ECONOMIC EFFECTS OF WHOLE COTTONSEED AND SUPPLEMENTAL TALLOW ON LACTATION WHEN FED WITH DIFFERENT FORAGES

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Dietary fat is supplemented in diets for lactating dairy cows to increase dietary energy concentration, e.g., Mcal NE_L/lb dietary dry matter (DM), and, hopefully, energy intake. In most cases, feed costs are increased by adding fat to diets but extra milk production is expected to more than offset increased costs. Some continuous feeding studies have even suggested that there were residual benefits of dietary fat that carried over after the feeding of supplemental dietary fat was discontinued (4, 22). Others have concluded that improved reproductive performance may be a secondary benefit to supplemental fat [e.g., review by Staples et al. (26)].

The milk yield response to supplemental fat appears to be variable with the type of forage being fed with fat a factor that accounts for some of the variation (24). Our objectives in this paper are to try to quantify a response range to whole cottonseed (WCS) and tallow with different dietary forage bases and to make some economic estimates to help in deciding whether or not to include these ingredients in diets for lactating cows.

Characterization of Milk Yield Response to Fat

Grummer (9) provided a good review of feeding strategies for supplemental fat and indicated the response in early lactation often is delayed until peak lactation as illustrated in Figure 1. In very early lactation, there seems to be a lag time until a milk response is observed. Cows seem to respond best to fat supplementation about the time that they reach positive energy balance. There is some evidence that there may be a lag time in mid-lactation as well before beneficial effects of fat are fully expressed, e.g., Tomlinson et al. (27) found that benefit to feeding calcium salts of long chain fatty acids (Ca-LCFA) over control diets was greater in week 4 after initiation of feeding than in week 3. Other studies, however, have found effects were expressed by week 3 (1, 25). In early lactation, body weight loss may not be reduced by feeding additional fat but gain usually is accelerated once cows reach positive energy balance (9).

The suggestion that beneficial effects of feeding supplemental fat may carry over after feeding of fat is discontinued (4, 22) is an important point to clarify. Many experiments, including most of our Florida experiments, used reversal type experimental designs so that diet comparisons could be made within cows rather than between cows and thus separate variation due to designed dietary treatments more effectively from variation between cows. If the effect of dietary fat supplementation carries over after the feeding of fat is discontinued, experiments in which treatments were reversed within cow during the same lactation would underestimate the effect of fat.

Presented at the 5th Florida Ruminant Nutrition Symposium, Gainesville, January 13-14, 1994

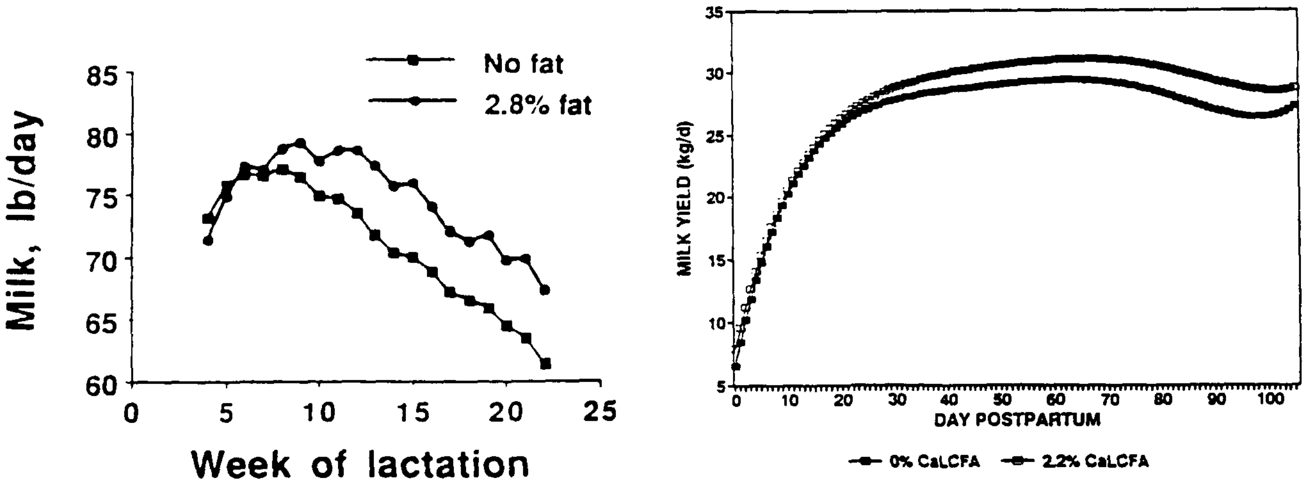

Figure 1. Milk response to fat often is delayed when supplementation is initiated at or shortly after calving. Left graph is from data of Hoffman et al. (10) as shown be Grummer (9); note that milk yield is in lb/day. Right graph from Garcia-Bojalil (8); note that milk yield is in kg/day.

We designed two experiments specifically to measure if dietary effects carried over after treatments were switched (25, 27) and found no evidence that effects of fat were not dissipated within a 2-week adjustment period allowed after dietary changes were made. The treatment effects measured in weeks 3 and 4 after dietary changes were free of carryover effects. Also, at least two continuous feeding studies (7, 23) showed that increased milk and solids-corrected-milk (SCM) yields associated with feeding Ca-LCFA returned to control levels after supplementation was discontinued. Thus, our conclusion is that carryover effects are not important and should not be projected to be part of the economic returns from dietary fat supplementation. However, if improved reproductive function occurs when fat is fed, as suggested by Staples et al. (26) and Garcia-Bojalil (8), an economic value for that contribution should be added to the effects on milk production. We did not try to appraise that value in this review because the data seem to be inconclusive at this point.

With a best case scenario, the amount of response expected to dietary supplementation with fat can be 5 lb of milk per cow daily or more in mature cows with some increase in milk fat percentage as well (9, 11) giving about 6 lb/day of fat-corrected-milk (FCM). There has been great variation, however, in the amount of response observed in controlled experiments. In a review of 74 research papers, Smith and Harris (24) found that only a few of the responses were equal to the best case scenario. Jenkins (11) identified the amount of unsaturated fatty acids in supplemental fats as a reason for some of the variation in responses. Figure 2 shows his analysis of milk yield response data from ten lactation studies with a total of 22 treatment comparisons with control diets. Responses were plotted according to concentration of supplemental fat in the diet, unsaturated fatty acids in the diet, and the ratio of unsaturated fatty acids to acid detergent fiber (ADF).

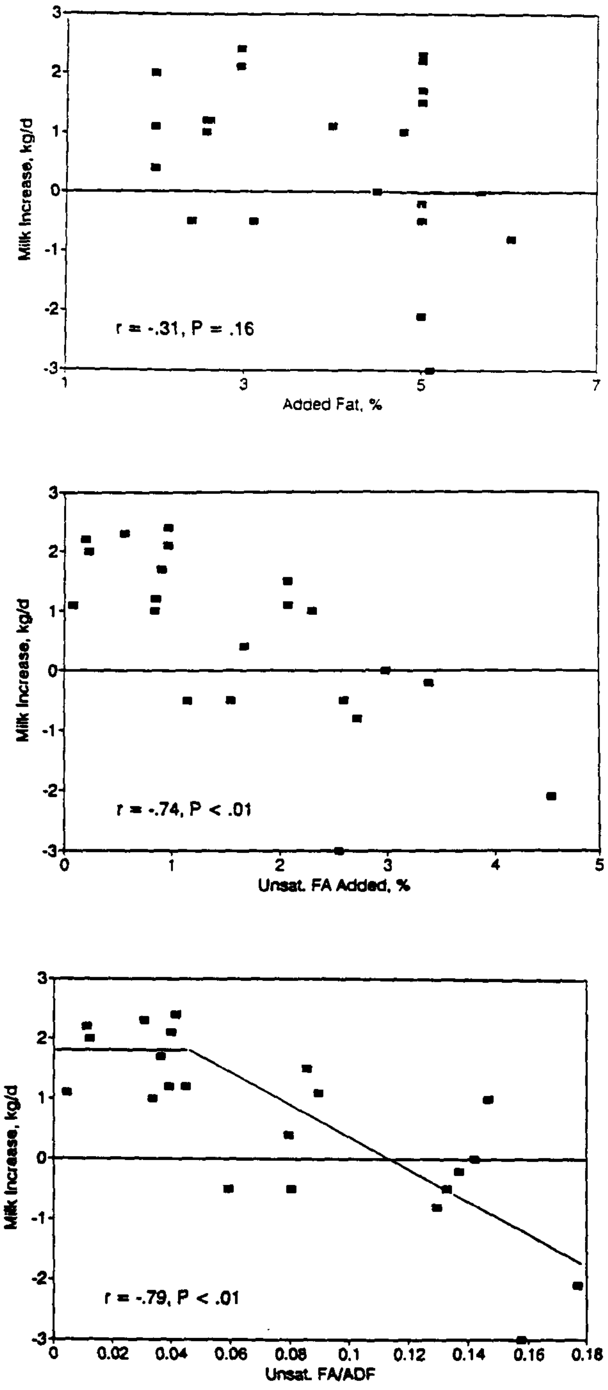

Figure 2. Milk response to supplemental fat described by added fat (% of diet DM), unsaturated fatty acids (% FA of diet DM), or ratio of supplemented unsaturated acids to ADF. Graphs are from Jenkins (11) from data he compiled from 10 experiments (2, 3, 6, 12, 13, 17, 18, 19, 20, 21).

Figure 2 shows that milk yield increases (or decreases) over control rations were quite variable when plotted on basis of added fat (as a % of diet DM). There was a small, negative correlation (-.31) between milk response and added fat. Although adding fat to the diet increased milk yields more than 5 lb/day in individual experiments, there were instances where milk yields were small, or even decreased. The dietary concentration of unsaturated fatty acids (% of DM) proved to be a much better predictor of milk response to added fat (correlation of -.74). However, the best predictor of milk response obtained by Jenkins (11) was when relating milk response to the amount of unsaturated fatty acids fed per unit of ration ADF (correlation of -.79) using a two-phase curve. The latter plot suggests there were no negative effects to supplemental fat until the amount of supplemental unsaturated fatty acids exceeded .06% of diet DM per percentage unit of ADF in diet DM. For example, if the diet contains 20% ADF, don't add more than 1.2% supplemental unsaturated fatty acids. This would correspond to about 2.5% tallow. Because WCS fat contains about 70% unsaturated fatty acids, 1.7% fat from WCS would be optimum in 20% ADF diets. This is equivalent to approximately 8.5% of diet DM from WCS (assuming WCS is 20% fat).

Smith and Harris (24) found that an appreciable part of the variation appeared to be associated with the type of forage cows consumed with supplemental fat. For example, in 9 experiments with WCS additions to corn silage-based diets, WCS decreased FCM production by an average of 4% whereas the addition of WCS to alfalfa hay based diets (6 experiments) increased average milk fat percent and FCM production by 11 and 7%. When WCS was included in diets with corn silage as the primary forage and alfalfa hay or bermudagrass hay was secondary forage, the fat-induced milk fat percentage depression found with corn silage-based diets appeared to be alleviated. They found the average FCM response to extruded soybeans was 2.4% with diets containing corn silage and alfalfa hay compared with 10% for diets when all forage was from alfalfa silage. Alfalfa diets supplemented with yellow grease increased average milk production by 6.6% with milk fat percentage unchanged.

A number of experiments at University of Florida (1, 5, 8, 14, 25, 27, 28) have been conducted to evaluate the amount and nature of the response to supplemental fat, whether as WCS, tallow, hydrolyzed animal and vegetable fats, or CaLCFA. In many of our experiments, small or negative responses have been observed. Results that deviated most from generally perceived beneficial effects of fat have been in experiments that showed no effect or negative responses when feeding WCS.

With respect to the effect of forage on the expected response to fat supplementation, we have conducted three experiments that were designed to test directly for interactive effects. Diets with WCS contained 12 to 15% of DM as WCS. Those experiments are summarized in Table 1. Milk and FCM or SCM yields are week 4 averages for the experiments of Smith et al. (25) and Adams (1) who utilized 4-week experimental periods and averages for weeks 4 plus 5 for Chik (5) who utilized 5-week experimental periods.

An interaction of WCS with diet forage type is evident for SCM in the experiments of Smith et al. (25) and Chik (5) in Table 1. This was expressed as a negative effect when corn silage was the only forage changing to a small negative effect on average with 12.5% of DM from alfalfa and no effect when 25% of diet DM was from alfalfa hay (25); the change became beneficial when all of the forage (40% of DM) was alfalfa haylage (5). In the experiment of Adams (1), WCS effects on SCM were negative in all of the forage combinations tested. Alfalfa, which was associated with more efficient utilization of WCS in the other experiments, apparently was not included in large enough quantity (11.25% of DM) to have a beneficial effect; neither was 12.5% enough to make WCS beneficial in the Smith et al. (25) experiment. Note that Adams (1) found CSH substitutions for part of the corn silage was beneficial. This suggests that the negative effects of WCS are associated with the raw oilseed component and not the hull component which often is beneficial to DMI and milk yields (1, 15).

These studies suggest that depression in milk yield, milk fat percentage, or both caused by WCS inclusion in corn silage-based diets can be overcome by replacing about 50% or more of dietary forage (25% or more of total diet DM) with alfalfa hay or haylage. It is still uncertain whether other types of legume or grass forages are as effective as alfalfa. However, dairymen expecting a response in milk yield from WCS in diets where more than 75% of forage is from corn silage probably will be disappointed and milk fat percentage likely will be depressed.

The ADF content of the diets fed in the three experiments reviewed in Table 1 were variable with most of the diets containing 20 and 30% ADF (DM basis); the higher ADF values tended to be associated with alfalfa-containing diets. The WCS supplementation levels of 12 to 15% of dietary DM in these experiments was slightly above optimum amounts derived from logic of Jenkins (11) which was discussed earlier in reference to data in Figure 2. Limiting supplemental fat from WCS to .06 units of unsaturated fatty acids per unit ADF would have have limited WCS to about 8% of DM from WCS in the corn silage diets fed in these experiments and about 12% of DM in diets with 25% or more of DM from alfalfa.

TABLE 1. Summary of experiments designed to measure interactive effects of whole cottonseed (WCS) and tallow with forage source.[1]

Treatment	Fat supplement	DMI	MY	SCM or FCM	MF	MP
Smith et al. (25)[2]		--------- (lb/day)		---------	------ (%) ------	
Corn silage (CS) 50% of DM	Control	56.0	49.1	48.0	3.41	3.19
" "	2.5% tallow	56.8	53.3	51.1	3.19	3.20
" "	Tallow + 12% WCS	55.8	47.1	44.1	3.06	3.21
" "	12% WCS	49.2	44.2	42.0	3.30	3.04
CS 37.5%, alfalfa hay 12.5%	Control	58.6	49.8	48.2	3.30	3.24
" "	2.5% tallow	54.7	51.7	51.1	3.44	3.14
" "	Tallow + 12% WCS	56.2	48.1	47.5	3.54	3.13
" "	12% WCS	56.4	49.1	49.1	3.49	3.17
CS 25%, alfalfa hay 25%	Control	58.0	50.1	47.8	3.25	3.08
" "	2.5% tallow	53.4	52.3	50.9	3.48	3.06
" "	Tallow + 12% WCS	58.4	50.5	52.2	3.98	3.13
" "	12% WCS	57.8	48.8	48.0	3.49	3.06
Adams (1)						
CS 45%	Control	47.4	58.8	57.6	3.67	3.08
" "	12.5% WCS	47.0	56.7	53.6	3.55	2.94
" "	2.5% tallow	46.7	58.4	56.7	3.33	3.09
CS 33.75%, alfalfa hay 11.25%	Control	49.2	57.8	59.3	3.66	3.13
" "	12.5% WCS	47.6	55.6	53.2	3.33	3.06
" "	2.5% tallow	48.7	60.7	59.0	3.46	3.08
CS 33.75%, bermudagrass hay 11.25%	Control	47.4	57.0	55.6	3.41	3.15
" "	12.5% WCS	45.4	52.4	49.8	3.60	3.17
" "	2.5% tallow	45.0	53.7	49.9	3.47	2.97
CS 33.75%, cottonseed hulls 11.25%	Control	50.0	60.0	59.9	3.53	3.10
" "	12.5% WCS	50.0	59.0	59.5	3.76	3.17
" "	2.5% tallow	48.3	59.8	58.3	3.62	3.11
Chik (5)						
CS 40%	Control	46.7	47.8	44.5	3.54	3.56
" "	15% WCS	47.4	48.8	42.7	3.22	3.44
Alfalfa haylage 40%	Control	56.0	48.5	43.5	3.37	3.47
" "	15% WCS	49.0	49.4	45.5	3.51	3.32
CSH 40%	Control	56.9	51.0	46.1	3.46	3.51
" "	15% WCS	55.6	52.5	47.1	3.38	3.36

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[1] DMI = dry matter intake, MY = milk yield, SCM = solids corrected milk, FCM = fat corrected milk, MF = milk fat, MP = milk protein, CS = corn silage, CSH = cottonseed hulls.

[2] Data from Smith et al. (25) are week 4 data from each period analyzed with a slightly different mathematical model. Thus, numbers are not exactly as presented in J. Dairy Sci. 76:205. 1993.

The effect of supplementing with 2.5% tallow (of total diet DM) was much more positive than with fat fed as WCS (Table 1). Smith et al. (25) obtained a significiant increase of 2.3 lb SCM/day with tallow. Also, a response to tallow does not appear to be dependent on the forage being fed, at least to the extent of WCS. In the Adams (1) experiment, cows fed tallow-supplemented diets produced significantly more milk than WCS-supplemented cows but not more than controls fed no supplemental fat.

Deciding How Much to Pay for WCS or Tallow

Whole cottonseed has been a key ingredient utilized by dairymen that have organized their feeding programs so as to permit purchase of one or more commodity ingredients and incorporate those ingredients into total mixed rations (TMR). Obviously, WCS is a good feedstuff or it would not be utilized widely as it is across the country. One of the primary points of this paper is that there are many dairymen who perceive the value of WCS to be greater than its true value in the diets fed to their cows. Since WCS is a bulky ingredient that usually is handled in floor-level commodity bins and loaded with front-end loaders into mixer wagons which deliver TMR to the cows, perhaps it can be evaluated most effectively in relation to other commodity options. Additions of dietary tallow, however, compose such a small portion of a TMR (e.g., 2.5% of DM) that it may be evaluated simply by comparing the cost of added tallow with expected increase in milk yields.

As discussed in the previous section, WCS effects may at times be neutral or negative as compared to the ingredients it replaced. In most experiments, those ingredients were corn and soybean meal. If the effect of WCS was neutral (no change in milk production) in a particular diet situation, then the assumption could be that the net energy value of WCS, when considering the total dietary effects, was essentially the same as corn. If the effects were negative, assigning an energy value somewhat lower than corn might be appropriate. Table 2 includes a list of several common feedstuffs which are available in the Southeast. The relative values included in the table are an attempt to put a combined value on the energy and protein in the feedstuff compared to standard ingredients, in this case corn and soybean meal. Three relative values are given for WCS. The first is based on protein and a net energy for lactation (NE_L) value from NRC (1989) that assumes the inherent energy value of WCS is utilized effectively for milk production. The second value for WCS in Table 2 considers its NE_L value to be equal to corn and the third discounts its energy value to .77 Mcal NE_L/lb DM. The third value may be a bit severe as far as energy utilization estimates are concerned. This is because many of the observed negative effects of WCS were because of negative effects on DM intake (DMI)

If the costs per ton (as fed) that were used in Table 2 are appropriate, the best commodity buys would be the ones that can be purchased for less than their value. This is reflected in a relative value/cost of greater than 100%. For example, WCS at energy value predicted by NRC (16) would be worth $178.7/ton based on costs to replace energy and protein with corn and soybean meal, the 113% relative value over cost ($140/ton as fed, $157/ton DM) would indicate it is a good feed buy. However, when energy is discounted to that of corn, value drops to $165/ton DM ($147 as fed) and on to $151 if further discounted. Thus, the point to be made with WCS is not to question whether or not it should be fed to dairy cows, but to establish realistic dietary values.

TABLE 2. Relative value of feedstuffs based on energy and crude protein.[1]

RELATIVE VALUE of feedstuffs in this example is the dollars that would need to be spent to replace the energy (NEL) and crude protein in one ton of the ingredient in question with NEL and CP from corn and soybean meal (49%). The value factors are derived from the following equations based on corn and soybean meal where a = value of a unit of NEL and b = value of a unit of CP. The equations:

\$115/ton corn = \$129.2/ton DM = .89*a + .100*b For this example: a = 114.3
\$220/ton SBM = \$255.6/ton DM = .91*a + .551*b b = 2.8

The constants a and b are multiplied by NEL and CP to calculate relative value, e.g.,

Relative value hominy = .91*114.3 + 11.5*2.8 = \$135.6/ton of dry mattter

Ingredient	DM	Cost/ton		Relative value/ton			NE_L (DM)	Crude protein		NDF	RVADJ[2]	RV[2]
	(%)	(as fed)	(DM)	(as fed)	DM	% cost	(Mcal/lb)	(% DM)	bypass	(% DM)	(fraction)	(%)
Ground corn	89	\$115.0	\$129.2	\$115.0	\$129.2	100.0%	0.89	10.0%	0.52	10%	0.20	2.0%
Hominy feed	90	115.0	127.8	122.1	135.6	106.1	0.91	11.5	0.52	23	0.40	9.2
Wheat	89	130.0	146.1	127.4	143.2	98.0	0.94	13.0	0.22	13	0.20	2.6
Barley	88	125.0	142.0	115.1	130.8	92.1	0.88	11.0	0.27	19	0.12	2.3
WCS, w lint	89	140.0	157.3	159.0	178.7	113.6	1.01	23.0	0.35	44	0.85	37.4
WCS, med. energy	89	140.0	157.3	146.8	165.0	104.9	0.89	23.0	0.35	44	0.85	37.4
WCS, low energy	89	140.0	157.3	134.6	151.3	96.2	0.77	23.0	0.35	44	0.85	37.4
Soybns, heat proc.	90	225.0	250.0	206.3	229.2	91.7	0.99	42.2	0.50	12	0.50	6.0
Tallow 1	99	400.0	404.0	298.7	301.7	74.7	2.64	0.0	0.00	0	0.50	0.0
Tallow 2	99	400.0	404.0	264.7	267.4	66.2	2.34	0.0	0.00	0	0.50	0.0
Tallow 3	99	400.0	404.0	226.3	228.6	56.6	2.00	0.0	0.00	0	0.50	0.0
Canola meal	92	195.0	212.0	193.4	210.2	99.2	0.78	44.0	0.28	26	0.20	5.2
Soybean meal 44%	89	200.0	224.7	211.7	237.8	105.8	0.88	49.9	0.35	14	0.20	2.8
Soybean meal 49%	90	230.0	255.6	230.0	255.6	100.0	0.91	55.1	0.35	10	0.20	2.0
Cottonseed meal	91	220.0	241.8	203.5	223.6	92.5	0.78	48.9	0.40	28	0.30	8.4
Peanut meal	92	200.0	217.4	216.5	235.3	108.2	0.80	52.3	0.25	17	0.30	5.1
Blood meal	92	500.0	543.5	292.2	317.6	58.4	0.68	87.2	0.87	12	0.10	1.2
Meat and bone meal	88	350.0	397.7	205.4	233.4	58.7	0.74	54.1	0.55	24	0.10	2.4
Feather meal	90	300.0	333.3	270.0	300.0	90.0	0.70	80.0	0.67			0.0
Dried brewers grns	92	175.0	190.2	135.8	147.6	77.6	0.68	25.4	0.49	47	0.35	16.5
Wet brewers grains	21	35.0	166.7	31.0	147.6	88.5	0.68	25.4	0.42	47	0.35	16.5
Dr. dist. gr.+ sol.	92	165.0	179.3	161.0	175.0	97.6	0.93	25.0	0.47	38	0.30	11.4
Corn gluten meal	88	310.0	352.3	257.2	292.3	83.0	0.94	67.2	0.55	10	0.20	2.0
Corn gluten feed	88	120.0	136.4	149.5	169.8	124.5	0.87	25.6	0.25	35	0.50	17.5
Wheat middlings	89	95.0	106.7	117.3	131.7	123.4	0.71	18.4	0.21	37	0.50	18.5
Citrus pulp	91	90.0	98.9	100.0	109.9	111.1	0.80	6.7	0.25	22	0.45	9.9
Soybean hulls	91	95.0	104.4	113.5	124.7	119.5	0.80	12.1	0.25	64	0.20	12.8
Bermuda hay	88	70.0	79.5	79.3	90.1	113.3	0.50	12.0	0.30	70	1.00	70.0
Bermuda hay #2	88	55.0	62.5	61.6	70.0	112.0	0.42	8.0	0.30	75	1.00	75.0
Alfalfa hay	88	160.0	181.8	113.8	129.3	71.1	0.65	20.0	0.28	40	0.95	38.0
Alfalfa hay #2	88	150.0	170.5	92.6	105.3	61.7	0.56	15.0	0.28	47	0.95	44.7
Perennial peanut	88	125.0	142.0	96.6	109.8	77.3	0.60	15.0	0.40	52	1.00	52.0
Corn silage	30	35.0	116.7	30.7	102.3	87.7	0.70	8.1	0.31	50	0.95	47.5
Sorghum silage	27	25.0	92.6	22.8	84.5	91.2	0.59	6.2	0.30	65	0.95	61.8
Cottonseed hulls	90	80.0	88.9	56.4	62.7	70.5	0.45	4.1	0.30	90	0.90	81.0
Peanut hulls	90	45.0	50.0	38.9	43.2	86.3	0.19	7.8	0.30	74	0.85	62.9

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[1] Note: Best buys may be considered to be those feedstuffs that have the highest relative value as compared to the cost per ton of dry matter (DM) expressed as a percentage (relative value/cost). However, other factors need to be considered such as an ingredient's effect on feed intake and whether or not composition of the actual ingredient is equal to assumed values listed above. If comparing to purchases from commercial feed companies where they absorb shrink losses, relative values need to be discounted by a percentage equivalent to expected shrink.

[2] RVADJ = roughage value adjustment factor which when multiplied times neutral detergent fiber (NDF) content yields estimate of roughage-value NDF (RV), or effective fiber, as described by Mertens (Mertens, D. R. 1992. Nonstructural and structural carbohydrates. Pages 219-235 in Large Dairy Herd Management, American Dairy Science Association, Champaign, IL. 1992).

A relative value estimate for tallow also is included in Table 1. Tallow was given an energy value of 2.64 Mcal NE_L/lb DM (16). With tallow at $400/ton (20 cents/lb), it is not a good relative feed buy, even at 2.64 Mcal/lb, unless there is no other way to obtain added energy intake in high producing dairy cows except through added tallow. If a pound of tallow were fed daily per cow in place of corn and that energy transfered to added milk production, the extra energy consumption of 1.75 Mcal (2.64 Mcal added from tallow less .89 Mcal replaced in corn) would be expected to increase milk yield about 5.6 lb per day (1.75 Mcal/.31 Mcal per lb milk). This amount of increase is about equal to the best case scenario described earlier. In reality, we estimate from the experiments reviewed that the return in milk production would be about 2.8 lb per day, or about half of the theoretical amount. Even the 2.8 lb milk per day from supplementing diets with 2.0 to 2.5% tallow is optimistic. With milk prices at 13 cents/lb, feeding tallow at 20 cents/lb would show a modest profit if 2.8 lb/day increase in milk yield were achieved. Milk value gained over tallow cost per cow of 16 cents/day probably would reduce to about 12 cents after accounting for the costs of handling and mixing. At higher milk prices and high production per cow, the odds of greater profitability should improve, partly through some likely benefit in reproductive performance.

Conclusions

In general, WCS does not appear to contribute more to productivity of dairy cattle than corn meal mixed with enough soybean meal or other suitable protein supplement to contribute equal protein. Thus, its value usually is less than calculated relative values based on on expected energy content, e.g., NRC (16) value. Tallow, on the other hand, is much more likely to be a profitable addition to diets for lactating cows even when only half of its added energy (compared to corn) is retrieved in increased milk yield. Expressing recommendations for fats which are active in the rumen, such as WCS and tallow, on the basis of amount of supplemented unsaturated fatty acids may be an improvement over recommendations based on amount of supplemental fat.

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