EVALUATION OF WHOLE COTTONSEED AS EFFECTIVE FIBER SOURCE IN EARLY LACTATING HOLSTEIN COWS

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Abstract

Twelve Holstein cows in early lactation were used in balanced changeover design to evaluate the effect of replacing alfalfa Neutral Detergent Fiber (NDF) with NDF from whole cottonseed at different levels (0,7,14,20 %) on dry matter basis. The diets were similar as crude protein and neutral detergent fiber on dry basis. Cows were fed with total mixed ration individually. Dry matter intake and milk yields were higher for cows fed with high whole cottonseed (14.20%) diets than for the alfalfa control diet. High whole cottonseed diet had best efficiency. Milk fat percentage and milk fat yield were highest for high whole cottonseed diets, but no significant difference were found among the another milk composition compounds (protein, lactose and SNF). Milk component yields were significantly different ($p<0.05$). Rumen pH and fecal pH were not significantly affected by experimental diets. Chewing activity increased linearly when whole cottonseed percentage increased. High percentage of whole cottonseed percentage was associated with increased physically effective fiber. Digestibility results were indicated that control diet and 7 % whole cottonseed diets had highest dry matter digestibility ($p<0.05$), while organic matter, crude protein and NDF digestibility were not significantly affected among diets. Daily weight gain and body condition score change were affected by diets. Thus, the 14 and 20 % whole cottonseed diets produced the highest daily weight gain and body condition score ($p<0.05$). Plasma urea nitrogen was higher for 14 and 20 % whole cottonseed in diets.

Key words: Early lactation, Holstein cows, Whole cottonseed, Alfalfa hay, Effective NDF, Chewing activity

Abbreviation Key: eNDF = effective NDF, NFFS = nonforage fiber source, WCS = whole cottonseed, BUN = blood urea nitrogen, ef = effective factor, control, B, C, D diets respectively diets containing 0, 7, 14, 20 percentage WCS

INTRODUCTION

Effective fiber has been defined as the actual capacity of the fiber to stimulate chewing activity, rate of digesta passage, salivation, ruminal acetate production and, consequently, milk fat Percentage (2, 3, 5, 6, 16). Generally milk fat percentage, chewing activity and particle size are used as response variables to eNDF. In early lactation, most limiting factor of DMI is rumen fill (32); therefore decrease of feed mass and increase density of nutrients improved early lactation problems.

While whole cottonseed has high energy, medium crude protein, it also has high NDF. Collection of these characteristics caused that WCS used as multi supplement. Various nonforage fiber source (NFFS) such as WCS have been used in diets of lactating cows to supplement conventional forage fiber during of low forage supply or high forage prices. It is vital role applying WCS in early lactating cows because WCS have high energy density. However, information about replacing WCS effect with forage on performance and best level of it is limited.

The propose of this evaluation was to determine replacing effect WCS at varying levels and its interaction in early lactation. Pervious studies evaluated just one level WCS with maximum 15 percentage (5, 6, 23, 27) in mid lactation cows (5, 6, 16). The determination effectiveness WCS in early lactation is very importance.

MATERIAL AND METHODS

Experimental data: Twelve Holstein cows in early lactation were used imbalanced changeover design (22). Cows were blocked by stage of lactation and DIM. Cows had averaged 28 DIM at beginning of first period. Periods were d 21; the first d 14 were used an adaptation, and last d 7 were used for sampling. Composition of experimental diets is shown in tables1 and 2. Dietary treatments containing four level WCS (0, 7, 14 and 20) on dry matter base that replaced to alfalfa hay. Four diets were formulated to contain 36.25 and 0 at control diet, 32 and 7 at second diet(B), 26 and 14 at diet C at last 20 and 20 at diet D alfalfa hay and WCS respectively. All diets were similar as crude protein and Neutral Detergent fiber on dry base (18 and 29.5% respectively). Cows were fed TMR in two separate feeding at 0800 and 1700 prepared daily by hand mixing in the manger and milked twice daily prior to feeding with milk yield measured and recorded at each milking. Milk samples were taken during d 15 and 17 and analyzed for milk fat, milk protein, milk lactose and milk SNF by Milko scan (Milko scan 134 A/B). Feed offered and refused were recorded daily to adjust feed offered for 10% refusal. Cows were housed in tie stall barn. Stall mattresses were to prevent ingestion of bedding.

Body weights were recorded in beginning and final of each period after a.m. milking. Body condition score was recorded at beginning of experiment and then at beginning and final periods.

Table 1. Ingredient composition of diets fed to cows during experimental periods in which diets differed in WCS percentage and forage NDF(% DM)

Ingredient	Diet[1]			
	control	B	C	D
Alfalfa hay	36.25	32	26	20.5
Barley	41.75	40	39	38
Whole cottonseed	-	7	13.5	19.8
Cottonseed meal	12	12	12	12
Soybean meal	8.25	7	6.5	6.5
Calcium carbonate	0.9	0.9	1	1.5
Sodium bicarbonate	0.5	0.5	0.5	0.5
Vitamins A, D and E[2]	0.25	0.25	0.25	0.25
Nacl salt	0.25	0.25	0.25	0.25

[1] control = diet without WCS, B = diet containing 7 % WCS , C = diet containing 14 % WCS, D = diet containing 20 % WCS.

[2] contained 20,000 IU of vitamin A/kg, 6,235 IU of vitamin D/kg , and 98 IU of vitamin E/kg.

Laboratory Analysis: Weekly samples of feed offered were dried in a forced air oven at 100°C to determine DMI. Samples were ground through a 2-mm screen indweller Mill (TOSHIBA, IRAN). Air dried samples were analyzed for DM, ash, OM, crude protein and ether extract according to methods of AOAC (1), Neutral Detergent Fiber, NDF, was determined according to the procedure Van soest (30) and acid insoluble ash was determined according Vankeulen method (29). A ruminal fluid sample was taken from each cow by stomach tube during d19 of period at approximately 3h after morning feeding and pH was measured immediately with a glass electrode pH meter. Fecal pH was determined on 3 consecutive last d of periods three times (with 1h delay for next day). Fifty grams of fecal material obtained from rectal was mixed with 50ml of deionized water and pH was immediately recorded. Collected feces were dried in an oven-dring at 65°C for 48h and were mixed for determining DM, OM and NDF digestibility. Blood samples were obtained on d 20 of each period from coccigial vein. Samples were obtained between 3h after morning feeding with vein inject tubes (pars Darrow, Iran). Blood.

Table 2. Chemical composition of diets fed to cows during experimental periods in which diets differed in WCS percentage and forage NDF(% of DM)

Item	Diet			
	control	B	C	D
DM	90.10	91.06	89.93	89.12
Ash	4.86	5.29	5.09	4.31
NEL, Mcal/kg of DM	1.68	1.70	1.75	1.77
CP	18.20	18.1	18.30	18.50
By pass protein (% of CP)	30.10	31.11	32.10	33
NDF	29.20	29.91	29.90	29.90
Forage NDF, %	16.67	14.72	11.96	9.25
ADF	18.70	19.40	19.56	19.60
NFC[1]	43.24	40.21	39.28	38.68
FAT	4.50	6.50	7.43	8.61
Ca	0.91	0.87	0.85	0.98
P	0.45	0.47	0.49	0.51
Mg	0.28	0.30	0.31	0.33

[1] Nonfiber carbohydrate calculated by difference 100 – (%NDF + %CP + %Ash +%EE).

Samples were centrifuged at 2118 xg for 10 min and the plasma was frozen at -20°C. Samples were analyzed for plasma glucose, BUN, TCP, Ca, P, Mg and cholesterol.

Chewing activity was determined by direct observation during d17 of each period. Oral activity (eating and rumination) of each cow was recorded at 10 min intervals throughout 24h period. Chewing activity during milking was not measured and is not included in daily totals. Cows were returned at the tie stall immediately after milking. Chewing activity per kilograms of DMI was calculated with the DMI during the day of chewing activity measurement.

Particle length of alfalfa hay were average 10 to 15 cm. Particle length was determined according to the American Society of Agricultural Engineers S424 protocol. Calcium and phosphorous requirements was calculated 15% over requirements (18).

Statistical Analysis

Data were analyzed by covariance analysis. Data were analyzed by ANOVA including period, treatment, square and cow with in square using the general linear model procedures of SAS (24). Type III sums of squares were used and the residual served as error term for all tests.

The following model was used:

$$Y_{ijkl} = \mu + T_i + P_j + B_k + B(k)_l + E_{ijkl}$$

Where Yijkl = dependent variable,
μ = overall mean, Ti = treatment effect,
Pj = period effect, Bk = square effect,
B(k)l = cow with in square and Eijkl = residual effect

Digestibility data were analyzed by completely randomized design. The following model was used for digestibility data:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Yij = dependent variable, μ = overall mean, Ti = treatment effect and Eij = residual effect

All means are least square means and differences were reported as significant when $P < 0.05$. Differences among treatment mean for significant

Effects were determined using the Duncan multiple range test.

RESULT AND DISCUSSION

The mean of different traits compartment are shown table 3. Dry matter intake of diets were significantly difference ($P < 0.05$).Milk yield, milk fat, fat yield, milk protein concentration, protein yield, FCM and DMI were lower for the control diet (table 3). So that DMI for diet D was highest (22.82kg/d) and for control diet was lowest (21.39 kg/d); In the other word, increasing DMI was associated with increasing WCS percentage diets.

DMI is a function of meal size and meal frequency that are determined and dietary factors affecting hungry and satiety (3, 14). Decreasing fill effect of diets with decrease alfalfa hay probably caused increasing DMI. According of NRC (17) DMI increased linearly (P<0.01) with increasing concentrate in diet, regardless of forage type. Some information has indicated that early lactation cows have a similar rumen capacity than do cows in later lactation (31).Varga, et al (31) fed diets to early lactation cows that low or high in fill and that had been formulated to differ in rate and extent of NDF. Although cows produced significantly more milk and milk protein on the low fill diet and almost twice fold fewer DM in the rumen, the cows did not consume more feed than those cow fed the high fill diet. Okine and Khorasani (21) also concluded with increasing concentrate on late lactation cow's diets, DMI is increased.

Table 3. Least square mean of performances of cows which were fed experimental diets

Item	Diet				SEM	effect	
	control	B	C	D		Diets	Period
DMI,kg/d	21.39a	21.50a	21.72a	22.82b	0.93	0.0001	0.0026
Milk,kg/d	30.05a	29.01a	32b	35.05c	2.07	0.0001	0.0001
Milk [1], kg/d	25.77a	25.07a	28.56a	32.50b	2.15	0.0001	0.0001
Milk effeciency[2]	1.40a	1.37a	1.54b	1.55b	0.13	0.0449	ns
Milk fat,%	3.06a	3.10a	3.31b	3.42b	0.29	0.0466	0.0196
Milk fat yield,kg/d	0.92a	0.89a	1.05a	1.20b	0.08	0.0001	ns
Milk protein,%	2.98	3.07	2.94	3.03	0.16	ns	ns
Milk protein yield,kg/d	0.89a	0.88a	0.93a	1.06b	0.07	0.0001	ns
Milk lactose,%	5.55	5.65	5.60	5.62	0.12	ns	ns
Ruminal pH	6.30	6.47	6.57	6.42	0.49	ns	ns
Fecal pH	6.49	6.60	6.50	6.53	0.14	ns	0.0237
BW change, kg/d	0.11a	0.13a	0.24ab	0.38b	0.13	0.067	0.0026
BCS[3] change	0.13a	0.20a	0.23a	0.54b	0.14	0.0021	0.037
Plasma metabolites							
Ca, mg/d lit	13.57	13.74	12.39	13.60	0.758	ns	ns
P, mg/d lit	8.76	7.72	10.02	10	1.41	ns	ns
Mg, mg/d lit	2.20	2.07	2.16	2.08	0.0978	ns	0.0001
Cholesterol ,	237.78	266.67	304.78	315.28	13.21	ns	ns
BUN,mg/d lit	18.16a	19.78a	23.32b	25.31b	1.53	0.0001	ns

a,b,c Means in row with different superscripts differ (p< 0.05).
n.s. = non significant
[1] Fat corrected milk for 4% fat(FCM)
[2] Milk production per kg DMI
[3] body condition scores(five point scale where 1 = thin to 5 = fat)

Clark and Armentano (6) found that DMI, milk yield and milk protein yield were higher for diet that replaced alfalfa haylage with 9 percentage WCS. Results of this experiment agreement with studies of Clark and Armentano (5), Frigens and Emmans (9), Zho and stock (34), Slater etal (27). Main factor is determined rumen capacity is milk production (31). Increasing milk production with increase WCS would be related high DMI (4,32), high NEL density (15)and fat effect of WCS.

Milk fat concentration was lowest for control diet and was different significantly (P < 0.05) among the diets suggesting that WCS at D (20%) and C (14%) diets were adequate substituting for alfalfa hay for supporting milk fat test. The range of fat test means between the three diets containing WCS indicated effectiveness of WCS difference among levels of WCS. Although this difference may have been due to the higher fat percentage in WCS diets. Yield of FCM was highest for D diet and was not different among the other diets. Effective NDF replacement values for NFFS may vary with changing forage chop length and fiber level or composition (5).

Table 4.Chewing activity, ruminating and eating in the cows fed experimental diets

Item	Diet				SEM	effect	
	control	B	C	D		Diet	Period
Chewing activity(min/d)							
Eating	183	181.66	183.83	191	3.47	ns	0.0057
Ruminating	343.83	340	345.83	365	6.89	ns	0.0047
total	526.33	521.33	529.66	556	8.39	ns	0.0061
Chewing activity(min/kg DMI)							
Eating	8.55	8.45	8.46	8.37	0.13	ns	ns
Ruminating	16.05	15.81	15.92	15.99	0.29	ns	ns
Total	24.60	24.26	24.38	24.36	0.39	ns	Ns
Chewing activity(min/kg NDF)							
Eating	27.33	27.29	27.32	27	0.47	ns	0.0529
Ruminating	52.02	52.96	52.29	52.51	1.14	ns	0.0172
Total	80.35	79.25	79.61	80.52	1.33	ns	ns
Chewing activity(min/kg FNDF)							
Eating	74.40[a]	83.49b	103.97c	129.84d	4.77	0.0001	0.0001
Ruminating	142.44[a]	160.59b	198.50c	247.51d	9.69	0.0001	0.0001
Total	217.84[a]	245.40b	302.30c	397.15	14.01	0.0001	0.0001

n.s = non significant.

a, b, c, d Means in row with different superscripts differ($P < 0.05$).

Skaln (26) found, in low forage diets, WCS was caused increasing milk fat percentage on FCM. FNDF content in diets C and D was 9.20 to 11.96 percentage of diet DM, respectively, lower than the control diet (16.67%DM) see to table 2. The ef factor for determining eNDF from NDF is based on the response in milk fat concentration per unit of added NDF from NFFS in relation to the fat concentration response per unit of added alfalfa NDF. Ef obtained was higher than based on previous bioassay of WCS (6, 5, 34) resulting in higher milk fat concentration from diets C and D. Previus study. Evaluated low percentage WCS and just mid lactation cows.The mean values of ruminal pH were > 6.8 when were fed diet contain WCS. These results were indicated WCS have ability maintained pH in early lactation. Zhu, et al (34) found pH < 6.0 when replaced NDF from forage with NDF from byproducts.

Rumination per kg FNDF increased. Grant (10) concluded the cows may possess an adaptive mechanism whereby they ruminant more effectively (more chews per kilogram of forage NDF intake under condition of limited amount of effective forage NDF.

Table 5. Digestibility of Diets that measured by acid insoluble ash

Item	Diet				SEM	ration effect
	control	B	C	D		
DM digestibility	76.58[a]	76.39[a]	71.17[b]	72.96[ab]	0.85	0.028
OM digestibility	70.08	73.21	75.61	75.20	1.30	ns
EE digestibility	70.86[a]	78.91b	71.74[a]	70.21[a]	1.82	0.031
NDF digestibility	49.23	50.08	52.09	51.91	1.29	ns

a, b, c, d Means in row with different superscripts differ($P < 0.05$).

This is clearly show that why chewing of FNDF increased dramatically in this experiment (table 4). Increasing passage rate (table 5) may have caused DM digestibility C and D diet; because when decrease forage percentage in diets, rumen mat hasn't formed effectively. Low DM digestibility was agreement with Smith et al (28) Avila et al (4), but disagreed by Coppeck et al (7, 8) results. OM and NDF digestibility not significant difference among diets. Although adding fat to diets generally caused crude fiber digestibility decreased (20, 33) but increasing fat as WCS percentage increased, not change to NDF digestibility. It is may has been caused by over required Ca, P and Mg supply of that recommended NRC (18). Another factor increased NDF digestibility was low NFC at these diets. Research was shown decreasing NFC when pH is increased, caused higher NDF digestibility (11).

Plasma metabolites concentrations hasn't significantly difference exception of BUN (table 3) increasing BUN with increasing WCS percentage of diets may have affected high rumen degradable CP of WCS, concentration ammonia in rumen or decrease microbial protein synthesis. Horner, et al (8) found diets containing WCS have higher BUN (20%) rather than control diet. High degradability CP of diets and low fermentable organic matter was caused increasing BUN in this experiment whereby suffusion energy for microbial N did not supply (25).

CONCLUSION

Results of the present research indicate that replacing forage NDF with NDF from WCS, increased short-term milk production and milk contents without affecting protein milk percentage. Rumen pH also not different among diet, conversely increasing NDF content of diets by addition of more WCS increased physically effective fiber, but not significant. There was interaction effects between different levels of WCS based eNDF. OM and CP digestion were unaffected by the substitution of forage NDF with NDF from WCS. Although ruminal pH was slightly increased when cows were fed diets containing WCS, ruminal fiber digestion did not differ among diets. In this research BUN increased over safety level, therefore more research are needed to determine eNDF of WCS with high fermentable OM.

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