Animal Feed Science and Technology 155 (2010) 18–24

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Safflower seeds in corn silage and alfalfa hay based early lactation diets: A practice within an optimum forage choice

A.R. Alizadeh[a], G.R. Ghorbani[a], M. Alikhani[a], H.R. Rahmani[a], A. Nikkhah[a,b,*]

[a] Department of Animal Science, Isfahan University of Technology, Isfahan 84156, Iran
[b] Department of Animal Sciences, Zanjan University, Zanjan 313-45195, Iran

ARTICLE INFO

Article history:
Received 6 May 2009
Received in revised form
19 September 2009
Accepted 25 September 2009

Keywords:
Iranian safflower seed
Cottonseed
Forage
Dairy cow
Rumen

ABSTRACT

Safflower seed (SS), *Carthamus tinctorius* L., has the highest concentration of linoleic acid among 80 oilseeds. It was hypothesized that an Iranian variety of SS can be effectively fed with cottonseeds (CS) to maintain feed intake, energy metabolism and productivity of early lactation cows under negative energy balance. Our objective was to determine effects of feeding diets containing 100 g whole CS with (1) no SS (SS0), (2) 75 g CS + 25 g SS (SS25), or (3) 50 g CS + 50 g SS (SS50), per kg of dietary DM, on feed intake, rumen fermentation, blood metabolites and milk production of early lactation cows fed diets based on a uniform mixtures of alfalfa hay and corn silage. Nine multiparous early lactation Holstein cows (46 ± 7 d in milk) were used in a replicated 3 × 3 Latin square design study with three 21-d periods. Each period had 14 d of adaptation and 7 d of data collection. Dietary inclusion of SS did not affect (P>0.10) DM intake, rumen pH and concentrations of ammonia and VFA, blood concentrations of insulin, non-esterified fatty acids, urea and triglycerides, and milk production. Adding SS linearly reduced blood glucose (P=0.05) and beta-hydroxybutyric acid (P<0.05), and increased blood total cholesterol (P<0.01) and low-density lipoproteins (P<0.05) concentrations. Results demonstrated that SS as an economical and rich source of essential fatty acids can be included up to 50 g/kg of dietary DM alongside CS for early lactation cows without affecting feed intake while maintaining rumen fermentation, peripheral energy supply and milk production.

1. Introduction

The world average safflower seeds (SS, *Carthamus tinctorius* L.) yield/ha is lower (0.72 ton) than soybean (2.34 tones), rapeseed (1.51 tones), groundnut (1.37 tones) and sunflower (1.14 tones). However, safflowers contain highest levels of linoleic acid (LA) among 80 oilseeds (Dubois et al., 2007) and are produced in certain regions of Iran (Dajue and Mündel, 1996). Feeding diets with 10% rolled SS has reduced DMI in bST treated dairy cattle during mid and late lactation (Stegeman et al., 1992). Little information exists on the effective use of SS for early lactation cows when DMI is insufficient. Selective use of high-LA SS may improve body condition score in beef heifers at times of prepartal energy deficiencies or suboptimal

Abbreviations: ADF, acid detergent fiber; aNDF, neutral detergent fiber; BHBA, beta-hydroxybutyric acid; BUN, blood urea nitrogen; CP, crude protein; CS, cottonseeds; DM, dry matter; EE, ether extract; LDL, low-density lipoproteins; NFC, nonfiber carbohydrates; SS, safflower seeds; TMR, totally mixed ration.

* Corresponding author at: Department of Animal Sciences, College of Agriculture, Zanjan University, Zanjan 313-45195 Iran. Tel.: +98 912 7891124; fax: +98 311 3913501.
E-mail address: anikkha@yahoo.com (A. Nikkhah).

0377-8401/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.anifeedsci.2009.09.014

energy status (Bottger et al., 2002). Scholljegerdes et al. (2007) observed that cracked SS early in the postpartum period altered fatty acid composition of medial basal hypothalamus, and uterine tissue in beef cows. Godfrey and Dhiman (2006) showed that ground or dry-extruded SS can be fed to dairy cows up to 2% of diet DM without affecting DM intake, and milk yield; however, blood metabolites and hormones were not monitored.

With the increasing levels of milk production above maintenance over the last 4 decades, essential fatty acids supply has become inadequate to maintain optimal production, reproduction and immune function (Moate et al., 2004; NRC, 2001). Meanwhile, human health implications of enriched dairy products with biologically active substances have expanded research and industrial focuses on oilseeds (*e.g.*, Bottger et al., 2002; Gagliostro and Chilliard, 1991; Petit, 2003). Moreover, considerable differences have been found in nutrient composition, especially lipid content, between SS produced in Iran and other varieties (Alizadeh et al., 2008). Furthermore, unique to evaluating SS in early lactation diets is feeding a mixture of dry and ensiled forages or corn silage and alfalfa hay, the common forages in most dairy farms in Iran (Kowsar et al., 2008; Nikkhah et al., 2004). Ensilage solubilizes nitrogen compounds and limits microbial access to ATP, thus reducing microbial protein synthesis (Beever, 1993; NRC, 2001). Feeding corn silage with short-cut alfalfa hay increases ration moisture and particle size uniformity, thereby improving effective fiber and energy intakes concomitantly while maintaining rumen health (Kowsar et al., 2008). In light of previously reported depressions in DM intake of mid and late lactation cows by feeding 100 g/kg SS (Stegeman et al., 1992), we hypothesized that SS at controlled dietary inclusion rates will be more effectively utilized by early lactation cows due in part to efficient rumen fiber dynamics via optimized dietary forage choices. DM intake is more critical to maintain and increase in early lactation than in mid and late lactation cows. Therefore, our primary objective was to determine how feeding an Iranian variety of safflower seed (IL-111) influences DM intake, rumen pH, as well as blood metabolites and insulin concentrations in early lactation cows fed a TMR based on a uniform mixture of dry and ensiled forages and cottonseeds.

2. Materials and methods

2.1. Experimental design, cows and management

Nine multiparous lactating Holstein cows (46 ± 7 d in milk at the commencement of the study) were used in a replicated 3×3 Latin square design experiment. Cows were housed in individual stalls at the Dairy Facilities of the Lavark Research Station (Isfahan University of Technology, Isfahan, Iran) from August 2007 to October 2007. The experiment had three periods of 21 d, with the first 14 d for adaptation and the last 7 d for sampling and data collection. Individual boxes ($4\,m \times 4\,m$) were equipped with concrete feed bunkers and automatic waterers. Clean wood shavings and sand were used for bedding and refreshed twice daily. Cows were offered a totally mixed ration (TMR) twice daily at 09:00 and 16:00 h (Tables 1 and 2). Diets were formulated to be isoenergetic and isonitrogenous using NRC program (2001). The treatments were diets containing (1) 100 g whole cottonseeds + 0 g safflower seeds (SS0), (2) 75 g whole cottonseeds + 25 g safflower seeds (SS25), and (3) 50 g whole cottonseeds + 50 g safflower seeds (SS50), per kg of dietary DM (Table 1). Oilseeds including SS (IL-111) and cottonseeds (CS) were provided by the Isfahan Branch of Oilseed Research and Development Corporation (Isfahan, Iran). A 5 cm screen size mesh was used to grind SS with Wiley mill (Wiley's pulverizer, Ogaw Seiki Co., Ltd., Tokyo, Japan). The ground meals were stored at 4 °C for a maximum of 2 d at the farm. The ground SS and whole CS were weighted and used to prepare different total mixed rations.

2.2. DM intake, feed analyses, and nutrient digestibility

Total mixed rations were offered to permit for 5–10% daily refusals. Samples of TMR and orts were collected during d 14–21 of each period. Grab fecal samples were taken daily from the rectum during collection periods and were frozen for later nutrient analysis. Feed and fecal samples were stored at −20 °C until analyzed for chemical composition. After thawing at room temperature, samples were dried at 55 °C for 48 h, and ground using a Wiley mill to pass through a 1-mm screen (Wiley's pulverizer, Ogaw Seiki Co., Ltd., Tokyo, Japan). All feed samples were analyzed for N (Kjeldahl procedure 988.05; AOAC, 1990), aNDF (using heat-resistant α-amylase without sodium sulfite; Van Soest et al., 1991), ADF (973.18; AOAC, 1990), ether extract (EE, 920.39; AOAC, 1990), ash (942.05; AOAC, 1990) and acid detergent insoluble ash (AIA, Nikkhah et al., 2004; Van Keulen and Young, 1977). The AIA content of feed and feces was used as an internal marker to determine apparent total tract nutrient digestibility coefficients. The aNDF and ADF fractions include residual ash. The SS contained 930 g DM, 195 g CP, 490 g NDF, 380 g ADF and 227 g EE/kg on a DM basis. From 1 kg of total fatty acids, SS contained 66 g palmitic acid, 29 g stearic acid, 129 g oleic acid, 734 g linoleic acid, and 2 g linolenic acid; while the respective values were 235, 24, 183, 506, and 4 g for CS.

2.3. Rumen fluid sampling and processing

On the last day of each period, rumen fluid was sampled at 11:30 h using a stomach tube. The initial 100 ml of the fluid aspirated was discarded to minimize saliva contamination. The pH of the second portion was measured immediately using a mobile pH meter (HI8314, Hanna Instruments, ClujNapoca, Romania), and 10 ml of the fluid was preserved with 1 ml of 5% sulfuric acid and frozen at −20 °C until analyzed for VFA and ammonia. For VFA analysis, rumen fluid samples