



Impact of feeding whole Upland cottonseed, with or without cracked Pima cottonseed with increasing addition of iron sulfate, on productivity and plasma gossypol of lactating dairy cattle

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Abstract

Lactating Holstein cows were fed one of four diets containing either whole Upland cottonseed (WCS) or whole Upland cottonseed and cracked Pima cottonseed (CrP) with increasing levels of iron sulfate. Effects of supplemental iron sulfate, and the impact of substitution of two-thirds of the WCS with CrP, on milk yield and dry matter (DM) intake of cows fed these diets containing relatively high levels of gossypol were determined. All diets contained 490 g/kg DM of a grain based concentrate, 100 g/kg DM of cottonseed and 410 g/kg DM of chopped alfalfa hay. The cottonseed portion of the Control diet contained 100 g/kg DM of WCS and the other three diets contained 67 g/kg DM of CrP and 33 g/kg DM of WCS. Cottonseed meats (i.e., the interior of the seeds after decortication) were analyzed for gossypol concentration, and whole cottonseed, whole Pima and CrP contained 6.5, 9.9 and 9.6 g/kg DM of free gossypol and 2.7, 5.2 and 5.2 g/kg DM of the minus (–) isomer of gossypol, respectively, in ‘meats’. Diets containing CrP were supplemented with 0, 250 or 500 mg of iron from iron sulfate/kg of diet DM. Eight cows (i.e., four primiparous and four multiparous) were used in

Abbreviations: ADFom, acid detergent fiber; BCS, body condition scores; BW, body weight; CP, crude protein; CS, cottonseed; CrP, cracked Pima cottonseed; DIM, days in milk; DM, dry matter; EF, erythrocyte fragility; NEFA, nonesterified fatty acids; aNDFom, neutral detergent fiber; PUN, plasma urea N; TMR, total mixed ration; WCS, whole Upland cottonseed; WP, whole Pima cottonseed

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a duplicated 4×4 Latin square design with periods of 28 d. Milk yield ($P=0.02$) and DM intake ($P<0.01$) decreased linearly with increasing levels of iron sulfate in the diet. Total plasma gossypol ($\mu\text{g/ml}$) increased ($P<0.01$) with substitution of CrP for WCS, and decreased at an increasing rate (linear $P<0.01$; quadratic $P=0.04$) with increasing inclusion of iron sulfate in the diet. Substitution of CrP for WCS increased DM intake ($P<0.03$) but milk yield was unaffected. Although addition of iron sulfate to the CrP diets reduced plasma gossypol concentrations, the reduced yield of milk and DM intake suggests that this method of reducing plasma gossypol concentrations is not commercially applicable.

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1. Introduction

Cottonseed (CS) is a by-product feedstuff of the cotton-fiber industry that is frequently used in ruminant rations. Whole Upland cottonseed (WCS) is fed to dairy cattle to provide energy, fiber and protein. Upland cotton (*Gossypium hirsutum*) is the predominant cotton grown in many areas of the world, but Pima cotton (*G. barbedense*) production is increasing in the Southwestern United States, and many other parts of the world, because cotton growers tend to be paid more for Pima versus Upland cotton due to the extra long staple length of Pima, which is desirable in manufacture of cotton cloth.

Upland CS is generally fed unprocessed, but Pima CS is naturally devoid of linters and is generally processed to increase digestion and nutrient utilization (Sullivan et al., 1993a,b), thus preventing appearance of whole seeds in feces (Osland and Wagner, 1985). Pima CS is considered nutritionally superior to WCS because of its higher fat and protein content (Sullivan et al., 1993a,b). However, dairy producers and nutritionists often discriminate against Pima CS because of its higher gossypol content.

Gossypol, which is found throughout the cotton plant, is a naturally occurring toxin that deters insect pests. It is a yellow, polyphenolic aldehyde compound, which is present in the highest concentrations in CS pigment glands (Blauwiekel et al., 1997). Gossypol exists in CS in both free and bound forms. Most gossypol found in whole CS is in the free form, but some becomes bound due to the heat, moisture and pressure associated with CS meal extrusion, and other types of CS processing (Mena et al., 2001; Calhoun et al., 1995a). The bound form of gossypol is generally considered to be nontoxic to ruminants although, during digestion, it has been suggested that some bound gossypol from processed WCS or CS meal may be converted to free gossypol (Mena et al., 2001; Noftsker et al., 2000; Blauwiekel et al., 1997). Gossypol also exists as a mixture of (+) and (–) stereoisomers, with the (–) isomer having the higher biological activity (Joseph et al., 1986). In recent studies, Pima CS was reported to contain more gossypol than WCS (Prieto et al., 2003; Robinson et al., 2001; Santos et al., 2002). Additionally, Pima CS contains a higher proportion of total gossypol as the (–) isomer versus WCS (Sullivan et al., 1993b; Calhoun et al., 1995a), suggesting that ruminant livestock producers feeding Pima CS should have a greater concern for potential gossypol toxicity of their livestock.

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