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Use of Alaska–Grown Whole Seed Canola in Dairy Cattle Diets—Year 2

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INTRODUCTION

The addition of fat supplements to dairy cattle diets generally is required to maintain high levels of milk production. This fat is most frequently supplied as either tallow or dried fat. Although tallow is less expensive than dried fat, a mixture of tallow and dried fat is sometimes used because of dietary problems associated with high amounts of tallow.

Whole canola seed, containing approximately 45 percent fat (oil), offers an alternative fat supplement in dairy cattle diets. Canola refers to a class of rapeseed varieties that have been genetically modified to contain negligible levels of glucosinolate and erucic acid, components that had previously limited the use of rapeseed as feed. Canola can be produced locally using available farm equipment and, since use as whole seed does not require that the oil be extracted, no additional processing facilities are required.

Because of the high oil content of the whole canola seed, the amount of whole canola seed that can be fed without adversely affecting milk production or quality is limited (Röbbelen et al., 1989). Previous research in Alaska demonstrated that 3 to 4 pounds of canola per day could be fed without adversely affecting milk production or quality (Randall et al., 1994).

Research conducted under controlled, experimental conditions is designed to isolate effects of individual variables; however, it is sometimes criticized for not accurately reflecting results that would be obtained under on–farm commercial production. In addition, research conducted under experimental conditions may not identify important economic constraints or procedural difficulties that might be encountered in on–farm production. Therefore, studies were conducted under both experimental and on–farm conditions. This circular reports on results from two separate studies: 1) a study conducted at the Agricultural and Forestry Experiment Station (AFES) facility in Palmer which specifically assessed the use of whole canola seed as an alternative fat source, and 2) an on–farm study conducted near Delta Junction which compared the performance of cows fed canola and non-canola diets in a commercial production situation.

MATERIALS AND METHODS

AFES TRIAL

Thirty cows (18 mature cows and 12 heifers) were blocked into homogeneous groups based on calving date, age, and, for mature cows, previous lactation production. Within each block, cows were randomly assigned to one of three diets. All diets were formulated to obtain a daily intake of 1.5 pounds of fat per day on an as-fed basis. For the first diet (hereafter called tallow + dried fat), cows received 1 pound tallow supplemented with 0.5 pound dried fat; in the

Table 1. Ingredient content of pelleted concentrate mixes in the AFES trial at Palmer.

	Concentrate Mix[1]		
	Tallow +dried fat	Dried fat	Canola
	pounds per ton		
Barley	1017	1016	939
Corn	209	209	209
Soybean meal	456	457	365
Salmon meal	104	104	104
Canola seed	-	-	278
Tallow	70	-	-
Dried fat[2]	35	105	-
Molasses	35	35	35
Limestone	45	45	44
Trace mineral salt	15	15	15
Magnesium oxide	6	6	5
Dicalcium phosphate	1	1	-
Potassium sulfate	2	2	1
Vitamin premix[3]	4	4	4
Selenium[4]	1	1	1

[1] Diets contained 57 percent concentrate: 43 percent silage on a dry matter basis and were formulated to provide 1.5 pounds fat per cow per day; [2] Trade name Megalac; [3] Contains 2 million international units (IU) vitamin A per pound, 1.6 IU vitamin D per pound, and 5,000 IU vitamin E per pound; [4] Contains 600 parts per million selenium

Table 2. Composition of pelleted concentrate mixes and brome silage in the AFES trial at Palmer.

	Concentrate mix[1]			
	Tallow + dried fat	Dried fat	Canola	Brome Silage
Dry matter (%)	88.19	88.02	87.89	39.81
	% of dry matter			
Organic matter (%)	90.81	90.33	91.34	92.49
Crude protein (%)	22.82	22.32	21.62	15.06
Neutral detergent fiber (%)	12.28	12.58	13.62	57.41
Acid detergent fiber (%)	4.81	4.54	5.46	31.42
Ether extract (%)	7.58	7.64	8.36	3.89
Phosphorus (%)	0.61	0.61	0.61	0.24
Potassium (%)	0.99	0.97	0.95	1.67
Calcium (%)	1.92	2.15	1.74	0.50
Magnesium (%)	0.40	0.40	0.40	0.20
In vitro dry matter disappearance (%)	91.00	91.00	90.00	60.00
Total digestible nutrients (%)	96.00	97.00	96.00	60.00
Metabolizable energy (Mcal/lb.)	1.62	1.62	1.61	0.97
Net energy lactation (Mcal/lb.)	1.16	1.16	1.15	0.63

[1] Diets contained 57% concentrate:43% silage on a dry matter basis and were formulated to provide 1.5 pounds fat per cow per day

second diet (hereafter called dried fat) cows received 1.5 pounds dried fat; and in the third diet (hereafter called canola) cows received their fat from oil contained in whole canola seed. The dried fat supplement used was Megalac®, produced by Church and Dwight of Princeton, N.J. All diets contained 57 percent concentrate and 43 percent brome silage on a dry matter basis, and were formulated to attain a productivity level of 80 pounds milk per day with a dry matter intake of 45 pounds feed per day. The ingredient content of pelleted concentrate mixes and the chemical composition of concentrate mixes and brome silage are presented in Tables 1 and 2, respectively. The diets were balanced to be isocaloric and contain approximately 17.5 percent crude protein on a total dry matter basis.

The canola used in both this study and the on-farm trials was produced by Dennis Green near Delta Junction, Alaska. The whole canola seed contained 18.5 percent crude protein and 46.4 percent fat, and levels of glucosinolate and erucic acid were acceptably low.

The trial began in October 1992 and ended November 1993. Cows started the trial their third week postpartum, and continued through their 15th week. All cows were fed a standard dairy ration during week three and were fed their assigned experimental diet from weeks four through 15. Data obtained during week three were used to adjust for differences among cows for milk production, and these adjustments were applied to milk production during weeks four through 15.

Cows were housed in group free-stalls, and an automated Calan® gate system allowed controlled individual feeding. A total mixed ration was weighed and mixed by a mechanical mixer cart. Daily feed intake after weighbacks was recorded for each cow. Forage and concentrate rations were collected weekly and combined into monthly samples for testing. Milk weights were recorded daily, and weekly milk samples were tested for fat, protein, and solids. Animals were weighed at the beginning and end of the experimental period, and twice more during the experiment.

On-Farm Trial

Two separate feeding trials, each lasting approximately six months, were conducted on Paul Knopp's farm near Delta Junction. The first trial will be referred to as the Year 1 trial, and the second as the Year 2 trial. In each trial, approximately 85 milk cows were randomly separated into two groups; unlike the AFES trial, previous milk production and number of days postpartum were ignored when randomizing cows to groups. All cows were housed in tie stalls.

Feed intake for each cow was based on data collected approximately every three weeks

throughout each trial. Milk production and composition data were determined through monthly Dairy Herd Improvement Association (DHIA) tests. The Year 1 trial began in late February 1992 and lasted 24 weeks; the Year 2 trial began in January 1993 and ran for 26 weeks.

Two rations were evaluated: 1) the normal dairy ration, containing no canola, and 2) a 3 pound whole canola seed per cow per day ration (6 percent canola in the total diet dry matter). In year 1, diets contained 55 percent concentrate: 45 percent silage on a dry matter basis; the concentrate included 23 percent of the total diet as pelleted concentrate and 32 percent as barley. In year 2, diets contained 48 percent concentrate: 52 percent forage on a dry matter basis. Concentrate included 16 percent of the total diet as pelleted concentrate and 32 percent as barley; forage included 44 percent of the total diet as alfalfa hay and 8 percent as brome hay. Pelleted concentrate for Year 1 and Year 2 are presented in Table 3, and chemical composition of the feeds used is presented in Tables 4A and 4B.

The concentrate rations varied significantly between the two trials, as did the type of forage fed. The same amount of canola (3 pound canola seed per cow per day) was fed both years, but the Year 2 rations were balanced so that the amount of pelleted concentrate fed was significantly reduced. Since there was a maximum amount of tallow that could be successfully incorporated into the non-canola concentrate, it was not possible to feed cows on the non-canola diet as much fat as those on the canola diet in the Year 2 trial.

RESULTS

AFES TRIAL

Results from the AFES trial are presented in Table 5. Total milk production was statistically equivalent for all three diets. Cows fed the dried fat and canola diets had similar dry matter intake, while cows fed the tallow + dried fat diet ate significantly less. This trend of higher dry matter intake when feeding canola in diets was also seen in a previous feeding trial using varying levels of canola (Randall et al., 1994). Because of the lower dry matter intake, the tallow + dried fat diet had the highest efficiency of milk production of the three diets. The efficiencies of the canola and dried fat diets were similar to each other.

Milk–fat percentage was low for all three diets. Cows fed the canola and tallow + dried fat diets produced milk with comparable milk-fat percentages. Percent milk-fat for the dried fat diet

Table 3. Ingredient content of pelleted concentrate mixes used in the Year 1 and Year 2 on-farm trials at Delta Junction.

	YEAR 1[1]		YEAR 2[2]	
LBS. CANOLA/COW/DAY	0	3	0	3
	LBS./TON			
Corn	345	315	615	200
Soybean meal	771	560	660	447
Salmon meal	172	158	170	170
Meat and bone meal	258	236	170	170
Canola seed	—	473	—	800
Fat (tallow)	172	—	172	—
Molasses	86	79	85	85
Limestone	42	35	50	50
Trace mineral salt	36	33	40	40
Magnesium oxide	25	20	25	25
Potassium sulfate	60	60	—	—
Urea	20	18	—	—
Vitamin premix	10	10	10	10
Selenium premix[2]	3	3	3	3

[1] Diets contained 55% concentrate:45% silage on a dry matter basis. Concentrate included 23% of the total diet as pelleted concentrate and 32% as barley.
[2] Diets contained 48% concentrate:52% forage on a dry matter basis. Concentrate included 16% of the total diet as pelleted concentrate and 32% as barley; forage included 44% of the total diet as alfalfa hay and 8% as brome hay.
[3] Contains 2 million IU vitamin A/lb., 1.6 million IU vitamin D/lb., 5,000 IU vitamin E/lb.
[4] Contains 600 ppm Se

Table 4A. Composition of pelleted concentrate mixes, silage, barley, and total mixed rations used in the Year 1 on-farm trial at Delta Junction.

	Lbs. canola/cow/day in concentrate[1]				Lbs. canola/cow/day in total mixed ration	
	0	3	Oat/pea Silage	Barley	0	3
Dry matter (%)	89.2	88.7	42.6	87.4	66.5	64.0
	% of dry matter					
Organic matter (%)	81.6	81.5	93.1	96.9	89.9	87.0
Crude protein (%)	35.5	32.6	9.9	13.5	18.3	17.2
Neutral Detergent Fiber (%)	12.9	13.6	53.1	25.8	33.3	37.2
Acid Detergent Fiber (%)	3.0	4.1	30.8	8.1	17.5	19.8
Ether Extract (%)	11.8	13.4	5.2	4.6	7.1	7.0
Phosphorus (%)	1.31	1.33	0.21	0.35	0.55	0.52
Potassium (%)	2.50	2.49	1.75	0.59	1.80	1.83
Calcium (%)	3.00	3.21	0.47	0.10	1.42	1.38
Magnesium (%)	0.99	1.02	0.27	0.17	0.58	0.55
In vitro dry matter disappearance (%)	92.00	91.00	60.00	77.00	73.00	71.00
Total digestible nutrients (%)	97.00	97.00	59.00	82.00	77.00	75.00
Metabolizable energy (Mcal/lb.)	1.63	1.62	0.96	1.33	1.23	1.20
Net energy lactation (Mcal/lb.)	1.17	1.16	0.62	0.92	0.84	0.82

[1] Diets contained 55% concentrate:45% silage on a dry matter basis. Concentrate included 23% of the total diet as pelleted concentrate and 32% as barley.

Table 4B. Composition of pelleted concentrate mixes, barley, and hay used in the Year 2 on-farm trial at Delta Junction.

	Lbs. canola/cow/day in concentrate[1]				
	0	3	Barley	Alfalfa hay	Brome hay
Dry matter (%)	88.9	89.1	86.4	83.6	86.5
	% of dry matter				
Organic matter (%)	86.6	86.3	97.6	91.9	93.9
Crude protein (%)	31.0	28.4	11.9	14.8	10.9
Neutral Detergent Fiber (%)	8.4	12.8	17.0	49.9	63.9
Acid Detergent Fiber (%)	3.0	6.2	4.7	36.7	34.9
Ether Extract (%)	10.6	19.5	2.7	1.1	1.9
Phosphorus (%)	1.08	1.13	0.32	0.18	0.21
Potassium (%)	1.16	1.05	0.55	2.14	2.36
Calcium (%)	2.66	2.68	0.06	1.23	0.25
Magnesium (%)	1.02	1.02	0.15	0.28	0.11
In vitro dry matter disappearance (%)	92.00	89.00	81.00	58.00	60.00
Total digestible nutrients (%)	97.00	95.00	86.00	55.00	57.00
Metabolizable energy (Mcal/lb.)	1.63	1.59	1.41	0.92	0.97
Net energy lactation (Mcal/lb.)	1.17	1.13	0.99	0.59	0.62

[1] Diets contained 48% concentrate:52% forage on a dry matter basis. Concentrate included 16% of the total diet as pelleted concentrate and 32% as barley; forage included 44% of the total diet as alfalfa hay and 8% as brome hay.

Table 5. Response of 30 cows (ten per treatment) fed diets containing 1.5 lbs. fat/day as tallow + dried fat, dried fat, or canola in the AFES trial.

	TREATMENT			
	TALLOW + DRIED FAT	DRIED FAT	CANOLA	LSD[1]
Milk production (lbs./cow/day)	84.1	83.9	85.6	2.4
Milk fat (%)	2.97	2.83	3.05	0.15
Milk fat (lbs.)	2.48	2.38	2.62	0.11
Milk protein (%)	2.84	2.76	2.89	0.04
Milk solids-not-fat (%)	8.45	8.33	8.50	0.05
Milk total solids (%)	11.42	11.15	11.56	0.14
4% Fat Corrected Milk (lbs.)	70.9	69.2	73.5	2.3
Solids Corrected Milk (lbs.)	70.8	69.9	73.6	2.1
Dry matter intake (lbs.)	39.2	41.6	41.6	1.6
Milk/dry matter intake	2.16	2.06	2.04	0.10
Fat corrected milk/dry matter intake	1.87	1.69	1.81	0.08
Solids corrected milk/dry matter intake	1.86	1.68	1.81	0.07
Body weight (lbs.)	1281.00	1258.00	1237.00	—
Body weight change (lbs.)	17.00	-9.00	21.00	50.00
Dry matter intake/body weight	3.13	3.24	3.33	0.49

[1]Least Significant Difference. Differences of at least this amount are considered statistically different (P = 0.05).

was significantly lower than percent milk-fat for the canola diet. Percent protein was slightly higher for the canola diet compared to the tallow + dried fat diet, with the dried fat diet producing the lowest protein. The canola diet produced the highest fat-corrected milk and solids-corrected milk; however, because cows fed the tallow + dried fat diet had lower dry matter intake, they produced the highest fat-corrected milk/dry matter intake and solids-corrected milk/dry matter intake.

Calculation of income over feed costs for the AFES trial is shown in Table 6. Income was calculated using adjusted milk price and average milk production for each diet. Feed costs are given on an as-fed basis, and silage costs are estimated from 1993 hay prices. Net income was highest for the canola ration, mainly because the concentrate was much cheaper than that of the other rations due to the high cost of dried fat. The higher milk production also contributed to the higher net income, despite the higher dry matter intake. The difference in net income is sufficiently large that even if all diets produced fat levels above 3.2 percent, the canola diet would still be the most cost-effective, using the assumed costs and experimental results of this trial.

Table 6. Income over feed costs for cows fed diets containing 1.5 lbs. fat/day as tallow + dried fat, dried fat, or canola in the AFES trial.

	TREATMENT[1]		
	TALLOW + DRIED FAT	DRIED FAT	CANOLA
Milk price/cwt.[2]	$19.37	$19.14	$19.50
Milk income/day	$16.29	$16.06	$16.69
Feed cost/day[3]	$5.58	$6.32	$5.66
Income over feed cost/day	$10.71	$9.74	$11.03

[1]Diets formulated to provide 1.5 pounds fat per cow per day. [2] Base price of $19.75per cwt. adjusted for 0.164 per cwt. fat differential below 3.2% fat. [3]Feed costs: Tallow + dried fat pelleted concentrate = $311[33] per ton; dried fat pelleted concentrate = $340[34] per ton; canola pelleted concentrate = $290[83] per ton; canola seed = $200 per ton (included in pelleted concentrate costs); forage cost estimated at $70 per ton.

This study demonstrates that using rations containing canola can result in milk production and overall economic efficiency comparable to rations containing dried fat or a combination of tallow and dried fat. It should be noted that, as with any crop, the quality and subsequent performance of canola in diets may vary yearly. Results from this study should, however, be representative of what can be expected using similar dietary formulations.

ON-FARM TRIAL

Results of the on-farm trials are presented in Tables 7A and 7B. Results are reported for three

groups: all cows on trial; mature cows with at least three months feed and DHIA data (hereafter called mature cows); and heifers with at least three months feed and DHIA data (hereafter called heifers). The "three months feed and DHIA test" criteria were used as a means of excluding animals that were either freshening or drying off during the trial. Creating the additional groups of mature cows and heifers was done to compare the performance of animals that were as similar to each other as possible. This effectively reduced experimental "noise" and allowed for more accurate measurement of differences attributable to diets.

Most of the milk to feed ratios, a measure of lactational efficiency, were similar for the 0 and 3-pound canola diets. However, for mature cows in Year 1, the milk to feed ratio was substantially higher for the 3 pound canola diet than the one that contained no canola. This is probably because of the large difference in days in milk for cows on these diets. Cows on the 0–pound canola diet averaged 181 days in milk, while cows on the 3–pound canola diet averaged only 114 days in milk. Ideally, each diet should contain cows whose average number of days in milk is similar, as animals with higher days in milk values will generally produce less milk due to the characteristic decline in milk production during the lactational cycle. Thus, some of the comparisons are confounded by large differences in days in milk, and these comparisons should be made with caution.

Calculation of income over feed cost for both years' trials is shown in Tables 8A and 8B. Income values are lower than those of the AFES trial; contributing to this are the lower milk prices at Delta Junction and the fact that the AFES cows all started the trial at week three postpartum and, therefore, participated in the trial during their peak production period. The cows on the on-farm trial, however, were at all

Table 7A. Response of cows fed 0 and 3 lbs. canola/day in the Year 1 on-farm trial at Delta Junction.

							Milk		
Canola in diet	Cow/heifer ratio	No. cows	Days in milk	Milk prod.	Dry matter intake	Milk/feed ratio	Fat	Protein	Somatic cell scale
lbs./day				lbs./day			%		
ALL ANIMALS									
0	2.2	38	152	59.0	41.9	1.41	3.6	3.1	3.1
3	1.6	37	174	57.1	38.4	1.49	3.5	3.4	3.3
MATURE COWS									
0	—	13	181	62.1	41.8	1.49	3.4	3.0	3.6
3	—	6	114	75.8	37.6	2.02	3.2	3.1	3.2
HEIFERS									
0	—	11	193	57.1	40.5	1.41	3.3	3.1	2.7
3	—	10	202	57.4	38.6	1.49	3.4	3.2	3.0

Table 7B. Response of cows fed 0 and 3 lbs. canola/day in the Year 2 on-farm trial at Delta Junction.

							Milk		
Canola/ day in diet	Cow/heifer ratio	No. cows	Days in milk	Milk prod.	Dry matter intake	Milk/feed ratio	Fat	Protein	Somatic cell scale
lbs.				lbs./day			%		
ALL ANIMALS									
0	1.6	37	47	75.8	42.3	1.79	3.3	3.3	2.6
3	1.5	42	48	73.7	41.3	1.78	3.1	3.3	2.8
MATURE COWS									
0	—	19	81	79.3	43.1	1.84	3.2	3.3	2.7
3	—	15	100	78.9	42.1	1.87	3.1	3.2	3.8
HEIFERS									
0	—	11	93	67.9	41.0	1.66	3.5	3.5	2.8
3	—	11	81	72.3	44.1	1.64	3.0	3.3	2.3

Table 8A. Income over feed costs from the Year 1 trial at Delta Junction.

	All animals		Mature cows		Heifers	
Lbs. canola/cow/day	0	3	0	3	0	3
Milk income/day[1]	$11.21	$10.85	$11.80	$14.40	$10.85	$10.91
Feed cost/day[2]	$4.37	$4.05	$4.36	$3.97	$4.22	$4.07
Income over feed cost/day	$6.84	$6.80	$7.44	$10.43	$6.63	$6.84

[1] Milk price: $19 per cwt; no fat or protein differential
[2] Feed costs: 0 lb. canola per cow per day pelleted concentrate - $389.67 per ton; 3 lb. canola per cow per day pelleted concentrate - $398.30 per ton; barley - $160 per ton; oat/pea silage estimated at $45 per ton; canola seed– $200 per ton (included in pelleted concentrate cost)

Table 8B. Income over feed costs from the Year 2 trial at Delta Junction.

	All animals		Mature cows		Heifers	
Lbs. canola/cow/day	0	3	0	3	0	3
Milk income/day[1]	$14.40	$14.00	$15.07	$14.99	$12.90	$13.74
Feed cost/day[2]	$5.69	$5.71	$5.80	$5.82	$5.52	$6.09
Income over feed cost/day	$8.71	$8.29	$9.27	$9.17	$7.38	$7.65

[1] Milk price: $19 cwt; no fat or protein differential
[2] Feed costs: 0 lb. canola per cow per day pelleted concentrate - $385 per ton; 3 lb. canola per cow per day pelleted concentrate - $430 per ton; barley - $160 per ton; brome hay $160 per ton; alfalfa hay - $235 per ton; canola seed - $200 per ton (included in pelleted concentrate cost)

stages of lactation.

Feed costs and formulations of the Year 1 and Year 2 canola concentrates are quite different, even though the same amount of canola was fed per cow per day in both years. The higher cost per ton of the Year 2 canola ration was offset by feeding less concentrate and more barley. The choice of ration would be dictated by the relative costs of barley and canola.

Conclusion

Our research demonstrates that whole canola seed can be used as a viable alternative fat source. In the AFES trial, canola proved more cost effective than either of the diets that contained dried fat. While cows tended to consume more feed when the diet contained canola, milk production also tended to increase. Cows found the canola diet palatable, as evidenced by the high dry matter intakes in the AFES trial.

Results of the two-year on-farm study demonstrate that canola can be used effectively in commercial milk production. Results from the on-farm trial were not consistent across years; this was influenced by the use of different diets, along with other factors that cannot be easily controlled in on-farm research. Use of canola is viable from the standpoint of total milk production; its economic viability in a given situation will depend on the relative costs of feed components. Hopefully, this research will provide a framework for such future decisions.

Experience from both on-farm and AFES trials demonstrates that canola can be readily incorporated into feeding programs. Canola mixes easier with other feed ingredients than tallow. Whole canola seed proved easy to incorporate into the concentrate rations, and no difficulty was found in feeding it. For the on-farm trials, the canola seed was trucked from Delta Junction to Anchorage and mixed with vitamin and mineral supplements; however, this extra transportation can be avoided. The canola can either be added directly to a cow's feed or can be proportionately mixed with barley in Delta Junction where both crops are grown.

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