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The inclusion of low quantities of lipids in the diet of ruminants fed low quality forages has little effect on rumen function

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ABSTRACT

Biohydrogenation within rumen fluid (RF) proceeds to varying degrees depending on retention time (RT) and type of basal diet, especially the profile of fatty acid (FA) being hydrogenised. The objective of this study was to examine the FA profile and the RT of liquid in the rumen of steers fed a low crude protein (CP) tropical grass (*Chloris gayana* hay, 38 g CP, 17 g crude lipid and 752 g neutral detergent fibre (aNDFom)/kg dry matter (DM)) supplemented with various lipids. Five rumen cannulated *Bos indicus* cross, five-year-old steers (799 ± 15 kg live weight (LW)) were allocated to a 5 × 5 Latin square design. The treatments were control, hay only, or the addition of 30 g/kg hay DM of lipid sources: Coconut (high lauric acid), cottonseed and soybean (high linoleic acid) or fish oil (high long chain FA (LCFA)). Retention time decreased with addition of soybean oil (14 h) but no differences between other treatments (mean 17 h). Coconut oil increased lauric and myristic acids in RF. There were no changes in total saturated FA (TSFA) in RF, with exception of a lower concentration for fish oil treatment. Addition of fish oil also decreased the concentration in RF of stearic and linolenic acid, but no differences to coconut and cottonseed treatments for linolenic acid. Fish oil also resulted in higher LCFA, linoleic and total unsaturated FA (TUFA), but no differences to soybean oil for the latter two acids. The conjugated linoleic acid (CLA) was only different in RF between cottonseed and fish oil treatments. Differences in FA profile of oils were only partially translated into the FA profile in RF of steers fed a tropical hay, without great changes in the proportion of CLA isomers observed.

1. Introduction

Fatty acid (FA) profile in the rumen fluid (RF) or adipose tissue of ruminant is influenced by the addition of oils in the diet, such as sunflower oil (Bessa et al., 2007), safflower oil (O'Kelly and Spiers, 1991), fish oil (Kim et al., 2008) and linseed oil (Shingfield et al., 2011). The common objectives in most studies using addition of FA in the diet, is to decrease saturated and trans FAs and increase

Abbreviations: RT, retention time; FA, fatty acid; RF, rumen fluid; CP, crude protein; aNDFom, neutral detergent fibre; ADFom, acid detergent fibre; DM, dry matter; LW, live weight; LCFA, long chain FA; TSFA, total saturated FA; TUFA, total unsaturated FA; CLA, conjugated linoleic acid; TOBCFA, total odd branched-chain FA; MCP, microbial crude protein

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conjugated linoleic acid (CLA)s, 18:3n-3, 20:5n-3, and 22:6n-3. These changes in FAs are related to human-health benefits (Ha et al., 1987; Ochoa et al., 2004), changes in the microbial population (Boeckaert et al., 2006), influences on animal metabolism (Bauman et al., 2011) or to enhancement of the overall performance of offspring, when fed to dams during pregnancy and lactation (Pickard et al., 2008; Or-Rashid et al., 2010). There are known differences between the FA profile of meat of grass fed animals and animals fed silage or concentrate-based diets (Poulson et al., 2004; Noci et al., 2005), but there is little information regarding the FA profile of cattle fed tropical grasses. Lipid profile and concentration in the diet are two factors that can influence the profile of fat in muscle and milk. Some isomers resulting from the biohydrogenation process are known to have effects on fat synthesis, and the longer RT of fluid in the rumen of animals fed tropical grasses may affect the extent of biohydrogenation and hence FA profile compared to other basal diets. One hypothesis in this study was that a higher polyunsaturated FA content of the supplement (highest being fish oil) was associated with a higher total unsaturated fatty acids (TUFA) of RF. A second hypothesis was that supplementation with lipids varying in FA profile resulted in different concentrations of CLA isomers, reflecting the FA profile of the supplement and the extent of biohydrogenation. The aim of this experiment was to determine differences in FA in response to the lipid supplement sources in cattle consuming a tropical grass hay.

2. Materials and methods

The experiment was conducted at the Center of Advanced Animal Science (CAAS). The procedures were conducted in accordance with the guidelines of the Australian code of practice for the care and use of animals for scientific purposes and were reviewed and approved by the University of Queensland animal ethics committee.

2.1. Animals, experimental design and treatments

Five Brahman-cross rumen cannulated steers (799 ± 15 kg LW, 5 years of age) at the commencement of the experiment were randomly allocated to one of five individual pens. Steers remained in their pens throughout the experimental period. Prior to the start of the experiment the steers were offered *ad libitum* Rhodes grass (*Chloris gayana*) hay containing 876 g organic matter (OM), 38 g crude protein (CP), 752 g ash-free neutral detergent fibre (aNDFom), 440 g ash-free acid detergent fibre (ADFom) and 17 g crude lipids per kg of dry matter (DM). The experiment consisted of a seven day adaptation period followed by an experimental period of five runs, each of which consisted of a feeding period of 18 days followed by a three day collection period (total 21 days).

The experiment consisted of a 5 × 5 Latin square design, consisting of five replicates (steers) and five treatments (lipids). Steers were allocated to one of the following treatments:

1. Control (Rhodes grass (RG) hay only); 2. Coconut oil plus RG; 3. Cottonseed oil plus RG; 4. Fish oil plus RG and 5. Soybean oil plus RG.

2.2. Feeding

Steers were offered RG at a total daily allocation of 9 g DM/kg LW in approximately equal amounts at 0700 and 1600 h each day. This level of intake was the average of the daily *ad libitum* intake in the 7 day adaptive feeding period. Lipids were offered at 30 g/kg hay intake on a DM basis, following the dose used by Shingfield et al. (2003), as total daily allocation split in half doses at 0700 and 1600 h each day and were administered via the cannula. No mineral or vitamin supplements were added. Hay residues of each steer were collected weekly.

2.3. Sampling procedures and measurements

2.3.1. Liveweight

Steers were weighed, unfasted, prior to feeding on the first day of each run.

2.3.2. Retention time of chromium ethylene diaminetetraacetic acid (Cr-EDTA) in the rumen

On day 19 of each run (day 1 of the RF collection period), a single dose of Cr-EDTA (approximately 65 mL/100 kg LW; 2.8 mg Cr/mL) was administered to three sites in the rumen (i.e. cranial, ventral and caudal sacs) of all steers via the cannula immediately prior to the morning feeding. Rumen fluid samples (approximately 300 mL) were collected prior to dosing and feeding (0 h) and then 4, 8, 12, 16, 24, 28, 32 and 48 h after dosing (and feed offered) with the use of a sampling probe.

2.3.3. Analytical procedures for feeds and rumen physical-chemical parameters

Duplicate sub-samples of weekly hay offered and residues were oven dried to a constant weight at 60 °C. Weekly samples were bulked within runs and ground through a 1 mm screen (RetschZM 200; Haan, Germany) and stored for chemical analysis. Residual moisture content of all samples was determined by drying samples at 105 °C for 24 h. Organic matter content of samples was determined after incineration at 550 °C for 8 h in a muffle furnace (Modutemp Pty. Ltd.; Perth, WA, Australia). Nitrogen content of the hays offered for each run was determined by the Kjeldahl method using a N analyser (Kjeltec, 8400 FOSS; Hillerod, North Zealand, Denmark), according to Thiex et al. (2002). A conversion factor of 6.25 was used to convert the total N to CP. Ash-free neutral detergent fibre was assayed with a heat stable amylase (aNDFom) (Mertens, 2002), and acid detergent fibre expressed exclusive of residual ash (ADFom) according to Van Soest et al. (1991).