as on variations in how animals are built morphologically and how they function physiologically (Provenza et al., 2003). As suggested by Forbes (2007), nutrients ingested in excess or deficit could produce a nutritional discomfort which motivates animals to search for other foods that alleviate the imbalance. But if no alternatives are available, it is unlikely animals will achieve a state of nutritional homeostasis and well-being (Broom, 1991).

Domestic livestock are generalist herbivores that evolved to eat a wide array of vegetal species and typically select a diverse diet even when their nutritional requirements can be met by ingesting a single food (Provenza, 1996). Animals develop transient aversions to foods or flavors that are eaten too often or in excessive amounts, while they increase preference for alternative foods or flavors (Provenza, 1996). This phenomenon, known as sensory-specific satiety (Rolls, 1986), encourages animals to eat a diverse array of foods. Seeking for alternative foods, sampling those available, and experiencing novel flavors and textures, are probably "behavioral needs" (*sensu* Jensen and Toates, 1993) most likely to be satisfied with a wide array of options.

Following this theoretical background, we hypothesized that the exposure to monotonous diets, even if they are considered to be nutritionally balanced, is stressful for lambs. The objective of this study was to determine behavioral responses and blood parameters in lambs exposed to two different feeding regimes: (1) a free-choice between several nutritionally complementary foods or (2) exposure to a single nutritionally balanced diet.

2. Materials and methods

The study was conducted at the "Centro de Recursos Naturales Renovables de la Zona Semiárida" (CERZOS) located in Bahía Blanca (38° 44′ S; 62° 16′ W), Argentina, from September 2011 to February 2012. All experimental protocols fulfilled animal welfare regulations of the Universidad Nacional del Sur (Bahía Blanca, Argentina) and adhere to the ASAB/ABS (2006) guidelines for the use of animals in research. Throughout the study lambs had free access to water and trace mineral salt blocks.

2.1. Animals, housing, and treatments

We used 24 2-month-old male Corriedale lambs with an average initial body weight (BW) of 19.2 ± 2.6 kg (mean ± SD). Animals were weaned, placed in a protected enclosure (20 m × 20 m), and fed alfalfa pellets *ad libitum* and 300 g/d of barley grain per animal for 15 d to satisfy their average nutrient requirements for maintenance and growth (National Research Council, 1985). Then, lambs were weighed and penned outdoors under a protective roof in individual adjacent pens measuring 2.5 m × 2.5 m.

Lambs were randomly assigned to two treatments (12 lambs/treatment) with restrictions of randomization such that all treatments were balanced for body weight. One group of lambs (hereafter "DIV") was fed simultaneously an array of four foods taken from a group of seven; three foods high in protein/energy ratio: soybean meal, sunflower meal, and alfalfa pellets; and four foods low in protein/energy ratio: barley grain, oat grain, milo grain, and corn grain (Table 1). Lambs from this treatment received 11 four-way choice combinations of two foods high in protein/energy ratio and two foods low in protein/energy ratio selected at random from all possible combinations (Table 2). Different four-way combinations of foods were

Table 1
Nutritional composition of foods offered during the 55-d exposure period (DM basis).

Foods	Nutrient composition				
	ME[a] (MJ/kg)	CP (g/100 g)	DigP[b] (g/100 g)	DigP/ME	NDF (g/100 g)
Low protein/energy ratio					
Barley grain	13.01	13.00	10.69	0.82	21.21
Oat grain	11.63	11.32	8.85	0.76	35.21
Milo grain	13.01	8.55	6.32	0.49	20.86
Corn grain	13.18	9.81	6.31	0.48	12.11
High protein/energy ratio					
Soybean meal	12.84	46.75	40.09	3.12	15.62
Sunflower meal	6.82	32.12	26.04	3.82	30.47
Alfalfa pellets	9.08	17.75	11.93	1.31	44.67
Mixed diet offered to MON	11.49	17.19	13.19	1.17	25.58

ME, metabolizable energy; CP, crude protein; DigP, digestible protein; NDF, neutral detergent fiber; MON, treatment fed only with this mixed diet.
[a] Estimated values from National Research Council (1985).
[b] Crude protein digestibility coefficients were estimated from National Research Council (1985).