COMPARATIVE VALUE OF FULL-FAT CORN GERM, WHOLE COTTONSEED, AND TALLOW AS ENERGY SOURCES FOR LACTATING DAIRY COWS

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Summary

We used 24 multiparous Holstein cows in 4 × 4 Latin square design to evaluate full-fat corn germ as a replacement for whole cottonseed and tallow in total mixed diets for lactating dairy cows. Experimental diets on a dry matter basis were: 1) control 3.5% fat; 2) whole cottonseed 5.1% fat; 3) tallow 5.1% fat; 4) full-fat corn germ 5.1% fat. Diets were fed as total mixed rations typical of that fed on commercial dairy operations. Cottonseed meal and cottonseed hulls were included in the control, tallow, and full-fat corn germ diets to balance for fiber and protein fractions equal to those in the whole cottonseed diet. Dry matter intake, milk production, and energy corrected milk did not differ among the diets. Milk from cows fed full-fat corn germ contained less fat than milk from cows fed whole cottonseed but was similar to that of milk from cows fed control or tallow diets. Milk protein percentage was lower for cows fed full-fat corn germ than those fed control, but similar to cows fed whole cottonseed or tallow. Percentage milk lactose did not differ among dietary treatments. Cows fed WCS produced more pounds of milk fat than cows fed full-fat corn germ or tallow, but protein and lactose yield did not differ among the diets. Cows fed whole cottonseed produced milk more efficiently than cows fed control, tallow, or full-fat corn germ. Unexpectedly, efficiency of energy corrected milk production was not improved by tallow and tallow did not depress dry matter intake. Somatic cell count did not differ among experimental diets. Urea nitrogen concentration was lower in milk from cows fed full-fat corn germ and tallow than those fed whole cottonseed. All diets led to gains in body weight.

The handling and storage characteristics of full-fat corn germ enhances its desirability as a feedstuff for dairy cattle. Full-fat corn germ supported milk production as well as whole cottonseed but not milk fat percentage or fat yield at the level fed in our diets. Additional studies need to be conducted to determine the most advantageous amount to feed full-fat corn germ and clarify the mechanisms by which it depresses milk fat production.

(Key Words: Energy, Full-Fat Corn, Tallow, Cottonseed, Cows.)

Introduction

Lipids are frequently incorporated into diets for lactating dairy cows to increase energy density without reducing fiber intake. Commonly used lipid sources include whole cottonseed and tallow. An alternative fat source may be available in the form of full-fat corn germ obtained from the wet milling of corn. Wet milling of corn involves steeping and coarse grinding resulting in a pulp-like material containing full-fat corn germ, hull, starch, and gluten. Full-fat corn germ (FFCG) can then be separated based on bulk density via a liquid cyclone separator. Normally, further processing

[1]Minnesota Corn Processors, Inc., Marshall, MN.

of full-fat corn germ takes place by pressing, expeller, or solvent procedures designed to recover corn oil. This results in concurrent production of corn germ meal. Full-fat corn germ can be stored using conventional bins and handled by standard augers or conveyors. Typically FFCG contains 3 to 6% moisture, 13 to 15% crude protein, 43 to 51% crude fat, and an estimated NE_L of 1.54 to 1.66 Mcal/lb; with approximate concentrations of major fatty acids: linoleic (18:2), oleic (18:1) and palmitic (16:0) at 56%, 28%, and 11% of crude fat, respectively. The objective of our study was to determine if FFCG is an acceptable source of fat for dairy cows to support lactation.

Procedures

We used 24 multiparous Holstein cows averaging 124 DIM, milked 2× daily in a 4 × 4 Latin square design. Cows were housed in a tie-stall barn and offered diets for ad libitum intake twice daily over four 28-day periods. Experimental diets (Table 1) were: control (C) at 3.5% fat; 2) whole cottonseed (WCS) at 5.1% fat; 3) tallow (T) at 5.1% fat; and 4) full-fat corn germ (FFCG) at 5.1% fat. Diets were offered as total mixed rations (TMR). Samples of TMR and feed refusals were collected weekly and dried at 105˚C to determine dry matter of diets. Alfalfa hay, corn silage, whole cottonseed, and grain mixes were sampled and composites by period were sent to Northeast DHI Forage Testing Lab, Ithaca, NY for analyses. Cottonseed meal and cottonseed hulls were included in the C, T, and FFCG diets to balance for fiber and protein fractions equal to those in the WCS diet. Individual feed intake and milk yield were recorded daily. Weekly milk samples (AM-PM composite) were analyzed for fat, protein, lactose, urea nitrogen (MUN), and somatic cells by Heart of America DHI Laboratory, Manhattan, KS. Individual body weights were measured on two consecutive days at the beginning of the study and at the end of each period following the AM milking. Body condition (1 = thin and 5 = fat) was scored at the beginning of the study and at the end of each period.

Results and Discussion

Dry matter intake, milk yield, energy corrected milk (ECM), lactose percentage, protein and lactose yield and SCC did not differ among diets. Efficiency of milk production was improved by the addition of fat from WCS, but not from T or FFCG when compared to cows fed C. Cows fed FFCG had lower ($P<0.05$) milk fat percentage and fat yield than cows fed WCS, but similar to cows fed C and T (Figures 1 and 2). Milk protein percentage ($P<0.05$), but not yield, was greater for cows fed C than for those fed diets containing the three fat sources. Concentrations of urea nitrogen were lower ($P<0.05$) in milk from cows consuming FFCG and T than in milk from cows fed WCS, but not for those fed C.

Milk fat depression in lactating dairy cows can result from a deficiency of lipid precursors delivered to the mammary tissue for milk fat synthesis and inhibition of milk fat synthesis by mammary tissue. Adding supplemental fat to the diet can depress ruminal fiber degradation, most notably when polyunsaturated fatty acids, such as linoleic acid (a long chain polyunsaturated fatty acid of plants), are fed. Dietary fat sources rich in saturated fatty acids, such as tallow, typically do not have the same negative effect on the rumen environment or milk fat synthesis by the mammary tissue. Lipid is metabolized in the rumen by two major microorganisms, *Butyrivibrio fibriosolvens* and *Anaerovibrio lipolytica*. Triglycerides are first hydrolyzed to free fatty acids then unsaturated fatty acids are hydrogenated to form saturated fatty acids by bacteria. Hydrolysis of triglycerides by bacteria and protozoa occurs rapidly in the rumen, whereas biohydrogenation by bacteria is gradual, which leads to ruminal accumulation of polyunsaturated long chain fatty acids that are toxic to fiber digesting bacteria and protozoa. Dietary fats, such as oils, are able to coat fiber particles and bacteria causing further reduction in fiber degradation in the rumen. Reduction in fiber digestion limits the availability of acetate for de novo synthesis of fat by the mammary gland.

Rumen bacteria possess an isomerase enzyme that changes the position of the double bond within linoleic acid and other unsaturated fatty acids, subsequently generating conjugated linoleic acid (CLA) and *trans* fatty acids (*trans*-11 and *trans*-10). *Trans*-11 (vaccenic acid) comprises greater than 80% of the *trans* fatty acids and can be transformed into *cis*-9, *trans*-11 CLA by desaturase enzyme activity within the mammary gland, thus increasing the CLA content of milk. The trans-10 isomer is transformed into *trans*-10, *cis*-12 CLA. The *trans*-10 isomer and *trans*-10, *cis*-12 CLA can inhibit milk fat synthesis by mammary tissue resulting in depressed milk fat percentage and yield. Lipids from intact seeds, such as WCS, release oil slowly in the rumen, which probably reduces the ruminal concentration of CLA and *trans* fatty acids, thus reducing the potential to depress de novo fatty acid synthesis in mammary tissue. The lower milk fat percentage for cows fed FFCG diet would suggest that the oil contained in FFCG was promptly liberated from the germ and negatively influenced the rumen environment or was converted to *trans* fatty acids, thus reducing mammary fat synthesis.

Efficiency of milk production is estimated by the ratio of milk yield to dry matter intake (ECM/DMI) and provides a measure of utilization of feedstuffs for milk production. Characteristically, lactating dairy cows fed diets supplemented with fat, such as T or WCS, produce milk more efficiently due to the increased caloric content of the diet. Historically, lactating dairy cows supplemented with fat show improved lactation performance over cows fed diets without supplemental fat. Cows fed WCS produced milk more efficiently than cows fed C, T, or FFCG, but we did not observe an improvement in efficiency for cows that consumed T compared to cows that consumed C. The lack of response to tallow was unexpected and may be due to an interaction between tallow and wet corn gluten feed.

Conclusion

The handling and storage characteristics of full-fat corn germ enhances its desirability as a dairy cattle feedstuff. Full-fat corn germ supported milk production as well as WCS and T, but milk fat percentage and fat yield were less with FFCG than WCS at the level fed in our diets. Unexpectedly, cows consuming T did not produce milk as efficiently as cows consuming C, perhaps indicating various factors other than fat source alter measures of lactation. Additional studies need to be conducted to determine the most advantageous amount of full-fat corn germ to feed and clarify the mechanisms by which it depresses milk fat production.

Table 1. Ingredient and Nutrient Composition of Experimental Diets

	Diet			
Item	Control	Whole cottonseed	Tallow	Full-fat corn germ
Ingredient	------------------------------ % of DM ------------------------------			
Alfalfa hay	23.05	23.01	23.0	3.08
Corn silage	9.94	9.92	9.92	0.95
Wet corn gluten feed	19.43	19.40	19.39	9.46
Corn ground	28.42	26.87	26.89	5.74
Whole cottonseed	-	9.44	-	-
Tallow	-	-	1.67	-
Full-fat corn germ	-	-	-	0.4
Cottonseed hulls	3.31	-	3.30	0.0
Cottonseed meal	4.49	-	4.48	0.52
Soybean meal, expeller[1]	6.99	6.98	6.98	0.98
Fish meal	1.30	1.30	1.30	0.30
Molasses	0.97	0.97	0.96	0.90
Limestone	0.66	0.70	0.68	0.68
Magnesium oxide	0.21	0.21	0.21	0.21
Trace mineralized slat	0.31	0.31	0.31	0.31
Sodium bicarbonate	0.73	0.73	0.73	0.73
Vitamin ADE premix	0.12	0.12	0.12	0.12
Selenium premix	0.01	0.01	0.01	0.01
Zinpro 4-plex™ [2]	0.05	0.05	0.05	0.05
Nutrient[3]				
CP	18.9	18.7	18.7	18.7
NDF	29.7	30.0	29.5	29.9
ADF	16.3	17.0	16.2	16.3
NFC	42.9	41.1	41.7	41.3
Fat	3.5	5.1	5.1	5.1
Calcium	0.89	0.91	0.90	0.90
Phosphorus	0.45	0.45	0.45	0.45
NE_L, Mcal/lb	0.71	0.74	0.73	0.73

[1]Soy Best - Grain States Soya, Inc., West Point, NE.
[2]Zinpro 4-plex - Zinpro Inc., Eden Prairie, MN.
[3]Values from Dairy NRC 2001.

Table 2. Lactation Performance of Cows

Item	Diet[1]				SEM
	Control	Whole cottonseed	Tallow	Full-fat corn germ	
DMI[2], lb/day	57.3	56.3	56.5	57.3	0.58
Milk, lb/day	90.2	90.8	89.8	91.0	1.02
ECM[3], lb/day	88.7	90.0	87.7	87.6	0.95
Efficiency, ECM/DMI	1.55[a]	1.60[b]	1.56[a]	1.54[a]	0.014
Milk fat, %	3.38[ab]	3.45[a]	3.37[ab]	3.26[b]	0.05
Milk protein, %	3.09[a]	3.06[b]	3.05[b]	3.06[b]	0.01
Milk lactose, %	5.29	5.26	5.25	5.29	0.01
Milk fat, lb/day	3.03[ab]	3.13[a]	2.99[b]	2.93[b]	0.05
Milk protein, lb/day	2.77	2.76	2.72	2.76	0.03
Milk lactose, lb/day	4.77	4.78	4.72	4.81	0.06
SCC[4], ×1000	254.0	429.0	431.0	287.0	98.0
Milk urea nitrogen, mg/dl	16.64[ab]	17.11[a]	16.29[b]	16.30[b]	0.14
Initial body condition score	2.69	2.75	2.72	2.74	-
Initial body weight, lb	1,542	1,547	-	1,540	-
Change in body weight, lb	29.9	16.2	28.8	34.1	7.0

[a,b]Means with different superscripts differ ($P<0.05$).
[1]Control = 3.5% ether extract; whole cottonseed, tallow, full-fat corn germ = 5.1% ether extract.
[2]DMI = dry matter intake.
[3]ECM = energy corrected milk.
[4]SCC = somatic cell count.

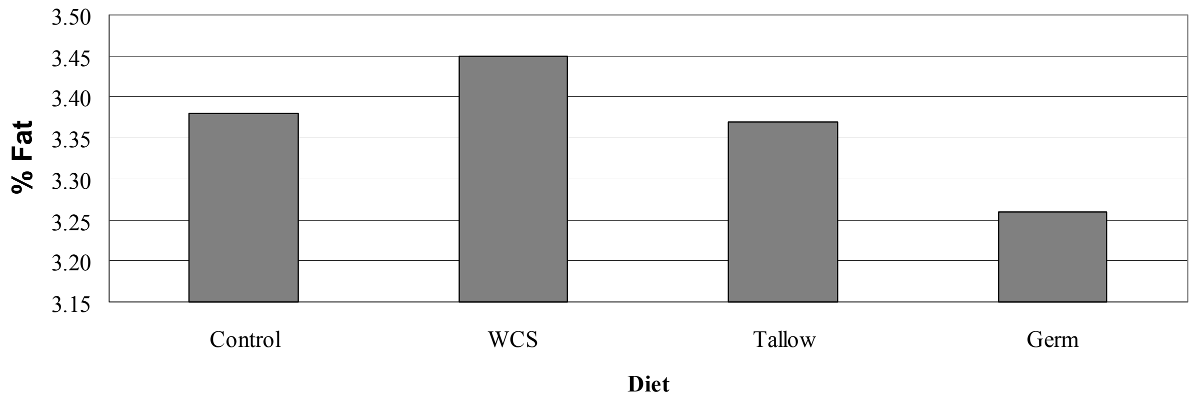

Figure 1. Percentage Milk Fat.

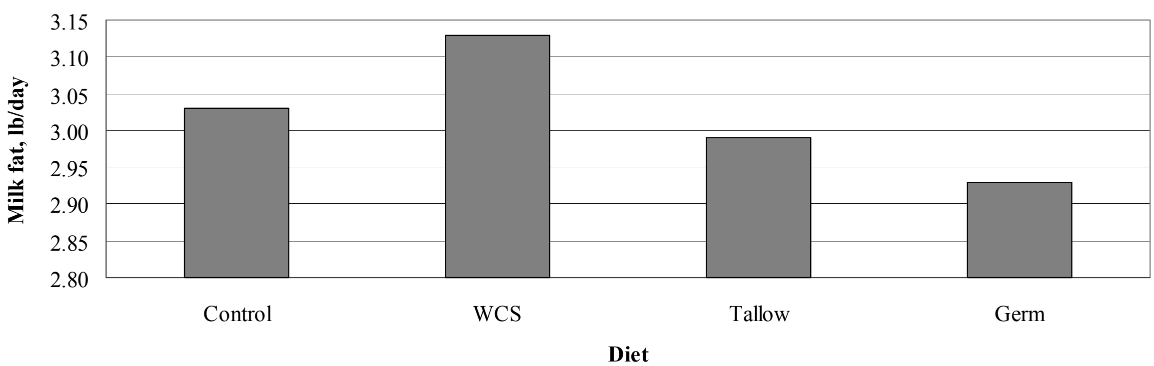

Figure 2. Pounds of Milk Fat Per Day.