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Effects of Fermented Total Mixed Ration and Cracked Cottonseed on Milk Yield and Milk Composition in Dairy Cows

C. Wongnen, C. Wachirapakorn, C. Patipan, D. Panpong, K. Kongweha[1], N. Namsaen, P. Gunun and C. Yuangklang[1,*]

Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, 40002, Thailand

ABSTRACT : Four lactating Holstein Friesian crossbred cows, with an average initial weight of 450 kg, 48±12 days in milk and initial milk yield of 18 kg/h/d, were randomly arranged according to a 2×2 factorial arrangement in a 4×4 in Latin square design with 21-d period to investigate the effects of type of total mixed ration (TMR) and type of whole cottonseed (WCS) on intake, digestibility and milk production. The dietary treatments were i) TMR and WCS supplementation at 0.5 kg/h/d, ii) TMR and cracked WCS (cWCS) supplementation at 0.5 kg/h/d, iii) fermented TMR (FTMR) and WCS supplementation at 0.5 kg/h/d, and iv) FTMR and cWCS supplementation at 0.5 kg/h/d. Voluntary feed intake was 15.9, 15.2, 15.4 and 15.6 kg DM/d in dietary treatment 1, 2, 3 and 4, respectively. Digestibility of DM, OM, CP, EE, NDF and ADF were not significantly different among dietary treatments. Ruminal pH, NH_3-N and volatile fatty acids in the rumen were also not significantly different among type of TMR or type of WCS. Blood urea-N concentration was not significantly different among dietary treatments. Ruminal bacteria population tended to increase but ruminal protozoa population tended to decrease with supplementation of cWCS, but they were not affected by FTMR. Milk yield and 3.5% FCM were not statistically different among treatments (16.6, 16.2, 17.0, 16.3 kg/d and 18.0, 18.6, 19.9 and 19.0 kg/d, respectively). Milk composition was not significantly different among dietary treatments. However, unsaturated fatty acids in milk fat in cows fed FTMR were lower ($p<0.05$) than in cows fed TMR. In conclusion, fermentation is a conceivable method to improve the quality of TMR for long-time storage and the cracking method is suitable to release the fat from cottonseed for enhancing fatty acid deposition in milk. Thus, the combination of FTMR and cWCS supplementation would be an alternative strategy to improve performance of lactating cows. (**Key Words** : Fermented Total Mixed Ration, Whole Cottonseed, Dairy Cow)

INTRODUCTION

Feeding a total mixed ration (TMR), a mixture of concentrate and roughage, is typically used in the dairy industry in developed countries. The advantage of TMR feeding is to avoid eating selection and to maintain rumen fermentation. TMR feeding enhances feed intake, improves the ecology of the rumen leading to stimulated microbial activity to digest more feed, and then finally increases productivity of the cows. Wachirapakorn et al. (1997) compared two feeding regimes (separate and TMR feeding) and found that TMR feeding increased dry matter intake (DMI) and milk production compared to separate feeding.

The fermented total mixed ration (FTMR) is a simple method to potentially improve nutrient utilization and extend the shelf life of the feed. FTMR is made by mixing roughage with concentrate and then fermenting under anaerobic conditions (ie ensiling) in a sealed container for 21 days. In dairy cows, Yuangklang et al. (2004) showed that FTMR increased feed intake and improved nutrient digestion. Vasupen et al. (2005, 2006) confirmed that FTMR improved the digestibility of dry matter (DM), organic matter (OM), fiber, and non-structural carbohydrate.

Wanapat et al. (1996) reported that addition of cottonseed in the diet can increase milk yield. Similar findings were reported by Smith et al. (1981) and Mena et al. (2001), which showed that cows fed a high whole cottonseed (WCS) diet had improved milk yield, milk fat, and fat corrected milk (FCM). However, Sullivan et al. (1993a, b) reported that cracked WCS (cWCS) improved animal performance better than WCS because the gossypol in cWCS bound with protein or another nutrient in the

* Corresponding Author: C. Yuangklang. Tel: +6642771460, Fax: +6642771460, E-mail: cyuangklang@yahoo.com
[1] Department of Animal Science, Faculty of Natural Resources, Rajamangala University of Technology-Isan, Sakon Nakhon Campus, Phangkhon, Sakon Nakhon, 47160, Thailand.
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rumen more than with WCS. Binding the gossypol with another compound reduces its toxicity resulting in improved nutrient availability (Calhoun et al., 1995). Processing of WCS may also reduce the chances of gossypol toxicity. High temperature favors the formation of stable bonds between gossypol and other molecules. Bound gossypol is generally considered to be physiologically inactive (Randel et al., 1992).

The aim of this experiment was to investigate the effect on intake, digestibility and milk production of processing WCS when used as a protein source in FTMR fed to dairy cows.

MATERIALS AND METHODS

Animals, treatments and experimental design

Four, early-lactation, multiparous Holstein Friesian crossbred cows, 48±12 d day in milk (DIM) and 450±13 kg BW, were randomly assigned to dietary treatments in a 2×2 factorial arrangement in a 4×4 Latin square design with four 21-d periods each comprising 14 d for dietary adaptation and 7 d for data collection (2 days for adaptation in the metabolism crates and another 5 days for total collection of feces). Dietary treatments were based on type of TMR (TMR or FTMR) and type of WCS (WCS or cWCS) supplementation and included the following:

Treatment 1 (T1) = TMR with 0.5 kg WCS per day
Treatment 2 (T2) = TMR with 0.5 kg cWCS per day
Treatment 3 (T3) = FTMR with 0.5 kg WCS per day
Treatment 4 (T4) = FTMR with 0.5 kg cWCS per day

TMR and FTMR were offered twice daily *ad libitum*, at approximately 0700 and 1700 h. Diets were allowed to have 15% feed refusal. Feed ingredients of the experimental diets are shown in Table 1. Water and mineral block were available at all times.

Animals were individually housed and intensively cared for according to the procedures of the Faculty of Natural Resources, Rajamangala University of Technology Isan, Sakon Nakhon campus.

The cows were milked twice a day, at approximately 0400 and 1500 h. Milk yield was measured daily.

Sampling and laboratory analysis

Whole cottonseed was sampled for chemical analysis. TMR and FTMR were sampled weekly. Feces samples were quantitatively collected for each cow, according to the total collection method, during the last 5 days of each period. The diets and feces were analyzed for chemical composition in terms of DM, ash, ether extract (EE) and crude protein (CP) (AOAC, 1990), and neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Goering and Van Soest, 1970). The total diets and WCS were analyzed for gossypol according to AOCS (1988).

Table 1. Composition of the experimental diet (% DM)

Ingredients	Inclusion level
Chopped rice straw	20.0
Cassava chip	40.0
Soy bean meal	7.0
Whole cottonseed	10.0
Dried brewer's grain	5.0
Tomato pomace	5.0
Molasses	8.0
Urea	1.5
Salt	0.5
Oyster shell	0.3
Di-calcium phosphate	0.2
Mineral-vitamin[1]	0.3
Sulphur	0.2
Tallow	1.0
Sodium bicarbonate	1.0

[1] Vitamin A = 44,000, D3 = 60,000, E = 30,000 IU/kg; Fe = 11.6, Co = 0.03, Mn = 5.3, Cu = 5.6, Zn = 11.6, I = 0.07, P = 15.0, Mg = 10.0, Se = 0.06, g/kg.

Ruminal fluid samples (approximately 500 ml) were collected by stomach tube at 0 and 4 h-post morning feeding on the last day of each period. The pH of the ruminal fluid was immediately measured using a portable pH meter. The samples were then filtered through four layers of cheesecloth. Samples were divided into two portions; one portion was used for NH_3-N analysis after 10 ml of 50% H_2SO_4 solution was added to 100 ml of ruminal fluid. The mixture was centrifuged at 16,000×*g* for 15 min and the supernatant was stored at -20°C prior to NH_3-N measurement (Bremner and Keeney, 1965) and volatile fatty acid (VFA) analysis (HPLC; model RF-10AXmugiL; Shimadzu; Japan) according to Zinn and Owens (1986). Another portion was fixed with 10% formalin solution in normal saline (0.9% NaCl, Galyean, 1989) and stored at 4°C. Total direct counts of bacteria and protozoa were made using the methods of Galyean (1989) based on the use of a haemocytometer.

A blood sample was taken from the jugular vein at the same time as ruminal fluid sampling, and then separated by centrifugation at 500×*g* for 10 min and the supernatant was stored at -20°C until analysis of blood urea-N (BUN) (Crocker, 1967).

Milk samples were collected and pooled by equal volume on the last 5 days (50 ml/d) of each period and two 50-ml aliquots were analyzed for milk composition. The first aliquot was stored at 4°C until analyzed for fat, protein, lactose, total solids and solids-not-fat (SNF) (AOAC, 1990) by Milko-scan (Model 133 V.3. 7 GB; Foss Electric, Hillerd, Denmark). The second aliquot was dried by a freeze dry

method (Heto PowerDry LL3000 Freeze Dryer; Thermo Fisher Scientific, Tehovec-Mukarov, Czech Republic) and analyzed for fatty acid content.

For the fatty acid analysis, each sample was added to a flask and 2 ml of ethanol was added to moisturize the sample. Subsequently, 10 ml of HCl (8 mol/L) was added; the contents were gently mixed, and the flask was placed in a water bath at 80°C for 30-40 min. The tubes were cooled down, 10ml of ethanol (96%) and 25 ml of petroleum ether (boiling point between 40 and 60°C) were added and the tube was vigorously shaken for 1 min. The fat-containing upper layer was decanted into a 150 ml round-bottom flask. The extraction procedure was repeated twice with 15 ml of diethyl ether and 15 ml of petroleum ether and the lipid extract was evaporated to dryness under N in a water bath at 40°C. The lipid-containing round-bottom flasks were dried overnight at 60°C and the total lipids were measured gravimetrically. Total lipids were saponified and methylated according to the procedure of Metcalfe et al. (1966) followed by gas liquid chromatography (Nelson, 1975) using a flame ionization detector, a Chrompack column (Fused silica, no.7485, CP.FFAPCB 25 m×0.32 mm, Chrompack, Middelburg, The Netherlands) and H as carrier gas. The individual fatty acids were expressed as weight percentage of total methyl esters.

Statistical analysis

All data were statistically analyzed as a 2×2 factorial arrangement in a 4×4 Latin square design using the PROC MIXED (SAS, 1996) according to the following model : $Y_{ijk} = \mu+\rho_i+\gamma_j+\alpha_k+\beta_l+\alpha\beta_{kl}+\varepsilon_{ijkl}$, where Y_{ijk} = represents of observation from animals, μ = overall mean, ρ_I = fixed effect of period (i = 1-4), γ_j = random effect of animal (i = 1-4), α_k = fixed effect of factor A (A = type of total mixed ration, i = 1-2), β_l = fixed effect of factor B (B = type of cottonseed, j = 1-2), $\alpha\beta_{kl}$ = fixed effect of interaction and ε_{ijk} = random residual. Significant differences between treatments were determined using Duncan's New Multiple Range Test (DMRT) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Chemical composition of feeds

The chemical composition of the TMR, FTMR and WCS is shown in Table 2. The composition of the WCS was similar to that reported by NRC (2001). The TMR, FTMR and WCS (Table 2) were high in linoleic acid (C:18:2), oleic acid (C:18:1) and palmitic acid (C:16:0). The fatty acid profile of the WCS was in agreement with that previously reported (NRC, 2001). The percentage of free gossypol was 0.04, 0.05 and 0.54% in FTMR, TMR and WCS, respectively.

Table 2. Chemical composition and fatty acid profile of experimental diets

	TMR	FTMR	Whole cottonseed
Chemical composition			
DM (%)	63.8	61.9	90.1
	---------- % of dry matter ----------		
OM	92.4	92.2	94.8
CP	16.1	15.7	21.3
EE	4.06	4.26	20.2
NDF	42.8	35.6	43.9
ADF	29.2	29.0	36.5
Ash	7.55	7.8	5.18
TDN	69.04	69.62	74.6
Fatty acid profile	---------- % of total fatty acids ----------		
C16:0	26.4	30.5	23.2
C18:0	2.3	2.3	2.1
C18:1	12.8	13.2	14.8
C18:2	44.1	42.7	52.4
C18:3	0.27	0.24	0.32
18:1+C18:2+C18:2	57.17	56.14	67.52
Free gossypol	0.05	0.04	0.54

Dry matter intake

As shown in Table 3, there was no difference in intake between TMR and FTMR, which confirms the study of Vasupen et al. (2005, 2006) who reported that DMI was not affected by FTMR, but disagrees with Yuangklang et al. (2004) who reported that cows fed on FTMR had higher DMI than cows fed TMR. Processing (cracking) the WCS did not affect DM, OM, CP, EE, NDF or ADF intake (Table 3). Similarly, Santos et al. (2002) also reported that DMI was not affected by cracked WCS.

The free gossypol intakes were 7, 7, 8 and 8 g/d for Treatment 1, 2, 3, and 4, respectively. These intakes were lower than the toxic (intake) level reported by Puschner (2000); who recommended that producing Holstein cows should consume no more than 20 g of free gossypol per day. With that limitation and the unpredictability of free gossypol levels in feeds, producing cows should receive less than 3 kg of whole cottonseed per day to minimize risk.

Digestibility

Digestibility of DM, CP, EE and ADF were similar. However, digestibility of DM, CP and EE were slightly higher in cWCS compared to WCS. OM and NDF digestibility were significantly affected ($p<0.05$) by the type of WCS (Table 3), which is in contrast to results of Bertrand et al. (2005) who reported that digestibility of DM, CP, EE, NDF ADF and acid detergent lignin (ADL) of cWCS did not differ from WCS. However, Pires et al. (1997) indicated that grinding of cottonseed increased the total tract

Table 3. Effect of fermented total mixed ration and cWCS on voluntary intake and apparent digestibility

Item	TMR		FTMR		SEM	p-value		
	WCS	cWCS	WCS	cWCS		TMR	WCS	TMR×WCS
Dry matter intake								
kg/d	15.9	15.2	15.4	15.6	0.49	0.88	0.69	0.38
BW, %	3.42	3.27	3.29	3.30	0.16	0.71	0.58	0.50
g/kg $BW^{0.75}$	159	152	153	154	4.85	0.68	0.54	0.44
Nutrient intake (kg/d)								
OM	14.7	14.1	13.9	14.4	0.44	0.61	0.94	0.25
CP	2.24	2.14	2.15	2.18	0.07	0.71	0.61	0.37
NDF	6.95	6.59	6.86	6.99	0.22	052	0.64	0.33
ADF	4.68	4.47	4.48	4.57	0.15	0.69	0.66	0.31
EE	0.65	0.62	0.65	0.68	0.02	0.18	0.76	0.26
Apparent digestion (%)								
DM	70.9	71.0	68.6	73.8	1.48	0.87	0.10	0.12
OM	73.3^{ab}	73.5^{ab}	69.8^{b}	75.7^{a}	1.21	0.61	0.03	0.04
CP	76.9	76.9	74.4	77.9	0.84	0.45	0.10	0.09
EE	84.6	85.8	85.6	88.5	1.12	0.14	0.10	0.47
NDF	57.9	58.5	58.3	64.6	1.50	0.04	0.03	0.06
ADF	54.9	55.2	54.4	60.7	2.65	0.37	0.25	0.28
ME[1] (Mcal/d)	41.0	39.6	37.1	41.8	1.15	0.45	0.10	0.09
ME (Mcal/kg DM)	2.57	2.59	2.40	2.66	0.05	0.28	0.28	0.40
MCP[2] (kg/d)	1.40^{ab}	1.35^{ab}	1.27^{b}	1.43^{a}	0.04	0.32	0.53	0.03

[a,b] Means in the same row with different superscript differ ($p<0.05$).
[1] 1 kg DOMI = 3.8 Mcal ME/kg DM (Kearl, 1982). [2] Microbial crude protein (MCP) (kg/d) = 0.13×kg DOMI.

digestibility of OM and N, and tended to increase ruminally undegradable protein of cottonseed. Similar results were observed by Sullivan et al. (1993a), who reported that the incomplete cracking of the seed coat of cWCS resulted in only a few whole seeds in feces, indicating an increase in total tract digestibility.

Digestibility of NDF was 57.9, 58.5, 58.3 and 64.3% in Treatment 1, 2, 3 and 4, respectively. NDF digestibility was higher with FTMR feeding compared to TMR. This increase was likely to be due to the fermentation of fibre during the preparation of the FTMR. The fermented fiber fraction in FTMR is easily digested by microbes in the rumen leading to increased fiber digestion after feeding FTMR to dairy cows (Yuangklang et al., 2004). The digestibility of NDF was also higher in cWCS compared to WCS. This result could be due to higher biohydrogenation of fats in the cracked cottonseed than in WCS. According to Baldwin and Allison (1983), some of the fat in the WCS diet is protected within the seed coat, limiting its biohydrogenation via ruminal microbes. It may then be reasonable to assume that feeding WCS results in more free unsaturated fatty acids within the rumen. Unsaturated fatty acids can inhibit ruminal microbes, particularly the cellulolytic organisms, resulting in decreased fiber digestion (Jenkins, 1993; Pantoja et al., 1994).

Digestibility of NDF was affected by cWCS ($p<0.05$) and digestibility of CP and EE tended to be affected by cWCS ($p<0.10$). These results could be due to the greater passage of seed in feces when feeding WCS (Osland and Wagner, 1985; Sulivan et al., 1993a). Similarly, Coppock et al. (1985) found that seeds passed in the feces were not different in nutrient content from the seeds consumed. This agrees with Sullivan et al. (1993b) who indicated incomplete cracking of some cWCS accounted for passage of a few whole seeds in feces from cows fed on that diet. Hence, no digestion of the excreted seeds occurs. Cracked or grounded seed causes a more rapid release of oil (Hawkins et al., 1984) and increased detoxification of gossypol by microbes. Cracking or grinding of the whole seed results in the release of some gossypol (Calhoun et al., 1995), which can bind to other feed particles before feeding, or by dilution, and slows absorption of free gossypol (Risco et al., 1992). This binding could enhance the degree of detoxification of gossypol by rumen microbes (Prieto et al., 2003).

The natural fibrous coating of the seed coat surrounding the oil in whole oilseeds could potentially alter the rate of ruminal bypass or the release of oil into the rumen (Baldwin and Allison, 1983).

Intake of ME in Treatment 3 was slightly lower than in other treatments. This response was also observed in microbial crude protein synthesis. ME intake and microbial

Table 4. Effect of fermented total mixed ration and cracked cottonseed on ruminal pH, ammonia nitrogen, volatile fatty acids and plasma urea nitrogen

Item	TMR		FTMR		SEM	p-value		
	WCS	cWCS	WCS	cWCS		TMR	WCS	TMR×WCS
Ruminal pH	6.87	6.85	6.81	6.83	0.02	0.09	0.36	0.36
NH_3-N[1] (mg%)	13.4	16.6	17.2	16.7	1.83	0.23	0.38	0.27
Volatile fatty acids (mol/100 mol)								
Acetic acid, C2	70.8	71.4	69.5	70.0	1.87	0.27	0.65	0.94
Propionic acid, C3	21.8	22.5	23.4	22.9	1.42	0.46	0.95	0.66
Butyric acid, C4	7.31	6.06	7.00	7.04	0.64	0.65	0.41	0.36
C2:C3 ratio	3.28	3.22	3.01	3.10	0.25	0.46	0.91	0.67
Total VFA	55.3	63.7	57.4	65.3	3.57	0.55	0.02	0.93
Bacteria (10^9 cell/ml)	9.68	9.96	9.56	11.31	0.46	0.32	0.13	0.24
Protozoa (10^5 cell/ml)	3.87	2.87	3.87	2.75	0.47	0.77	0.04	1.00
BUN[2] (mg%)	13.8	13.0	15.6	13.2	1.51	0.44	0.54	0.23

[1] Ammonia nitrogen. [2] Blood urea nitrogen.

protein synthesis were adversely affected by cWCS and were the result of decreased OM intake (Table 3). Similarly, Chen and Gomes (1995) showed MCP synthesis was increased by increasing levels of intake.

Rumen ecology and production of fermentation

Ruminal pH was similar in all treatments (6.87, 6.85, 6.81 and 6.83 for Treatment 1, 2, 3 and 4, respectively), with no difference ($p>0.05$) between FTMR and TMR, and cWCS and WCS (Table 4). Vasupen et al. (2006) also found that ruminal pH was not affected by FTMR. These ruminal pH were in the optimum range, as reported by Van Soest (1994).

Ruminal VFA concentrations (Table 4) did not differ among treatments. Ruminal acetate:propionate ratio was similar among dietary treatments. A similar observation was reported by Dayani et al. (2007). There was no difference in total VFA production for WCS and cWCS; however, the molar proportion of isovalerate was lower for cWCS compared to WCS. Total VFA was higher for cWCS compared to WCS. This result may be explained by the fact that cWCS improved digestibility of NDF (Table 3).

Type of TMR and type of WCS supplementation did not alter ruminal NH_3-N concentration among dietary treatments. Concentration of ruminal NH_3-N was higher than 5 mg%, which is the optimal level of NH_3-N for microbial protein synthesis (Satter and Slyter, 1974).

Bacteria and protozoa population in the rumen was not altered by the type of TMR, but protozoa population was decreased by the type of WCS (Table 4). This finding is similar to that reported by Vasupen et al. (2006). In contrast, Yuangklang et al. (2004) demonstrated that cows fed FTMR had higher bacteria counts and lower protozoa counts than cows fed TMR. Cows supplemented with cWCS had a lower protozoa count. Dayani et al. (2007) reported that feeding WCS decreased the total protozoa population from approximately 500,000 to 250,000 cell/ml. Several reports have shown that unsaturated fatty acids reduced protozoa population (Machmuller and Kreuzer, 1999). Thus, use of cWCS in diets may release unsaturated fatty acids such as linoleic acid (C18:2), potentially resulting of a reduction in the protozoa population.

BUN (Table 4) was not significantly different ($p>0.05$) among treatments, and the values were similar to the appropriate BUN of 15 mg% reported by Baker et al. (1995).

Milk yield and milk composition

As shown in Table 5, neither the type of TMR nor the type of WCS supplementation had any influence on milk yield, milk composition, or feed efficiency ($p>0.05$). A similar result was observed by Vasupen et al. (2006) who reported that production and composition of milk were unaltered by FTMR feeding.

cWCS supplementation did not alter milk yield, milk composition and feed efficiency ($p>0.05$), which was to be expected as DMI was not affected, as also reported by Beede and Collier (1986). Brown et al. (1982) and Santos et al. (2002) found that yields of milk and milk components were similar between cows fed diets of whole Pima cottonseed and cracked Pima cottonseeds. However, milk fat of the cows supplemented with cWCS was lower than that of the cows supplemented with WCS. Hawkins et al. (1984) observed a decrease in milk fat percentage with ground seed compared to whole seed, probably because of a more rapid release of oil from the ground seed. In general, supplemental fat decreases fat percentage in milk (Dhiman et al., 2000); however, these reductions would seem to be due to the highly unsaturated fatty acid sources affecting rumen fermentation. Jenkins and Palmquist (1983) found a

Table 5. Effect of fermented total mixed ration and cracked WCS on milk yield and milk composition and fatty acid profile

Item	TMR		FTMR		SEM	p-value		
	WCS	cWCS	WCS	cWCS		TMR	WCS	TMR×WCS
Milk yield (kg/d)	16.6	16.2	17.0	16.3	1.47	0.68	0.53	0.73
4%FCM (kg/d)	18.0	18.6	19.9	19.0	1.70	0.46	0.95	0.62
Feed efficiency								
kg milk/kg feed	1.08	1.07	1.19	1.08	0.08	0.66	0.64	0.72
4% FCM kg/kg feed	1.16	1.23	1.32	1.25	0.09	0.45	0.86	0.47
Milk composition (%)								
Fat	4.45	3.97	4.53	4.26	0.29	0.50	0.20	0.73
Protein	3.27	3.44	3.36	3.27	0.11	0.73	0.74	0.32
Lactose	5.37	5.17	5.28	5.27	0.06	0.98	0.06	0.08
Total solids	13.3	13.7	13.6	13.8	0.36	0.67	0.38	0.77
SNF[1]	9.36	9.32	9.25	9.27	0.16	0.64	0.94	0.85
Fat:protein	1.21	1.28	1.26	1.39	0.08	0.27	0.21	0.72
Fatty acids profile								
C14:0	12.1	12.9	12.2	12.6	0.94	0.80	0.24	0.66
C16:0	25.4	25.7	26.0	26.7	0.32	0.08	1.00	0.65
C18:0	12.7	12.8	12.8	12.5	0.76	0.82	0.83	0.73
C18:1	26.7	27.2	24.3	24.5	0.05	0.01	0.51	0.80
C18:2	4.03	4.35	3.95	4.30	0.14	0.62	0.02	0.92
C18:3	0.30	0.28	0.29	0.27	0.03	0.66	0.38	0.82
C18:1+C18:2+C18:3	31.0	31.9	28.5	29.1	0.68	0.01	0.27	0.83

[1] Solids-not-fat.

negative correlation *in vitro* between the acetate:propionate ratio and chain length of unsaturated fatty acids, suggesting that diets rich in polyunsaturated fatty acid could decrease milk fat percentage as compared to cows fed a more saturated fatty acid source.

Fatty acid profile in milk of dairy cows fed experimental diets

The fatty acid concentration in milk fat is shown in Table 5. The concentrations of C14:0, C16:0, C18:0, C18:2 and C18:3 were not affected by type of TMR. However, the concentration of C18:1 and the proportion of unsaturated long chain fatty acids were higher in the cows that received TMR than in the cows that received FTMR ($p<0.01$).

The concentrations of C14:0, C16:0, C18:0, C18:1 and C18:3 were not affected by cWCS; however, the concentration of C18:2 was higher in the cows supplemented with cWCS than in the cows supplemented with WCS. These results are in agreement with Sulivan et al. (1993a) who reported that feeding cWCS produced milk higher in linoleic acid (C18:2) compared to feeding with WCS. The higher C18:2 on the cWCS diet was probably because of less efficient ruminal biohydrogenation. The lint of WCS has been proposed as a means by which seed is sequestered in the ruminal mat thereby slowing its rate of passage from the rumen (Coppock et al., 1985; Mena et al., 2001). Unsaturated fatty acids in milk fat in cows fed TMR were higher than in cows fed FTMR ($p = 0.01$). This observation may be explained by the fact that unsaturated fatty acids in FTMR were hydrogenated by microbes during ensiling (Table 2).

CONCLUSION

Based on experimental data, FTMR is a conceivable method to improve the quality of TMR for long-time storage without adversely affecting the performance of animals. Cracking is a suitable method to release the fat from cottonseed for enhancing fatty acid deposition in milk. Thus, the combination of FTMR and cWCS supplementation would be an alternative strategy to improve performance of lactating cows.

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