# Dry matter intake, milk composition and production in dairy cows fed whole and processed cottonseed

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## ABSTRACT

The objective of this study was to evaluate the effect of grinding and heating of whole cottonseed (WCS) on milk composition and production of Holstein lactating cows during early lactation. Multiparious cows (n=8) averaging 84.50±10.34 days (DIM) in milk and 36.10±4.46 milk yield (MY) were used in a 4×4 Latin square design. Cows were divided into four groups, receiving one of the following treatments: 1) WCS; 2) Ground cottonseed (GCS); 3) GCS heated in 140°C and steeped for 2.5 minute (GHCS1); or 4) GCS heated in 140°C and steeped for 20 minute (GHCS2). Diets were similar CP, NDF and NEL. The percentage of whole or processed cottonseed was fixed at 14%. The mean dry matter intake (DMI) was significantly ($P<0.01$) affected by diets and in treatments of WCS, GCS, HGCS1 and HGCS2 were 25.97, 27.24, 27.63, and 27.63 (kg/d), respectively. MY was significantly ($P<0.01$) affected by the diets and was greatest for HGCS2 (34.13 kg/d) and the lowest for WCS (31.13kg/d). Supplementation with HGCS2 resulted in increased milk fat percentage ($P<0.05$) and milk fat yield ($P<0.01$). Milk protein percent was progressively increased, averaging 3.21%, 3.02%, 3.42% and 3.42% for WCS, GCS, HGCS1 and HGCS2 treatments, respectively. Milk protein yield tended ($P<0.05$) to be higher for cows fed GHCS1 and GHCS2 than for cows fed WCS and GCS.

## Introduction

Whole cottonseed (WCS) is a by–product of the cotton-gin industry. This feedstuff is of significant feeding value for average and high-yielding dairy cattle (1). WCS provides a unique blend of energy, protein and fiber compared with other feed ingredients (2). The crude protein (CP): net energy for lactation (NEL) ratio (about 1gr CP to kcal NEL) makes WCS a favorable supplement meets the combined energy and CP requirements for high producing dairy cows(1).

In Iran, concentrate based on barley include high ratio of lactating cow diets and results increase of nonfibrous carbohydrates (NFC) higher than NRC (2001) recommendation. Inclusion WCS with high NEL concentration and low NFC can solve the problem. Moony and et al (1997) found that effectiveness of WCS nonforage fiber was more short–cut alfalfa silage, but less than long–cut alfalfa silage (9).

Cottonseed protein is of high biological value, its protein efficiency ratio is greater than that of a number of other vegetable proteins (8). In the rumen, WCS protein is more highly degradable (74-77%) (1) than other commonly used CP supplements. Milk CP and casein contents may decrease when WCS is fed to dairy cows (8). Consequently, so that advantage can be taken of its potentially high biological value, WCS protein must be protected from excessive degradation in the rumen. Heat treatment is used to decrease the solubility of CP and increase the RUP fraction of cottonseed (8).

Grinding WCS increased total tract digestibility of organic matter (OM) and CP and tended to increase rumen undegradable protein in cottonseed (11). The objective of this research was to determine the effect of processing WCS (grinding and heating) on milk production and composition of Holstein lactating cows.

## Material and Methods

Eight lactating multiparous Holstein cows from the research dairy farm of agriculture faculty of ferdowsi university of Mashhad averaging 84.50± 10.34 DIM and producing 36.10±4.46 kg/d of milk ware used in 4×4 latin square trail. Animal were housed individually in tie stalls with continuous access to water. Each experimental period was 21d. The 14d of each period were for adaptation to the diets and last 7d were for sample collection.

Four isonitrogenous and isocaleric diets (Table 1) were formulated to provide 14% of the dietary DM from different processed (WCS, GCS, HGCS1 and HGCS2) and to meet minimum NRC (2001) requirements. The GCS were prepared by mill (Carver Cotton Gin Co. Mass U.S.A) and was heated by cooker (French, Machinary Co. U.S.A) for HGCS1 and then steeped for 20 minute in barrels and spread out in a 2-cm layer for cooling (HGCS2). Diets were individually fed twice daily ad libitum as a TMR in amounts to ensure 10% orts.

Table 1 ingredient and nutrient composition of diets (DM basis)

| Feed | % |
|---|---|
| Alfalfa hay | 20 |
| Corn silage | 17 |
| Barley grain | 19 |
| Corn grain | 3 |
| Whole or processed cottonseed | 14 |
| Soybean meal | 13.5 |
| Cottonseed meal | 6 |
| Beet sugar pulp | 3 |
| Wheat bran | 3 |
| Ca carbonate | 1 |
| Min&Vit supplement | 0.25 |
| Salt | 0.25 |
| Nutrients | |
| $NE_L$,Mcal/kg | 1.58 |
| CP,% | 18.5 |
| NDF,% | 35.1 |
| EE,% | 4.6 |

During each period, the amount of TMR offered and orts before morning feeding were recorded daily. Samples of ingredients, TMR and orts were collected daily to determine the DM content and were composited by collection period. Sample of feed, orts were analyzed for DM (Memmert, schwabach, 845), Ash (exciton, Atash–1200) and N (Buchi Co. switzerland) (AOAC, 1990) (cot 23). NDF and ADF (Fibertec system Tecator 1010, Sweden) of samples were determined according to van soest et al. (1991)(5). Intake of DM, CP, ADF and NDF were estimated from analyzed diet composition minus orts.

Milk production was recorded daily at 0400, 1200 and 2000. Milk samples were collected on the last 3 d of each period from three consecutive milkings, composited by cow and used to determine percentages of milk fat, protein, lactose and SNF (Milkoscan 605, foss electric, hiller, denmark).

Ruminal Samples were taken via stomach tube on d 21 of each period at approximately 2h post feeding. Ruminal pH was measured in fresh samples immediately.

The general linear model (GLM) procedure of SAS (7$^{th}$ version) was used for data analysis(13).

## Results and discussion

Nutrient intake of lactating cows fed diet containing WCS and processed cottonseed are listed in table 2. Intake of DM, CP and NDF was greatest for cows fed HGCS2 and HGCS2 diets and lowest for cows fed WCS diet. The effect of WCS feeding on DM intake is an important issue for the dairy cattle feeding. DM intake response to the inclusion of WCS in the diet is function of both climate and dietary factors. A decrease in particle size of CS by grinding may increase passage rate of fiber and kernel of CS. Concentration of fat, fiber, energy and perhaps CP degradability in the ration may control dairy cattle DM intake WCS diets (1).

**Table 2. Nutrient intake of lactating cows fed diet containing WCS and processed cottonseed**.

| Item | Diets | | | | SE |
|---|---|---|---|---|---|
| | WCS | GCS | HGSC1 | HGCS2 | |
| Intake (Kg/d) | | | | | |
| DM | $25.97^{b}$ | $27.24^{a}$ | $27.63^{a}$ | $27.63^{a}$ | 0.18 |
| CP | $4.80^{b}$ | $5.04^{a}$ | $5.11^{a}$ | $5.11^{a}$ | 0.03 |
| NDF | $8.98^{b}$ | $9.42^{a}$ | $9.56^{a}$ | $9.56^{a}$ | 0.06 |
| ADF | $5.22^{b}$ | $5.47^{a}$ | $5.55^{a}$ | $5.55^{a}$ | 0.04 |

a, b, c means within a row with unlike superscripts ($p<0.05$)

WCS=Whole cottonseed GCS=Ground cottonseed HGCS1=Ground cottonseed heated in 140°C HGCS2=Ground cottonseed heated in 140°C and steeped 20 min.

In dairy cattle consuming diets that were similar in energy and fiber content, supplementation of 150 g/kg WCS was associated with increased DM intake (1). Pires et al. (1997) reported DMI were similar for cows fed the WCS diet and GCS. Feed intake was not different when low to moderate producing were fed raw or heat – treated cottonseed(8).

Physical processing of WCS did not affect ruminal pH, averaging 6.6 (Table 3). Cows fed the WCS diet had a higher ruminal pH than did cows fed the other diets. Fiber from lint and hulls from WCS caused that intact seed to reside in the rumen longer than GCS, HGCS1 and HGCS2 , thereby increasing chewing activity and secretion of saliva (9) which contains high concentrations of bicarbonate- and phosphate buffers and aids in maintaining a rumen pH level suitable for microbial activity (7).

Milk production and composition are listed in table 3. Significant differences in milk yield were observed between diets. In contrast, milk yield was higher when cows were fed GCS, HGCS1 and HGCS2. 4% fat corrected milk was different ($P<0.05$) for cows fed treatment diets. These finding are in agreement with previous studies regarding WCS and heated cottonseed supplementation. The potential of cottonseed protein for increasing dairy cattle milk production was revealed in experiments in which cottonseed meal was infused post – ruminally, resulting in increased milk and protein yield, in manner comparable to that observed with soybean meal and casein infusion(12).

Pires et al. (1997) reported roasting WCS increased milk yield by 5% and milk protein yield by 13%(11). When WCS was supplemented to dairy cattle diets for 100 days, roasting of WCS increased milk protein yield by 6% (1). Satter, as cited by wedegaertner and lalor, observed an increase in milk yield with heated WCS compared with WCS (14). In a 28 week trail, heating did not affect milk yield or composition (4). These results indicate that roasting WCS can potentially improve milk yield, presumably through improved amino acid to the small intestine. Because heat causes a chemical reaction to occur between the protein and sugars present in feedstuffs. This results in the formation of protein- sugar complexes known as maillard products. The extent of these reactions is influenced by the temperature, during of heating and amount of sugar present(14).

Heat treatment of protein can increase the amount of protein escaping degradation in the rumen. Too little heat, however, results in poorly protected protein. To much heat cause the formation of maillard products that can not be utilized in the intestine. Several studies have shown that heat treatment of cottonseed can reduce protein degradation in vitro and *in situ*, as well as *in vivo* (14).

Higher milk protein yield and percent was observed in the HGCS1 and HGCS2 ($p$<0.05)(Table 3). Mabjeesh et al. (2000) reported milk protein yield was significantly affected by heating in 149°C for 30 min (8). The concentration of branched- chain amino acid in blood plasma are more highly correlated to protein uptake from the small intestine than other amino acid. Thus, concentrations of branched- chain amino acid in blood plasma can be a useful indicator of protein uptake from the intestine. Satter et al. (1997) reported heating of cottonseed increased the concentration of BCAA in blood plasma , with the highest concentrations being achieved with the two highest temperatures (156°C–30 min and 166°C–30 min).Based on this experiment, it appears that the optimum treatment was between 145°C–30 min and 155°C–30 min(14).

**Table 3. Rumen pH, milk production and composition data of cows fed CS processed in different ways.**

| Item | Diets | | | | SE |
|---|---|---|---|---|---|
| | WCS | GCS | HGSC1 | HGCS2 | |
| Rumen pH | 6.69 | 6.63 | 6.59 | 6.63 | 0.06 |
| Milk yield(kg/d) | $31.13^{b}$ | $32.88^{b}$ | $32.04^{ab}$ | $34.13^{a}$ | 0.37 |
| Milk yield(kg/d)* | $29.93^{b}$ | $29.46^{b}$ | $31.16^{ab}$ | $34.12^{a}$ | 0.50 |
| Milk composition | | | | | |
| Fat (%) | $3.68^{ab}$ | $3.33^{b}$ | $3.59^{b}$ | $3.98^{a}$ | 0.08 |
| fat (kg/d) | $1.15^{b}$ | $1.09^{b}$ | $1.19^{b}$ | $1.38^{a}$ | 0.03 |
| Protein (%) | $3.21^{ab}$ | $3.02^{b}$ | $3.42^{ab}$ | $3.52^{a}$ | 0.06 |
| protein(kg/d) | $1.01^{b}$ | $0.99^{b}$ | $1.12^{ab}$ | $1.19^{a}$ | 0.03 |

a, b, c means within a row with unlike superscripts (p<0.05)

* 4% fat corrected milk

WCS=Whole cottonseed GCS=Ground cottonseed HGCS1=Ground cottonseed heated in 140°C HGCS2=Ground cottonseed heated in 140°C and steeped 20 min.

Bernard and et al. (1997) observed milk protein percentage was highest (p<0.05) for cows fed roasted CS and lowest for cows fed pelleted blend of 71% WCS and 29% soybean meal containing 48% CP(3). Pires et al (1997) reported milk protein production and percentage were increased by roasted CS, possibly because of the numerically higher intake of rumen undegradable protein(11).

Fat production and percentage were significantly different across treatments ($p$<0.05)(Table 3). Noftsger et al. (2000) Found an increase in milk fat concentration when cows were fed diet containing expanded–expelled CS (10). Bernard and Calhoun (1997) found a decrease in milk fat concentrations when cows were fed a 50:50 mixture of extruded WCS and soybean in comparison to WCS (cot 17 , 5). Mabjeesh et al. (2000) reported when linted WCS was heated, fat and protein production and percentage increase (p<0.01)(8). Harvatine et al (2002) noted milk fat percentage was not decreased despite the lower ruminal pH, when forage replaced WCS(6).

## CONCLUSIONS

Heat and grinding of cottonseed influences its utilization by dairy cows. The DMI was higher for cows fed ground cottonseed than WCS. Steeping of heated cottonseed improved utilization cottonseed nutrients and increased milk protein (HGCS2 vs. HGCS1). However, the long term effects of feeding similar diets need further investigation.

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