Small Ruminant Research 116 (2014) 71–77

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Carcass traits and fatty acid profile of meat from lambs fed different cottonseed by-products

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ARTICLE INFO

Article history:
Received 5 October 2012
Received in revised form 4 November 2013
Accepted 7 November 2013
Available online 17 November 2013

Keywords:
Whole cottonseed
Cottonseed meal
Carcass traits
Conjugated linolenic acid
Vaccenic acid

ABSTRACT

The aim of this study was to evaluate the changes in carcass traits and fatty acid profile of meat by feeding lambs with cottonseed by-products. Twenty-four 5-month old ram lambs received one of four diets: 19.5% of dry matter intake (DMI) of whole cottonseed (WCS), 19.5% DMI cottonseed meal (CSM), 19.5% DMI high oil cottonseed meal (CSC) and a control group (CTL) without cottonseed by-products. After 95 experimental days, the lambs were slaughtered. Carcass weight and 12th rib composition (chemical and centesimal) were measured. Samples of *Longissumus dorsi* muscle were taken for fatty acid profile analysis. The animals that received CSM showed higher hot carcass weight, carcass yield and rib eye area than animals from the WCS group. Meat from CSM and CSC groups had higher levels of conjugated linolenic acid (CLA) than others and yet CSC group showed higher vaccenic acid than others. Meat from animals that received whole cottonseed had less unsaturated fatty acids, CLA and vaccenic acid. Therefore, processed cottonseed by-products (CSM and CSC) should be preferred for use in ruminant feed over whole cottonseed. The meat from animals that did not receive cotton by-products had higher n-3 fatty acids, and also better n-6 to n-3 ratio compared to others, which may indicate a problem in using these products in ruminant nutrition due to current importance given to these fatty acids in human nutrition.

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http://dx.doi.org/10.1016/j.smallrumres.2013.11.004

1. Introduction

Low cost alternatives for ruminant feed are sought, as feed costs are responsible for over 70% of lamb production costs (Paim et al., 2011). Whole cottonseed and its by-products are alternative feed sources, which can decrease the cost of the animal diet (Paim et al., 2010). These products have high levels of fatty acids, which may lead to increased weight gain, greater fat deposition in the carcass, and changes in fatty acid profile in meat, which can influence its acceptability by consumer and impact in human health (Calkins and Hodgen, 2007).

A major limitation for using cotton by-products in animal nutrition is the presence of high levels of gossypol, which is a toxic compound. Their toxicity is related to a reaction between the aldehyde radical and free amino radicals in proteins, forming stable Schiff bases (Zhang et al., 2009). Gossypol toxicity is generally low in ruminants due to rumination process, which promotes binding of gossypol to proteins. But, some questions on the effect of gossypol in ruminant metabolism, meat quality (changes in enzyme activity) are unknown, as well as the possibility of residues of this compound in the meat.

The quantity and type of fats in animal products is a topic of frequent public discourse. A decrease in the prevalence of deleterious fats and cholesterol as well as an increase in the prevalence of monounsaturated and n-3 fatty acids is consistent with dietary recommendations for cardiovascular health (Simopoulos, 1999).

Conjugated linoleic acids (CLA) occur in ruminant products and are also important in terms of human health. CLA, principally the C18:2 *cis*9 *trans*11 isomer, may be anticarcinogenic and anti-atherosclerotic, decreasing fat accumulation, can modulate the immune response and thus enhance cell-mediated responses, lowering the inflammatory response (Pariza et al., 2001).

Industrial production of animal feeds rich in grains containing n-6 fatty acids, has led to production of meat and milk rich in n-6 fatty acids and poor in n-3 fatty acids (Crawford et al., 1970). Changes in fatty acid profile of food from animal sources are becoming an important research issue (Raes et al., 2004; Wood et al., 2004; Daley et al., 2010). There are a large number of studies on animal nutrition to produce functional foods (De Smet et al., 2004; Raes et al., 2004). An increase in the n-3 content in meat can be achieved by including fish oil/meal, linseed and/or forages in animal diet (Daley et al., 2010; Oliveira et al., 2011). So, feeding animals with oilseed by-products can alter the n-3 and n-6 content in meat, which should be included in animal nutrition trials aiming to evaluate the useful of these by-products. Therefore, in this study we investigated the impact of feeding lambs with cotton by-products on fatty acid profile of meat, carcass traits and meat composition.

2. Materials and methods

2.1. Experimental design

Twenty-four Santa Inês ram lambs, 5-month old, with mean body weight of 20.6 ± 1.9 kg were housed in individual covered pens on a concrete floor. These animals were divided randomly into four diets: control (without cottonseed by-products, CTL); whole cottonseed (WCS); solvent-extracted cottonseed meal (CSM); pressure-extracted high oil cottonseed meal (CSC) (Table 1).

This experiment was carried out after approval by the university animal ethics committee. The experimental period lasted 95 days and was preceded by an adaptation period of 14 days. The diets were elaborated according to NRC (2007) for a daily body weight gain of 200 g/day. The proportion concentrate:forage was 50:50 with Coast cross hay (*Cynodon dactylon* (L.) Pers) used as forage. Mineral salt and urea were added to the concentrate in the same amount for all groups. Soybean oil was added to the concentrate in CTL, CSM and CSC. The animals were fed twice daily, morning (8 h) and afternoon (17 h). The amount of feed offered was adjusted according to animal consumption to achieve ort of 10% of offer. Animals were weighed every 15 days during the experiment, after 10 h fast. The free gossypol concentrations in diets were obtained through spectrophotometry UV-VIS method of Wang (1987).

2.2. Carcass traits measurements

At the end of experimental period, the animals were weighed (SBW) and slaughtered after a 24 h fast, according to Brazilian laws. After bleeding and evisceration, hot carcass weight (HCW) was taken and carcass yield (Y) calculated (Y = HCW/SBW). After 24 h at 0 °C, cold carcass weight was taken (CCW) and a fraction of the rib was removed by transverse cuts at the 11th and 13th ribs. Rib eye area was determined using a standard transparent grade (0.5 cm^2/cell), by drawing around the *Longissimus dorsi* muscle exposed by the transverse cut of the 12th intercostal space. The 12th rib was weighed and tissues were dissected into muscle, bone and fat. The component rib tissues were minced together for freeze drying. Muscle samples and the rib tissues were analyzed using AOAC (1995) procedures.

2.3. Fatty acid profile analysis

Samples from *Longissimus dorsi* at 11th rib were collected without subcutaneous fat for fatty acid profile analysis. Lipids were extracted from the muscle and diets in accordance with procedures established by Folch et al. (1957) and were methylated according to Hara and Radin (1978). The transmethylated samples were analyzed with a gas chromatograph (model Focus CG-Finnigan, Thermo Finnigan, San Jose, CA) with a flame-ionization detector and a capillary column (CP-Sil 88; Varian, Palo Alto, CA) measuring 100 m in length × 0.25 mm i.d., with a thickness of 0.20 μm. Hydrogen was used as the carrier gas at a flow rate of 1.8 mL/min. The initial temperature of the oven was 70 °C and was increased by 13 °C/min to 175 °C, where it was maintained for 27 min. The temperature was then increased by 4 °C/min to 215 °C, where it was maintained for 9 min, followed by another increase by 7 °C/min to 230 °C, where it remained for 5 min. The temperature of the injector was 250 °C, and the temperature of the detector was 300 °C. Identification of the fatty acids was carried out by comparison of the retention times with standards of fatty acids from butter, and the percentage of fatty acids was obtained by means of Chromquest 4.1 software (Thermo Electron, Milan, Italy). The fatty acid profiles of diets are shown in Table 2.

The amount of desirable fatty acids (DFA) was determined as monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and stearic acid according to Landim et al. (2011). The activities of the Δ^9-desaturase (C16 and C18) and elongase enzymes were determined as described by De Smet et al. (2004). The atherogenicity index (ATHERO) was calculated in accordance with Ulbricht and Southgate (1991). This index is considered an indicator for the risk of cardiovascular disease. Calculations were performed as follows:

$$\text{DFA} = \text{MUFA} + \text{PUFA} + \text{C18:0} \quad (1)$$

$$\Delta^9\text{-desaturase C16} = 100\left[\frac{\text{C16:1}\,cis\text{-9}}{\text{C16:1}\,cis\text{-9} + \text{C16:0}}\right] \quad (2)$$

$$\Delta^9\text{-desaturase C18} = 100\left[\frac{\text{C18:1}\,cis\text{-9}}{\text{C18:1}\,cis\text{-9} + \text{C18:0}}\right] \quad (3)$$

$$\text{Elongase} = 100\left[\frac{\text{C18:0} + \text{C18:1}\,cis\text{-9}}{\text{C16:0} + \text{C16:1}\,cis\text{-9} + \text{C18:0} + \text{C18:1}\,cis\text{-9}}\right] \quad (4)$$

$$\text{ATHERO} = \frac{\text{C12:0} + 4 * (\text{C14:0}) + \text{C16:0}}{\sum \text{SFA} + \sum \text{PUFA}} \quad (5)$$