THE INFLUENCE OF FORAGE TYPE ON THE PRODUCTION RESPONSE OF LACTATING DAIRY COWS SUPPLEMENTED WITH DIFFERENT TYPES OF DIETARY FAT

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ABSTRACT

Research has demonstrated a difference in fat utilization with different forage types by lactating dairy cows. Responses appear to be greatest on alfalfa diets and poorest on all corn silage diets. When extruded soybeans was added to dairy diets containing corn silage and alfalfa hay fat corrected milk (FCM) production was increased by only 2.4%. The supplementation of diets with alfalfa silage or haylage as the sole forage increased FCM-production by 10%. In 11 experiments, corn silage diets containing whole cottonseed (WCS) decreased FCM-production by an average of 4%. Supplementing alfalfa hay diets with WCS increased milk fat percent and FCM-production by 11 and 6% respectively. When WCS was included in diets with corn silage as the primary forage and alfalfa hay or bermuda grass hay as the secondary forage the fat induced milk fat depression found on corn silage based diets seemed to be alleviated. Yellow grease supplementation of alfalfa diets increased milk production by 6.6% with milk fat percent unchanged. Results supported the inclusion of tallow at 500g/cow/day in diets based on ryegrass silage while the inclusion of tallow or blended animal-vegetable fats on corn silage or cottonseed hull based diets was not supported by summarized experiments. Supplementing corn silage/alfalfa silage based diets with prilled fat increased FCM-production by 6.2% while the inclusion of prilled fat in alfalfa silage or corn silage based diets had inconsistent effects on production responses. The supplementation of different forage based diets with Ca-salts of fatty acids resulted in a constant FCM-production increase of approximately 5%.

INTRODUCTION

The feeding of fat to dairy cows has received much interest and has been reviewed by many authors (Palmquist and Jenkins, 1980; Storry, 1981; Moore and Christie, 1984; Palmquist, 1984; Shaver, 1990; Palmquist and Eastridge, 1991; Smith, 1991). The inclusion of fats in diets for high producing dairy cows has also become a routine practice for many dairy farmers in the U.S. Because of the variation in responses obtained with the inclusion of fat in feeding programs, there is still uncertainty about the correct use of fats in diets for high producing dairy cows. For some years researchers in Florida have obtained poor results with whole cottonseed in corn silage based diets (B. Harris Jr., 1991 - Personal communication). Staples et al. (1991) summarized five experiments in which corn silage made up the primary dietary forage and concluded that although the addition of whole cottonseed (WCS) increased milk yield, milk fat percent was decreased. The

interaction between the type of forage and fat included in diets appear to influence the performance of dairy cattle. The effects of various fat sources in combination with various forage sources on milk production and composition will be evaluated in this review. Some conclusions will also be made to assist dairy farmers and nutritionists in a better understanding and application of the results to their individual situations.

PRODUCTION RESPONSES OBTAINED WHEN USING DIFFERENT DIETARY FATS

SOYBEANS - Raw or heat treated soybeans are excellent sources of protein and energy for high producing dairy cows. Raw soybeans have a high energy (91% TDN or 2.11 Mcal NE_L/kg DM), high protein (42.8%/DM), low ADF (10.0%/DM) and a high fat content (18.8%/DM) (NRC, 1989). Soybeans are heated to destroy the trypsin inhibitor, inactivate urease activity, destroy enzymes (mainly lipase) and to increase the amount of bypass protein and improve palatability (Barmore, 1988).

In three experiments summarized in Table 1, supplementation of corn silage based diets with raw soybeans increased daily milk yield from 27.7kg to 28.6 kg per cow (3.3%). Milk fat percent was decreased from 4.02 to 3.76 (6.5%) while 4% FCM-production was

Table 1 Effect of Including Raw or Heat Treated Soybeans in Corn Silage Diets on Dry Matter Intake (DMI) and Milk Yield and Composition.

Corn Silage in Diet %DM	Soy-beans in Diet %DM	Treat-ment	DMI kg/d	Milk Yield kg/d	Milk Fat %	4% FCM kg/d	Milk Prot %	Refs
Based	0.0		22.3	26.9	4.50	28.5	3.93	1
Based	10.5	Raw	21.5	29.2	3.89	28.0	3.59	
46.0	0.0		20.6	30.7	3.61	28.9	3.23	2
45.9	9.4	Raw	20.5	31.9	3.74	30.5	3.21	
45.0	0.0		22.7	25.4	3.94	25.0	3.31	3
45.0	14.0	Raw	20.9	23.8	3.64	22.8	3.40	
46.0	0.0		20.6	30.7	3.61	28.9	3.23	2
45.9	9.4	Roast	21.2	32.2	3.53	29.9	3.20	
56.0	0.0		22.5	37.5	3.14	32.7	3.14[a]	4
56.0	16.5	Extr	21.3	38.5	3.19	33.9	2.93[b]	

[ab]Means with different superscripts differ($P<0.05$).

Refs: 1-Baker et al. (1989); 2-Bernard (1990); 3-Van Horn et al. (1984); 4-Voss et al. (1988).

unchanged. According to these findings, the inclusion of raw soybeans in corn silage diets had a slight positive effect on milk production but a negative effect on milk fat percent.

Two experiments in which heat treated soybeans was added to diets for lactating dairy cows with corn silage as the only forage source are also summarized in Table 1. Voss et al. (1988) reported that the inclusion of 16.5% extruded soybeans in corn silage diets had little or no effect on milk production. They suggested a possible advantage for using heat treated soybeans in alfalfa haylage diets because of the greater solubility of its protein. A similar suggestion was offered by Bernard (1990) because of a lack of response to the inclusion of roasted soybeans in dairy diets with corn silage as the sole forage.

Table 2 shows the summary of six experiments using extruded soybeans in diets containing corn silage as the primary forage and alfalfa hay as the secondary forage for lactating dairy cows. Average daily milk yield was increased from 28.6 to 30.8 kg (7.7%) when extruded soybeans was added at an average of 17% of diet dry

Table 2 Effect of Including Extruded Soybeans in Corn Silage and Alfalfa Hay Diets on Dry Matter Intake (DMI) and Milk Yield and Composition.

Corn Silage in Diet %DM	Alfalfa Hay in Diet %DM	Soy-beans in Diet %DM	DMI kg/d	Milk Yield kg/d	Milk Fat %	4% FCM kg/d	Milk Prot %	Refs
40.0	10.0	0.0	21.1[a]	31.7	3.24	28.1	3.03	1
40.0	10.0	17.5	19.7[b]	33.8	3.05	28.6	2.94	
40.0	10.0	0.0	21.0	31.8	3.29	29.3	3.03	1
40.0	10.0	17.5	20.6	35.3	2.91	29.4	2.96	
25.0	25.0	0.0	17.8	29.2[a]	3.20[a]	25.7	2.99	2
25.0	25.0	17.0	18.4	32.4[b]	2.69[b]	26.0	2.93	
43.0	11.0	0.0	21.2	28.6	3.57	26.5	3.00	3
43.0	11.0	11.2	21.5	29.1	3.61	27.2	2.92	
30.0	15.0	0.0	19.3	32.2[a]	2.98[a]	27.2	2.99	4
30.0	15.0	19.3	20.5	36.2[b]	2.63[b]	28.5	2.85	
36.0	13.0	0.0	15.5	17.9	3.17	15.7	3.32	5
36.0	13.0	19.4	15.6	18.0	3.26	16.0	3.22	

[ab]Means with different superscripts differ($P<0.05$).

Refs: 1-Casper et al. (1990); 2-Kim et al. (1990); 3-Mielke and Schingoethe (1981); 4-Schingoethe et al. (1988); 5-Stern et al. (1985).

matter. Average milk fat percent was decreased from 3.24 to 3.03 (6.5%) while the average FCM-production was increased from 25.4 to 26.0 kg/cow/day (2.4%). Although milk production was slightly increased, the decrease in milk fat percent removed the expected increase in FCM. Milk protein percent decreased from 3.06 to 2.97 (2.9%) while cows on soybean supplemented diets consumed the same amount of feed, (19.4 vs 19.3 kg DM) as cows on control diets. The results appear to be more related to economics rather than production responses obtained from including extruded soybeans.

Two experiments in which roasted soybeans was added to diets for lactating dairy cows with corn silage as the primary forage and alfalfa silage as the secondary forage are summarized in Table 3.

Table 3 Effect of Including Roasted Soybeans in Corn Silage/ Alfalfa Silage Diets on Dry Matter Intake (DMI) and Milk Yield and Composition.

Corn Silage in Diet %DM	Alfalfa Silage in Diet %DM	Soy-beans in Diet %DM	DMI kg/d	Milk Yield kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
40.0	15.0	0.0	23.1[a]	26.2	3.53	24.4	3.45[a]	1
40.0	15.0	20.0	20.9[b]	26.9	3.59	25.2	3.21[b]	
27.5	27.5	0.0	20.3	37.2	3.52	34.5	2.89	2
27.5	27.5	15.0	20.2	38.7	3.73	37.0	2.78	

[ab]Means with different superscripts differ (P<0.05).
Refs: 1-Mohamed et al. (1988); 2-Voss et al. (1988).

Although an increase in FCM was obtained in the studies (1.7 kg/cow/day) Voss et al. (1988) concluded that the feeding of roasted soybeans had little or no effect on milk production with corn silage or mixed silage diets respectively. The authors suggested that matching protein supplement and forage type according to ruminal protein degradation and amino acid content may provide an efficient way to utilize proteins. Resistant proteins may provide a more consistent increase in milk production with alfalfa silage than in feeding programs with 50% or more of the forage coming from corn silage.

Table 4 contains a summary of four experiments in which roasted soybeans was added to diets for lactating dairy cows containing alfalfa silage or haylage. Daily milk yield was increased from 35.1 to 38.2 kg (8.8%) with roasted soybeans at an average of 15.5% of diet dry matter. Voss et al (1988) found that the increase in milk production with roasted soybeans above soybean meal in alfalfa silage based diets became greater as the lactation progressed.

Table 4 Effect of Supplementing Alfalfa Silage/Haylage Diets with Roasted Soybeans on Dry Matter Intake (DMI) and Milk Production and Composition.

Alfalfa Silage or Haylage in Diet %DM	Soy-beans in Diet %DM	DMI kg/d	Milk Yield kg/d	Milk Fat %	FCM Yield kg/d	Milk Prot %	Refs
50.0	0.0	21.9	34.5[a]	3.41	33.4[a]	2.99	1
50.0	13.0	22.8	38.9[b]	3.41	38.0[b]	2.85	
35.0	0.0	24.6	34.9	3.23[a]	33.3[a]	3.11	2
35.0	12.0	24.9	37.5	3.20[a]	35.5[b]	3.03	
35.0	18.0	25.0	38.8	3.32[b]	37.5[c]	3.00	
35.0	24.0	24.9	38.8	3.37[b]	37.8[c]	3.01	
50.0	0.0	24.7[a]	36.0	3.45	33.0	3.00	3
50.0	13.0	22.5[b]	37.5	3.35	33.8	2.95	
55.0	0.0	19.6	35.2	3.47	32.3	2.82	4
55.0	13.0	20.7	37.4	3.82	36.4	2.72	

[abc]Means with different superscripts differ (P<0.05).

Refs: 1-Faldet and Satter (1989); 2-Knapp and Grummer (1990); 3-Socha and Satter (1991); 4-Voss et al. (1988).

Cows receiving soybean meal diets peaked in production 40 days into lactation while cows on roasted soybean diets continued to increase at day 70 of lactation (Figure 1). The authors concluded that the

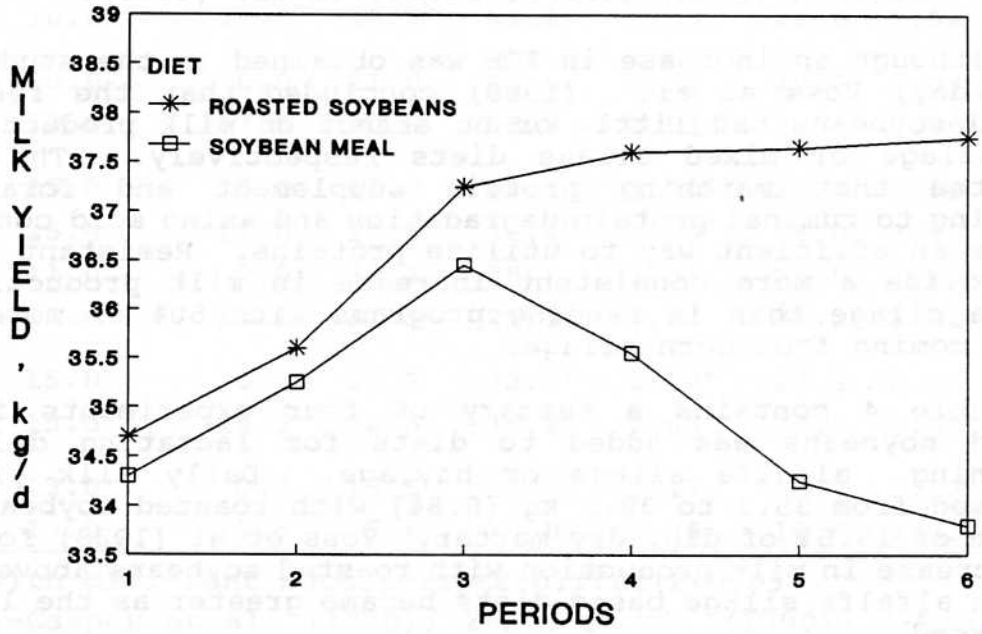

Figure 1 Adjusted means for milk production during six 10-d subperiods of the 60-d treatment period for alfalfa silage diets supplemented with soybean meal (□) or roasted soybeans (*) (Voss et al., 1988).

increase in milk production with the roasted soybean diet could be attributed to the additional energy as well as the protected protein. Average milk fat percent (Table 4) increased from 3.34 to 3.42 (2.4%) for cows on diets supplemented with roasted soybeans while the average FCM-production was increased from 33.1 to 36.5 kg/cow/day (10.3%). Milk protein percent was decreased from 3.02 to 2.93 (2.9%). Dry matter intake was similar for cows receiving both diets (23.5 vs 23.3 kg DM/d).Although the limited data in Table 4 does not allow accurate conclusions it seems as if the inclusion of 13 to 24% roasted soybeans in alfalfa silage or haylage based diets could result in significant FCM-production increases without decreasing milk protein percent.

WHOLE COTTONSEED - Whole cottonseed (WCS) is an excellent and unique ingredient and frequently used in diets for high producing dairy cows. (De Peters et al., 1985; Coppock et al., 1987). It contains a high level of energy (96% TDN or 2.23 Mcal NE_L/kg DM), protein (25%/DM), ADF (26%/DM) and fat (23.8%/DM) (NRC, 1989).

The results of feeding whole cottonseed (WCS) to lactating dairy cows appears to be influenced by the type of forage in the diet. Staples et al. (1991) reviewed five experiments where corn silage was the primary dietary forage and reported that the inclusion of WCS increased milk yield but decreased milk fat percent. Lubis et al. (1990) also reported that the addition of fat in the form of hydrolyzed mixtures of vegetable and animal fats, animal fats or WCS usually reduced milk fat percentage in experiments conducted at the Florida station. In Table 5 nine experiments are summarized in which WCS was supplemented in diets with corn silage as the only forage source. Average daily milk yield was unchanged at 25.3 kg/cow for both control diets and for cottonseed supplemented diets when WCS was included at an average of 16.2% of diet dry matter. The average milk fat percent was decreased from 3.58 to 3.37 (5.9%) while milk protein percent was unchanged. Cows on WCS-diets produced 0.9 kg less 4%-FCM per day than cows on control diets (22.7 vs 23.6) and also consumed 0.9 kg less dry matter (20.2 vs 21.1). The results of the nine trials summarized in Table 5 does not support the inclusion of WCS in diets for lactating dairy cows when corn silage is the only dietary forage, except when economics dictate.

Although the mechanism by which WCS and other rumen active fats affect rumen fermentation and milk fat concentration is not clearly established, several theories have been suggested. Devendra and Lewis (1974) summarized several studies and proposed several possible modes of action on rumen fermentation. The effect is probably due to the coating of the fibrous portion of the diet with lipids, thus preventing microbial enzyme activity. Lipid supplementation also modifies the rumen population concerned with cellulose digestion. Fatty acids inhibit the growth of certain micro-organisms due to an effect on cell permeability brought about by adsorption of fatty acids to the cell wall. There is also a reduced retention of calcium and magnesium due to complex formation with fatty acids.

Table 5 Effect of Supplementing Corn Silage Based Diets with Whole Cottonseed (WCS) on Dry Matter Intake (DMI) Milk Yield and Composition.

Corn Silage in Diet %DM	WCS in Diet %DM	DMI %DM	Milk Yield kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
Based	0.0	22.3	26.9	4.50	28.5	3.93	1
Based	10.5	20.2	28.0	3.92	26.9	3.49	
45.0	0.0	-	24.4	4.41	25.0	3.39	2
45.0	12.0	-	24.5	4.33	25.0	3.37	
20.0	0.0	-	24.5	2.87	20.2	-	3
20.0	[1]20.0	-	23.1	2.76	18.8	-	
20.0	[2]20.0	-	22.9	3.30	20.2	-	
40.0	0.0	-	24.6	3.43	22.5	-	3
40.0	[1]15.0	-	24.9	3.60	23.1	-	
40.0	[2]15.0	-	24.3	3.52	22.7	-	
40.0	0.0	21.1	21.7	3.55	20.2	-	4
40.0	15.0	21.5	22.0	3.20	19.4	-	
45.0	0.0	-	22.8	3.49	21.1	3.35	5
35.0	15.0	-	21.3	3.35	19.2	3.48	
25.0	30.0	-	21.5	3.12	18.7	3.37	
50.0	0.0	26.2	35.2	3.47	32.4	-	6
44.2	18.5	18.0	31.1	3.20	27.4	-	
47.0	0.0	18.9	27.5	3.72	26.4	3.30	7
47.0	18.5	17.9	27.5	3.71	26.3	3.27	
45.0	0.0	18.8	24.0	3.30	21.5	2.84	8
37.5	15.0	20.7	26.3	3.22	23.2	2.89	
[3]45.0	0.0	22.7	25.4	3.93	25.0	3.31	8
[3]45.0	14.0	22.7	26.7	2.83	21.4	3.52	
[4]45.0	14.0	23.0	27.7	3.31	25.0	3.30	
52.0	0.0	16.1	24.7	3.37	22.4	3.09	9
52.0	10.4	17.7	27.7	3.12	23.6	3.01	

[1]Linted cottonseed. [2]Delinted cottonseed. [3]Diets contained 14.0% estimated crude protein. [4]Diets contained 18.0% estimated crude protein.

Refs: 1-Baker et al. (1989); 2-Baker et al. (1985); 3-Chalupa et al. (1985); 4-Chik (1987); 5-Coppock et al. (1985); 6- Cummins and Sartin (1987); 7-Hawkins et al. (1985); 8-Van Horn et al. (1984); 9-Umphrey (1989).

It has also been suggested that when long chain acyl CoA inhibits acetyl CoA carboxylase activity, the reduced NADPH utilization decreases oxidation of glucose through the pentose phosphate pathway, effectively decreasing glucose uptake and thus milk fat production (Palmquist and Jenkins, 1980).

Selner and Schultz (1980) found that the accumulation of trans acids in the rumen during the hydrogenation of unsaturated long chain fatty acids (USLCFA) caused significant milk fat depression. Mohamed et al. (1988) found that the addition of free soybean or cottonseed oil to the diet increased the C_{18} concentration of ruminal contents ($P<0.01$) and showed a stronger relationship (negative) to milk fat percentage than did ruminal acetate:propionate ratios.

It is not clear why corn silage diets seem to be more subject to fat induced milk fat depression. Corn silage could possibly be more subject to the modes of action summarized by Devendra and Lewis (1974) because of the relative short particle size and soft physical structure. Although digestion studies was reported by Coppock (1985), Chik (1987) and Umphrey (1989) no evidence was found to suggest lower fiber digestibility on the WCS supplemented diets.

Although results reported by Baker et al. (1989) indicated that Ca-salt supplementation of corn silage based diets,including WCS, could have advantages, a study by Lubis et al. (1990) showed no production advantages. The results in Table 5 did not support the inclusion of WCS in dairy diets based on corn silage while the results in these two studies indicate inconsistent results when WCS and Ca-salts are included in diets for lactating dairy cows.

When WCS is included in dairy diets in which the primary dietary forage is alfalfa hay an increase in milk fat percentage and fat corrected milk production is usually observed. When WCS was included at an average of 18% of diet dry matter with alfalfa hay as the primary dietary forage (Table 6) daily milk production was unchanged. Fat percent and FCM-production however were increased from 3.46 to 3.85 (11.3%) and from 24.4 to 25.9 (6.2%). Milk protein percent was decreased from 3.16 to 3.07 (2.9%) and DMI was unchanged at 19.2 kg per cow per day in the six experiments it was reported. Results from the seven experiments summarized in Table 6 support the inclusion of WCS in dairy diets with alfalfa hay as the primary dietary forage, especially to increase milk fat percent.

Downer et al. (1987) found that supplementing alfalfa hay diets containing whole cottonseed with 2.5% Ca-salts of fatty acids increased 3.5% FCM-production from 32.8 to 34.2 kg/cow/day ($P<0.01$). The increased FCM-production response in this experiment appeared favorable for the addition of Ca-salts to dairy diets based on alfalfa hay and WCS.

Table 6 Effect of Including Whole Cottonseed (WCS) in Alfalfa Hay Diets on Dry Matter Intake (DMI) and Milk Yield and Composition.

Alfalfa Hay in Diet %DM	WCS in Diet DM	DMI kg/d	Milk Yield kg/d	Milk Fat %	FCM Yield kg/d	Milk Prot %	Refs
Based	0.0	-	27.6	2.28[a]	20.5	2.82	1
Based	15.0	-	28.1	2.86[b]	23.3	2.74	
50.0	0.0	19.0	24.4	3.14[a]	21.2[a]	3.22	2
50.0	10.0	19.3	25.0	3.49[b]	23.1[b]	3.14	
50.0	15.0	19.1	25.5	3.49[b]	23.6[b]	3.14	
50.0	20.0	19.0	25.4	3.61[b]	23.9[b]	3.16	
28.0	0.0	21.7	29.7	3.46	30.1	3.20	3
28.0	13.8	21.2	28.5	3.65	29.2	3.12	
30.0	0.0	17.6	21.9[a]	3.20[d]	19.2[d]	2.95	4
30.0	25.0	18.3	23.0[b]	3.86[e]	22.5[e]	2.95	
Based	0.0	18.8	32.1	3.70[a]	30.7	3.14[a]	5
Based	15.0	18.5	30.4	4.00[b]	30.4	2.99[b]	
Based	30.0	19.1	31.7	4.18[b]	32.6	3.01[b]	
Based	0.0	18.8	32.1	3.70	30.7	3.14	6
Based	15.0	18.5	30.4	4.00	30.4	2.99	
Based	30.0	19.1	31.7	4.18	32.6	3.01	
65.0	0.0	19.7	20.8	3.95[a]	20.2[a]	3.31	7
61.7	5.0	19.0	19.4	3.90[a]	19.2[a]	3.24	
55.2	15.0	19.1	21.6	4.29[b]	22.6[b]	3.20	
48.7	25.0	20.4	21.2	4.52[b]	22.9[b]	3.22	

[ab]Means with different superscripts differ (P<0.05).
[de]Means with different superscripts differ (P<0.01).
Refs: 1-Brown et al. (1982); 2-De Peters et al. (1982); 3-Heinet al. (1990); 4-Smith (1988); 5-Smith and Collar (1980); 6-Smith et al. (1980);7-Smith et al. (1981).

Table 7 contains three experiments in which WCS was included in diets containing corn silage as the primary forage and alfalfa hay or bermuda grass hay as the secondary forage. Average daily milk production was unchanged while milk fat percent was increased from 3.41 to 3.72 (9.1%) and FCM-production was increased from 23.3 kg/cow/day to 24.5 kg/cow/day (5.2%).Although the limited data in Table 7 does not allow accurate conclusions, it appears that the inclusion of 10-20% hay in corn silage based diets alleviates the

Table 7 Effect of Supplementing Corn Silage and Bermuda Grass or Alfalfa Hay Diets with Whole Cottonseed (WCS) on Dry Matter Intake (DMI) and Milk Production and Composition.

Corn Silage in Diet %DM	Hay in Diet %DM	WCS in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
	Bermuda Grass							
30.0	10.0	0.0	23.2	31.2	2.97[a]	26.4[a]	3.13	1
30.0	10.0	15.0	23.4	31.6	3.38[b]	28.7[b]	3.02	
	Alfalfa							
33.3	16.7	0.0	17.4	21.8	3.66	20.8	3.47	2
33.3	16.7	9.4	18.0	22.6	3.97	22.2	3.40	
33.3	16.7	20.2	16.8	21.5	4.02	21.6	3.42	
33.3	16.7	32.2	15.9	20.9	4.32	21.9	3.34	
	Alfalfa							
30.0	10.0	0.0	21.0	30.1	3.11	27.8	3.30	3
30.0	10.0	15.0	22.5	31.4	2.93	28.0	3.13	

[ab]Means with different superscripts differ ($P<0.05$).

Refs: 1-Horner et al. (1986); 2-Palmquist (1987); 3-Wilks et al. (1991).

fat induced milk fat depression caused by the inclusion of WCS. These results are in the order of the results found when WCS was included in dairy diets with alfalfa hay as the primary dietary forage (Table 6).

GREASE AND TALLOW - Grease and tallow, animal fats with a titer of lower and higher than 40, have been included beneficially in dairy diets. Both contain 177% TDN/DM or 5.84 Mcal NE_L/kg DM (NRC,1989).

When Grease or tallow is fed to dairy cows with alfalfa hay as the only dietary forage, an increase in milk yield is usually observed. In the four experiments reported (Table 8) the average milk yield per cow was improved from 27.1 to 28.9 kg per day (6.6%) when fat was fed at an average of 3.1% of diet DM. The two lower levels of fat supplementation (Martinez et al., 1991) increased milk yield from 30.8 to 31.5 kg (2.3%) per cow per day while the higher levels of fat supplementation (Wren et al, 1978; De Peters et al, 1989) increased milk yield from 23.5 to 26.3 kg (11.9%) per cow per day. The 2% level of fat supplementation increased milk fat percent (4.1%) while the 3.5% level had no influence and the 4.9% level of fat supplementation decreased milk fat percent from 3.5 to 3.0% (14.3%). The higher levels of fat supplementation

Table 8 Effect of Supplementing Alfalfa Hay or Alfalfa Haylage Diets with Commercial Fats (Tallow or Grease) on Dry Matter Intake (DMI) and Milk Production and Composition.

Alfalfa Hay or Haylage in Diet %DM	Added Fat in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
Hay							
50.0	0.0	18.9[a]	23.4[a]	3.29	20.9[a]	3.21	1
50.0	3.5	20.4[b]	26.8[b]	3.25	23.7[b]	3.03	
[1]40.0	0.0	23.8	30.8	3.29	27.5	2.99	2
[1]40.0	2.0	23.6	31.7	3.43	29.0	2.94	
[2]40.0	0.0	23.3	30.8	3.28	27.5	2.97	2
[2]40.0	2.0	23.2	31.2	3.41	28.4	2.94	
55.0	0.0	17.3	23.5[a]	3.50[a]	16.0	3.20	3
51.0	4.9	19.5	25.8[b]	3.00[b]	16.6	3.10	
Haylage							
[3]50.0	0.0	20.2	34.3	3.16[a]	32.3[a]	2.82	4
[3]50.0	5.0	19.9	35.4	3.42[b]	35.0[b]	2.84	
[4]50.0	0.0	14.2	27.8	3.15[a]	26.1[a]	2.62	4
[4]50.0	5.0	14.9	28.1	3.51[b]	27.9[b]	2.56	

[1]Diets without supplementary niacin. [2]Diets with supplementary niacin. [3]Cool environment. [4]Heat stress environment.

[ab]Means with different superscripts differ (P<0.05).

Refs: 1-De Peters et al. (1989); 2-Martinez et al. (1991); 3-Wrenn et al. (1978); 4-Knapp and Grummer (1991).

decreased milk protein percent from 3.20 to 3.07%. According to the four studies (Table 8) grease or tallow could be supplemented successfully to dairy diets based on alfalfa hay. The maximum response occurred with diets containing 3.0 to 3.5% tallow (/DM). De Peters et al (1989) reported an increased 4% FCM-production of 13.4% when 3.5% fat was included in a ration containing 50% alfalfa hay. Although daily DM intake was not changed by 2% fat supplementation it was increased from 18.1 to 19.9 kg per cow on the two higher levels of fat supplementation (Table 8). Knapp and Grummer (1991) used a fat source containing 40% tallow and 60% prilled long chain fatty acids to supplement alfalfa haylage diets for dairy cows in a cool or heat stress environment (Table 8). Average daily milk production in both environments was increased 31.1 to 31.8 kg while milk fat percent was increased from 3.16 to 3.47 (9.8%). Average daily FCM-production per cow was increased

from 29.2 to 31.5kg (7.9%). Milk protein percent was not changed while DMI increased slightly for the fat supplemented diet in the heat stress environment. The results of these two experiments support the inclusion of 5% supplemental fat containing 40% tallow and 60% prilled long chain fatty acids in alfalfa haylage based diets.

Table 9 Effect of Supplementing Rye-grass Silage Diets with Tallow on Dry Matter Intake (DMI) and Milk Production and Composition.

Grass Silage in Diet %DM	Added Fat in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
51.6	0.0	15.2[a]	20.7	3.91	20.4	3.13[a]	1
54.2	2.4	15.0[a]	22.3	4.15	22.8	2.90[b]	
55.2	3.8	14.9[a]	22.0	4.17	22.6	2.91[b]	
56.1	5.1	14.6[a]	21.7	4.27	22.6	3.02[b]	
56.1	6.7	14.1[b]	22.7	4.27	23.6	2.90[b]	
55.5	0.0	10.8[a]	13.9	3.81[a]	13.5	3.15[a]	1
55.5	4.1	10.0[a]	14.7	4.34[b]	15.5	3.02[b]	
53.7	10.0	8.4[b]	13.7	4.30[b]	14.3	2.98[b]	

[ab]Means with different superscripts differ (P<0.05).

Ref: 1-Clapperton and Steele (1983).

Clapperton and Steele (1983) found positive results supplementing ryegrass silage diets with tallow (Table 9). Milk yield was increased from 20.7 to 22.3 kg/cow/day (7.7%) by supplementing 2.4% tallow per diet DM in the first experiment and from 13.9 to 14.7 kg/cow/day (5.5%) by supplementing 4.1% tallow in the second experiment. Milk fat percent increased from 3.9 to 4.15% by supplementing 2.4% tallow while milk protein percent was decreased from 3.13 to 2.90. DMI was not influenced by fat supplementation at 2% of diet DM but was decreased at higher levels of fat inclusion. Clapperton and Steele (1983) concluded that there seems little point in adding more than 500 g/cow/day of tallow to the diet of lactating dairy cows, which is approximately 3.0 to 3.5% of diet DM. When rumen active fats are included in diets for lactating dairy cows with corn silage as the only or one of the dietary forages the results seem to be inconsistent and mostly dissappointing. With corn silage as the only dietary forage Jenkins and Jenny (1989) found no positive effects when 5% yellow grease was included per diet DM. FCM-production was decreased from 29.6 to 25.9kg/cow/day (Table 10) when grease was supplemented. In the five other experiments reported in Table 10 (Palmquist and Conrad,1978; Palmquist and Conrad, 1980; Heinrichs et al., 1981; Lough et al., 1988) fat supplementation increased daily milk production per cow from 27.7 to 28.8 kg (1.8%) while milk fat percent was decreased from 3.52 to 3.36 (4.6%). The lower levels

Table 10 Effect of Supplementing Corn Silage Diets and Corn Silage with other Forages Based Diets with Commercial Fats on Dry Matter Intake (DMI) and Milk Production and Composition.

Corn Silage in Diet %DM	Other Forages in Diet %DM	Added Fat in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
50.0	-	0.0	22.9	32.0	3.50	29.6	3.20	1
50.0	-	[1]5.0	20.5	31.5	2.83	25.9	3.07	
	Alfalfa Hay							
Based	Based	0.0	19.8	24.9	3.72	25.6	-	2
Based	Based	[2]3.0	19.9	26.3	3.53	26.4	-	
	Alfalfa Hay							
Based	Based	0.0	16.1	15.8	3.99	17.1	-	2
Based	Based	[2]3.0	16.1	16.8	3.85	17.6	-	
	Grass Silage							
25.0	25.0	0.0	22.3	26.3	4.23	26.8	3.55	3
25.0	25.0	[2]5.0	21.6	28.0	3.70	26.4	3.31	
	Alfalfa Hay							
16.0	42.0	0.0	20.2	30.6	3.51	28.3	3.06	4
16.0	42.0	[2]2.5	21.2	33.0	3.42	30.3	3.04	
16.0	42.0	[2]8.4	20.2	30.2	3.04	27.2	3.12	
	Alfalfa Hay							
25.0	25.0	0.0	19.2	32.7[a]	2.85	27.0	3.24	5
25.0	25.0	[2]5.0	18.6	33.7[a]	3.00	28.7	3.21	
25.0	25.0	[3]5.0	18.2	29.7[b]	2.98	25.5	3.22	

[1]Yellow Grease. [2]Blended Animal and Vegetable Fat. [3]Tallow.

[ab]Means with different superscripts differ (P<0.01).

Refs: 1-Jenkins and Jenny (1989); 2-Heinrichs et al. (1981); 3-Lough et al. (1988); 4-Palmquist and Conrad (1978); 5- Palmquist and Conrad (1980).

of fat supplementation (2.5 and 3.0%) (Palmquist and Conrad, 1978; Heinrichs et al., 1981) increased daily milk production per cow from 23.8 to 25.4 kg (6.7%) while milk fat percent was decreased from 3.74 to 3.60 (3.7%). The experiment by Palmquist and Conrad (1978) in which corn silage comprised only 16% of diet DM showed the best results in favour of fat supplementation. These results as well as the relative small effects that was found when fat was supplemented to diets in which corn silage comprised approximately 50% of the dietary forage (Palmquist and Conrad, 1980; Heinrichs et al., 1981; Lough et al., 1988), and the negative effects that was found by Jenkins and Jenny (1989) when corn silage was the only dietary forage questions the supplementation of corn silage based diets with rumen active fats. Diets containing 20 to 30% corn silage should probably not be supplemented with more than 2.5% rumen active fat.

Van Horn et al. (1984) supplemented dairy diets, based on cottonseed hulls, with 2.5% tallow (Table 11). Milk production was not changed by fat supplementation while milk fat percent decreased from 3.59 to 3.02 (15.9%). Based on these limited results it is probably not justified to supplement dairy diets based on cottonseed hulls with rumen active fats.

Table 11 Effect of Supplementing Cottonseed Hull Based Diets with Tallow on Dry Matter Intake (DMI) and Milk Yield and Composition.

Cotton Seed Hulls in Diet %DM	Fat in Diet %DM	DMI kg/d	Milk Yield kg/d	Milk Fat %	FCM kg/d	Refs
30.0[1]	0.0	20.9	22.2	3.62	20.9	1
30.0[1]	2.5	20.5	21.1	3.20	18.6	
30.0[2]	0.0	20.9	22.8	3.55	21.3	1
30.0[2]	2.5	21.2	24.2	2.83	20.0	

[1]Diets without supplemental sodium bicarbonate.
[2]Diets with 0.75% supplemental sodium bicarbonate.
Ref: 1-Van Horn et al. (1984).

SATURATED FATS - Saturated fatty acids have a high melting point with low microbial inhibition in the rumen. However, the same physical characteristics which contribute rumen inertness to this type of fat may also lower absorption from the small intestine (Palmquist, 1988). Although higher energy values have been quoted these fats probably does not contain more than 177% TDN/DM or 5.84 Mcal NE_L/kg DM.

Average daily milk production increased from 24.8 to 26.0 kg/cow (4.8%) when an average of 3.9% prilled fat was added to diets for lactating dairy cows with corn silage and alfalfa silage as forage sources (Table 12). Milk fat percent was unchanged while

FCM-production was increased from 22.7 to 24.1 kg/cow/day (6.2%) on fat supplemented diets. Milk protein percent and DMI was also

Table 12 Effect of Supplementing Corn Silage/Alfalfa Silage Diets with Prilled Fat on Dry Matter Intake (DMI) and Milk Production and Composition.

Corn Silage in Diet %DM	Alfalfa Silage in Diet %DM	Added Fat in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM kg/d	Milk Prot %	Refs
26.3	26.3	0.0	19.9	28.2	3.42	25.7	3.03	1
26.3	26.3	2.0[1]	20.3	30.2	3.64	28.4	3.01	
26.3	26.3	5.0[2]	21.3	30.5	3.88	30.2	3.01	
26.3	26.3	2.0[1]	20.7	29.3	3.40	26.6	3.04	
26.3	26.3	5.0[2]	19.7	30.4	3.51	28.1	2.97	
27.5	27.5	0.0	18.4	20.0	3.58	20.1	3.51	2
27.5	27.5	3.8	17.9	20.2	3.72	20.6	3.56	
27.5	27.5	5.0	17.5	20.7	3.50	20.7	3.56	
27.5	27.5	0.0	18.4	22.8	2.99	19.3	3.15	3
27.5	27.5	3.7	18.8	24.0	3.00	20.0	3.19	
27.5	27.5	5.0	18.4	22.4	2.77	18.3	3.30	

[1]Saturated tallow fatty acids. [2]Saturated triglycerides.
Refs: 1-Eastridge and Firkins (1991); 2-Grummer (1987); 3-Schauff and Clark (1989).

unchanged. Results in Table 12 suggest that prilled fats (high melting point fats) could be used in diets based on corn silage and alfalfa silage to increase the energy content of the diet.

Jerred et al. (1990) fed prilled fat to lactating dairy cattle in diets based on alfalfa silage (Table 13) and concluded that supplemental prilled fat increased milk fat percentage in early lactation but had no effect on milk yield or energy intake.

In a study by Jenkins and Jenny (1989)the supplementation of corn silage based diets with hydrogenated yellow grease (HYG) seemed to have possibilities to increase milk yield (Table 13). The authors concluded that the disadvantage of the HYG used in the study was its poor digestibility which limited milk production response.

CALCIUM SOAPS OF LONG CHAIN FATTY ACIDS - Calcium soaps of long chain fatty acids, which were developed by Jenkins and Palmquist (1982), are being produced commercially as a dairy energy supplement (162% TDN/DM). The calcium soap product is rumen inert, as long as the fatty acids are maintained as a calcium soap.

Table 13 Effect of Supplementing Alfalfa Silage or Corn Silage Based Diets with Prilled Fat or Hydrogenated Yellow Grease on Dry Matter Intake (DMI) and Milk Production and Composition.

Silage in Diet	Added Fat in Diet	DMI	Milk Prod	Milk Fat	FCM	Milk Prot	Refs
%DM	%DM	kg/d	kg/d	%	kg/d	%	
Alf Sil							
46-85	0.0[1]	23.6	39.2	3.57	36.5	2.89	1
44-84	5.0[1]	22.1	38.8	3.88	37.8	2.87	
C. Sil							
50.0	0.0[2]	22.9	32.0	3.50	29.6	3.20	2
50.0	3.0[2]	22.5	31.9	3.34	28.8	3.17	
50.0	5.0[2]	23.5	33.6	3.74	32.3	3.09	

[1]Prilled fat. [2]Hydrogenated yellow grease.
Ref: 1-Jerred et al. (1990); 2-Jenkins and Jenny (1989).

Being pH sensitive, any tendency towards acidosis will result in some breakdown of the soaps and the liberation of long chain fatty acids, which will be detrimental to rumen function (Chandler, 1988).

Seven experiments in which calcium salts of fatty acids was the only supplementary fat added to dairy diets in which corn silage was the primary forage source are summarized in Table 14. Average daily milk yield per cow was improved from 31.0 to 32.7 kg (5.5%) when Ca-salts was supplemented at an average of 2.9% of diet dry matter while milk fat percent was unchanged. The average milk protein percent in the last five experiments was decreased from 3.33 to 3.14 (5.7%) by the supplementation of Ca-salts. The inclusion of Ca-salts increased FCM-production from 29.9 to 31.5 kg/cow/day (5.4%). DMI in the last five experiments was decreased from 21.7 to 20.7 kg/cow/day by the inclusion of Ca-salts. The results of these trials suggest that 3.0% Ca-salts could be supplemented to diets for lactating dairy cows based on corn silage to provide additional energy during early lactation when high producing cows are in a nagative tissue energy balance. Calcium salts should not have any adverse effects on rumen fermentation (Schneider et al., 1988) or on fiber digestibility (Schauff and Clark., 1989; Andrew et al., 1991) in lactating dairy cows.

In Table 15 six experiments are summarized in which Ca-salts of fatty acids was included in dairy diets with alfalfa haylage or silage and corn silage as forage sources. Average daily milk yield was improved from 32.6 to 33.5 kg/cow/day (2.8%) when Ca-salts was supplemented at an average of 3.9% of diet DM. Milk fat percent was increased from 3.10 to 3.22 (3.6%) while milk protein percent

Table 14 Effect of Supplementing Corn Silage Diets with Ca-salts of Fatty Acids on Dry Matter Intake (DMI) and Milk Production and Composition.

Corn Silage in Diet %DM	Added Ca-salts in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM Yield kg/d	Milk Prot %	Refs
[1]40.0	0.0	20.5	31.8[d]	3.70	30.2	3.23[a]	1
[1]40.0	3.0	19.3	34.2[e]	3.30	30.9	2.97[b]	
[2]40.0	0.0	20.5	32.2[d]	3.56	30.1	3.13[a]	1
[2]40.0	3.0	19.6	34.3[e]	3.57	32.1	2.96[b]	
Based	0.0	22.3	26.9	4.50[a]	28.5[a]	3.93	2
Based	2.7	20.8	29.8	4.32[b]	30.4[b]	3.50	
43.3	0.0	-	29.3[a]	3.10	27.3[d]	-	3
43.3	2.5	-	30.5[b]	3.20	29.1[e]	-	
35.0	0.0	23.1	36.0	3.20	33.8	2.80	4
35.0	3.5	22.1	35.7	3.10	33.5	2.80	
30.0	0.0	-	36.5[a]	3.10	33.7[a]	-	5
30.0	2.5	-	39.3[b]	3.20	37.2[b]	-	
29.3	0.0	22.3	24.5	4.39	25.9	3.56	6
29.3	3.2	21.6	24.9	4.63	27.1	3.45	

[1]Diets contained 16.0% crude protein/DM. [2]Diets contained 20.0% crude protein/DM.

[ab]Means with different superscripts differ (P<0.05).
[de]Means with different superscripts differ (P<0.01).

Refs: 1-Andrew et al. (1991); 2-Baker et al. (1989); 3-Schneider et al. (1988); 4-Schneider et al. (1990); 5-Robb and Chalupa 1987); -West and Hill (1990).

was decreased from 3.18 to 3.08 (3.1%). Daily FCM-yield was increased from 28.2 to 29.5 kg/cow/day (4.6%) which compares well with the 5.4% increase that was calculated when Ca-salts was supplemented to diets for lactating dairy cows with corn silage as the primary forage source (Table 14). Klusmeyer et al. (1991) found a significant interaction between the amount of forage and Ca-LCFA included in the diet for FCM-production, milk fat percentage and milk fat production. This interaction ocurred because feeding Ca-LCFA to cows consuming the low fiber diet produced a larger amount of milk fat than feeding Ca-LCFA to cows consuming the high fiber diet.

Table 15 Effect of Supplementing Alfalfa Haylage/Corn Silage or Alfalfa Silage Based Diets with Ca-salts of Fatty Acids on Dry Matter Intake (DMI) and Milk Production and Composition.

Alfalfa Haylage /Silage in Diet %DM	Corn Silage in Diet %DM	Added Ca-Salts in Diet %DM	DMI kg/d	Milk Prod kg/d	Milk Fat %	FCM Yield kg/d	Milk Prot %	Refs
27.5	27.5	0.0	18.4	20.0	3.58	20.1	3.51	1
27.5	27.5	3.8	17.9	23.0	3.48	22.9	3.38	
[1]30.0	20.0	0.0	25.1	39.9	3.01	33.6	2.94	2
[1]30.0	20.0	4.0	23.8	39.9	3.30	35.2	2.87	
[2]30.0	20.0	0.0	23.4	41.7	3.14	36.2	3.03	2
[2]30.0	20.0	4.0	22.3	40.5	3.32	35.6	2.88	
30.0	20.0	0.0	25.5	36.0	2.81	29.4	3.28	3
30.0	20.0	4.0	24.0	37.4	3.01	31.7	3.14	
40.2	26.8	0.0	24.7	35.3	3.07	30.3	3.51	3
40.2	26.8	4.0	23.3	35.7	3.13	30.8	3.38	
27.5	27.5	0.0	18.4	22.8	2.99	19.3	3.15	4
27.5	27.5	3.7	18.6	24.7	3.07	21.0	3.12	
Based	0.0	0.0	-	28.7	-	27.1	3.10	5
Based	0.0	2.5	-	29.6	-	28.3	3.00	
70.0	0.0	0.0	18.1	27.0[a]	3.75	26.8[a]	3.05[a]	6
70.0	0.0	2.6	18.2	28.0[b]	3.79	27.9[b]	2.98[b]	
50.0	0.0	0.0	21.8	30.4[a]	3.54	28.8[a]	3.15[a]	6
50.0	0.0	2.6	20.7	31.6[b]	3.66	30.4[b]	3.07[b]	

[1]Protein source - soybean meal. [2]Protein source - fishmeal.

Refs: 1-Grummer (1987); 2-Klusmeyer et al. (1991a); 3-Klusmeyer et al. (1991b); 4-Schauff and Clark (1989); 5-Burgess et al. (1987); 6-Canale et al. (1990).

Three experiments in which Ca-salts of fatty acids was supplemented to dairy diets based on alfalfa silage are also summarized in Table 15. Average daily milk yield was increased from 28.7 to 29.7 kg/cow (3.5%) with Ca-salts supplemented at an average of 2.5% of diet dry matter. Ca-salt supplementation resulted in an increase in milk fat percent from 3.65 to 3.73 (2.2%) in the two experiments reported by Canale et al. (1990) while milk protein percent was decreased from 3.10 to 3.02 (2.3%).

FCM-yield was increased from 27.6 to 28.9 kg/cow/day (4.7%). Although definite conclusions cannot be made from the few experiments reported in Tables 14 and 15, it is probably worthy to note that milk protein percent was less decreased on the diets based on mixed silage diets and on the diets based on only alfalfa silage (Table 15) than on the corn silage based diets (Table 14).

The mechanism whereby the feeding of supplementary fat or protected fat depresses the protein percentage of milk has yet to be defined. Emery (1978) suggested that milk protein concentration is increased by increased digestable carbohydrate content of the diet.

Palmquist and Moser (1981) found that cows fed high fat diets may have a lower milk protein percentage because of an insulin resistance which adversely affects amino acid utilization for protein synthesis by the mammary gland.

Block et al. (1981) found a possitive correlation between concentration of essential amino acids in blood serum and percent milk protein. Mohammed et al. (1988) found that the concentrations of esssential amino acids were particularly low when soy oil was added to the diet and concluded that dietary oil addition may adversely affect amino acid supply available for milk protein synthesis in some situations.

Cummins and Russell (1985) showed that the addition of fat in the diet decreased the mammary uptake of glucose. Mohammed et al (1988) found that added soy oil in the diet reduced the ratio of serum glucose to ULCFA with a lower ($p<0.05$) milk protein percentage. This however was not observed with the addition of cottonseed oil to the diet which had no significant effect on the milk protein content.

SUMMARIZING CONCLUSIONS

SOYBEANS - The supplementation of corn silage based diets with raw soybeans decreased milk fat percent and had no influence on FCM-production. The authors of both studies that were summarized on supplementing corn silage based diets with heat treated soybeans questioned its effect on milk production and composition. When extruded soybeans was added to diets based on corn silage and alfalfa hay FCM-production was increased by 2.4%, while roasted soybeans increased FCM-production by 5.6% in diets based on corn silage and alfalfa silage. The price of extruded soybeans will probably determine whether it will be included in these diets. Voss et al (1988) concluded that roasted soybeans would probably provide a more constant increase in milk production when alfalfa silage provided 50% or more of the dietary forage. FCM-production was increased by 10% when roasted soybeans was added to dairy diets based on alfalfa silage or haylage. The results on heat treated soybeans indicate that more constant increases in milk production can be expected with its inclusion in alfalfa based diets.

WHOLE COTTONSEED - The supplementation of corn silage based diets with whole cottonseed (WCS) decreased milk fat percent by 5.9% and

FCM-production by 4%. When WCS was included in diets based on alfalfa hay milk production was unchanged while milk fat percent and FCM-production was increased by 11 and 6% respectively.Including WCS in diets with corn silage as the primary forage and alfalfa hay or bermuda grass hay as the secondary forage increased milk fat percent by 9% and FCM-production by 5%. It seems as if the inclusion of 10 - 20% hay in corn silage based diets alleviates the fat induced milk fat depression caused by the inclusion of WCS.

TALLOW AND GREASE - The supplementation of alfalfa hay based diets with yellow grease increased milk production by 6.6% with milk fat percent being unchanged.The best level of supplementation seemed to be 3.0 to 3.5% of diet DM. Results also supported the inclusion of tallow at 500 g/cow/day (Clapperton and Steele, 1983) in diets for lactating dairy cows based on ryegrass silage and 5% supplemental fat, containing 40% tallow and 60% prilled long chain fatty acids in alfalfa haylage based diets. Dissappointing results were found when tallow or blended animal - vegetable fats were added to diets in which corn silage was the only forage source or comprised 50% or more of the dietary forage. Diets containing 20 - 30% corn silage should probably not be supplemented with more than 2.5% rumen active fat. Results also did not support the supplementation of cottonseed hull diets with tallow.

PRILLED FATS (HIGH MELTING POINT RUMEN INERT FATS) - The supplementation of corn silage/alfalfa silage based diets with prilled fat increased FCM-production by 6.2%. When prilled fat was used to supplement alfalfa silage based diets the authors concluded that the supplemental prilled fat increased milk fat percentage in early lactation but had no effect on milk yield or energy intake (Jerred et al, 1990). Although Jenkins and Jenny (1989) found some production response when corn silage based diets was supplemented with hydrogenated yellow grease(Table18), they concluded that the disadvantage of the grease used in the study was its poor digestibility, which limited milk production response.

Ca-SALTS OF FATTY ACIDS - When diets for lactating dairy cows based on corn silage was supplemented with Ca-salts of fatty acids FCM-production was increased by 5.4% while milk protein percent was decreased from 3.33 to 3.14. These results suggest that Ca-salts can be used successfully to supplement corn silage based diets for high producing dairy cows. Supplementing diets based on alfalfa haylage/silage and corn silage with Ca-salts of fatty acids resulted in an increase of FCM-production of 4.6% and a decrease in milk protein percent of 3.1%. Alfalfa silage based diets supplemented with Ca-salts of fatty acids resulted in a FCM-production increase of 4.7 while milk protein percent was decreased by only 2.3%. Although the data on Ca-salt supplementation is limited it is interesting to note that as alfalfa silage or haylage replaced corn silage as the primary dietary forage the reduction in milk protein percent declined. Ca-salt supplementation seemed to increase milk production reasonably constant in diets based on different forage sources.

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