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Value of Aspen Sawdust as a Roughage Replacement in High-Concentrate Dairy Rations[1]

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Abstract

In two lactation trials we determined if aspen sawdust could be a roughage replacement in high-concentrate dairy rations. In Experiment 1, 20 lactating Holstein cows were separated into four equal groups and fed ad libitum one of the following four all-pellet4 rations for a 6-wk experimental period: (1) grain mix with 10% sawdust; (2) grain mix with 10% sawdust, 5% sodium bentonite, and 2% sodium bicarbonate; (3) grain mix with 20% sawdust; or (4) grain mix with 30% sawdust. The four rations did not produce significant differences in milk production, percent milk protein, percent milk solids-not-fat, feed intake, or body weight. Milk fat percent, rumination time (h/day), and ruminal acetate-to-propionate ratios were affected and averaged 2.1, 2.0, 1.24; 2.6, 1.6, 1.75; 2.8, 3.2, 1.58; and 3.7, 4.1, 2.60 for each of the four groups. Experiment 2 was similar to Experiment 1 except 12 lactating cows were separated into three equal groups; each group was fed one of the following three rations during the experimental period: (1) grain mix with 2.3 kg alfalfa hay; (2) grain mix with 12% sawdust and 2.3 kg hay; or (3) grain mix with 12% sawdust, 5% sodium bentonite, 2% sodium bicarbonate, and 2.3 kg hay. Effects of treatment were not significant on milk production or composition, feed intake, or body weight. Milk fat percent, rumination time (h/day), and ruminal acetate-to-propionate ratios averaged 3.4, 5.1, 1.81; 3.5, 6.3, 2.17; and 3.6, 5.1, 3.43, respectively. Aspen sawdust can be a partial roughage substitute in lactating dairy cow rations, and it is helpful in maintaining near-normal milk fat content in high-concentrate rations. The sawdust cannot, however, serve as the only source of roughage for lactating cows because of the irregular feed intake that results if no other forage is fed.

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Introduction

Interest in roughage substitutes for beef and dairy cattle has grown in recent years. Traditional sources of forage have become scarce or costly in certain areas of the United States or are incompatible with automated feeding systems.

An earlier study (4) indicated that aspen sawdust was effective as a partial forage substitute in a high-grain dairy ration. In that study cows fed 2.3 kg of hay and about 17 kg of a pelleted ration containing one-third aspen sawdust maintained normal milk fat. Cows receiving a similar ration but without sawdust produced milk with half as much fat.

Rations containing one-third sawdust are not feasible because of the handling cost of a bulky material such as sawdust. It was desirable to know, therefore, if less dietary aspen would be as effective in maintaining milk fat test. Thus, the purpose here was to determine the minimum sawdust required for maintaining a near-normal milk fat test and determine if combinations of sodium bentonite, sodium bicarbonate, aspen sawdust, and small amounts of hay could maintain milk fat test on high-grain diets.

Methods and Procedures

Experiment 1. Twenty lactating Holstein cows averaging 161 days postpartum were fed a ration of one part long alfalfa hay and one part all-pelleted concentrate (Table 1) during

TABLE 1. Composition of rations[a] fed to each animal group for Experiments 1 and 2.

Ration and group	Aspen sawdust	Ground[b] or cracked[c] shelled corn	Ground[b] or rolled[c] oats	Soybean oil meal	Dry molasses	Wheat bran	Urea	Dicalcium phosphate	Trace mineral salt	Sodium bentonite	Sodium bicarbonate
	(%)										
					Experiment 1						
Pelleted concentrate (pre-experimental)	...	63	20	10	5	...	...	1	1	...	...
Pelleted ration (experimental)											
1	10	46.2	19	12	5	5	.8	1	1	...	...
2	10	39.2	16	15	5	5	.8	1	1	5	2
3	20	37.2	15	15	5	5	.8	1	1	...	...
4	30	30	12	15	5	5	1	1	1	...	...
					Experiment 2						
Ground concentrate (pre-experimental)	...	63	20	10	5	...	...	1	1	...	...
Ground concentrate (experimental)											
1	...	65	15	13	5	...	...	1	1	...	...
2	12	51	15	15	5	...	...	1	1	...	...
3	12	42	15	17	5	...	...	1	1	5	2

[a] 2,200 IU of vitamin A and vitamin D and .22 unit of vitamin E were added per kg of ration. Percent composition is expressed on an air-dry basis.
[b] Experiment 1.
[c] Experiment 2.
[d] Each cow also received 2.3 kg of long alfalfa hay/day.

a 5-wk pre-experimental period. At the end of 5 wk, cows were separated on milk production and fat test into four experimental groups. Each group was then fed one of the four all-pelleted rations (Table 1) for 6 wk. Wood shavings were used for bedding, and with the exception of an occasional cow that would eat negligible amounts of wood shavings, the only roughage consumed was sawdust of bigtooth aspen (*Populus grandidentata* Michx.) incorporated in the feed pellet. Exceptions were made to this on occasion when small amounts of hay were offered to cows when they were off feed by about 30% or more.

The four pelleted rations were expected to cause varying degrees of depression in milk fat. Sodium bentonite and sodium bicarbonate were added to one of the low-fiber rations to determine their effect in maintaining normal milk fat content.

The sawdust was from a mill that sawed bark-free logs of aspen. After air-drying, the sawdust was hammermilled through a .16-cm screen. Other aspen sawdust handled similarly (4) resulted in 54% of the material in the −10 +40 mesh and 36% in −40 +80 mesh. The amount of feed offered was adjusted so small feed refusals that occurred seldom exceeded l kg/day. Feed intake, therefore, was essentially ad libitum for both periods.

Feed intake, milk production, milk composition, concentration of ruminal volatile fatty acids, and rumination time were measured during the last 14 days of the pre-experimental period and the last 11 days of the experimental period. Feed intake and milk production were recorded daily, and milk composition was determined twice weekly on combined morning and evening milk, with a total of four samples during each period. Milk composition and concentration of ruminal volatile acids were determined as described (4). Rumen fluid was obtained by stomach tube (3) 4 to 6 h after feeding on 2 separate days during each period.

Times of eating and of rumination during a 24-h period were observed on 2 separate days during each period. A check was made every 5 min to determine if a cow was ruminating, resting, or eating. It was assumed that 5 min of rumination accompanied each momentary observation of rumination. Since rumination periods were usually 20 min or longer, this was a fairly accurate measure.

Changes in body weight were obtained by averaging three consecutive daily weighings at the beginning and end of the pre-experimental period and at the end of the experimental period.

Differences among treatment means in the experimental period were statistically analyzed after adjustment by covariance for differences between groups in the pre-experimental period. Duncan's multiple range test was used to identify significant differences between the four treatment rations (5).

Experiment 2. Since high concentrations of dietary aspen were necessary to maintain near-normal milk fat on all-pelleted, high-concentrate rations in Experiment 1, it was desired to determine if low concentrations of aspen would be effective in rations with less propensity to depress milk fat. Twelve lactating Holstein cows averaging 173 days postpartum were fed a ration of one part long alfalfa hay and one part coarsely ground concentrate (Table 1) during a 4-wk pre-experimental period. At the end of the period, the cows were separated on the basis of milk production and fat test into three experimental groups. Each group was fed one of three ground concentrates (Table 1) and 2.3 kg long alfalfa hay/cow per day. The experimental period lasted 7 wk. The bedding was wood shavings.

Aspen sawdust similar to that used in Experiment 1 was mixed with the concentrate. In contrast to Experiment 1, the shelled corn was coarsely cracked, the oats were rolled, and the ration was not pelleted. Feed intake, however, was essentially ad libitum for both periods.

The same observations and procedures of Experiment 1 were used, except milk solids-not-fat was not determined. All observations were made in the last 2 wk of each period. The statistical analysis was similar to that in Experiment 1.

Results and Discussion

Experiment 1. Three cows were removed from experiment because of health problems, two during the pre-experimental period and one during the experimental period. Although unconfirmed, displaced abomasum was thought responsible for the inappetence of the cows. Since two cows developed the condition before the experimental period, it did not appear that the sawdust or the all-pelleted ration was the cause.

Changes in feed intake and body weight are in Table 2. Feed intake was constant and almost equal for all groups during the pre-experimental period, but on switching to the all-pelleted ration, feed intake was variable. This was due to about 40% of the cows going

TABLE 2. Effect of aspen sawdust on feed intake and body weight changes.

Group	Feed intake[a]				Body wt change	
	Pre-experimental		Experimental			
	Concentrate	Hay	Concentrate	Hay[b]	Pre-experimental	Experimental
	(kg/cow per day)				(kg gain/cow per period)	
			Experiment 1[c]			
1	10.1	9.7	16.1	.3	27.3	10.0
2	10.0	9.4	17.1	1.1	25.5	0
3	10.2	9.8	18.0	.3	32.7	7.3
4	9.3	8.9	19.7	.5	14.1	7.7
			Experiment 2[d]			
1	10.0	9.3	14.9	2.3	27.3	1.4
2	9.0	8.9	16.5	2.3	18.2	20.7
3	9.8	9.7	14.3	2.3	23.4	−8.4

[a] Air-dry basis, averaging about 90% dry matter.
[b] Hay was fed on occasion to several cows that went off feed in Experiment 1. This represents hay consumption averaged for all cows, although some cows did not get hay.
[c] Each group was fed the same pelleted ration during the pre-experimental period but was fed either 10, 10, 20, or 30% aspen sawdust in the experimental period.
[d] Each group was fed the same ground ration during the pre-experimental period but was fed either 0, 12, or 12% aspen sawdust mixed with the concentrate during the experimental period. Group 3 also received sodium bentonite and sodium bicarbonate.

off feed at least once during the experimental period. Groups 1 and 2 experienced the greatest difficulty, particularly Group 2. Small amounts of hay were fed to assist a cow to regain appetite if its feed intake was persistently low. Although the differences in feed intake between groups during the experimental period were not significantly different, the trend was toward increased feed consumption with the high aspen rations. As reported (4), the cows apparently compensated for the lower digestibility of the sawdust by eating more of the total ration; thus, they maintained total digestible energy intake. Body weight changes were not affected by treatment, although they appeared to be less during the experimental period.

The effect of sawdust on milk production and milk composition is shown in Table 3. Effects of treatment were not significant on milk production, percent milk protein, or percent milk solids-not-fat. Milk fat increased with an increase in dietary sawdust. Dietary bentonite and sodium bicarbonate in combination with 10% dietary aspen apparently were more effective in maintaining milk fat than 10% dietary aspen alone, but the difference was not significant. Feeding 30% aspen sawdust was

TABLE 3. Production and composition of milk.

Group	Pre-experimental				Experimental			
	Milk	Fat	Protein	SNF[a]	Milk	Fat	Protein	SNF[a]
	(kg/day)	(%)			(kg/day)	(%)		
				Experiment 1[b]				
1	20.2	3.0	3.33	8.5	16.0	2.1*[b]	3.78	8.7
2	19.4	3.1	3.53	8.6	15.9	2.6*	3.75	8.6
3	18.1	3.0	3.78	8.7	14.0	2.8*	4.02	8.9
4	20.9	3.1	3.41	8.6	15.9	3.7**	3.79	8.9
				Experiment 2				
1	19.5	3.5	3.40	...	16.6	3.4	3.48	...
2	19.3	3.5	3.37	...	14.8	3.5	3.53	...
3	19.5	3.3	3.36	...	15.3	3.6	3.45	...

[a] SNF = solids-not-fat.
[b] Means within the same column having different superscripts are significantly different ($P < .05$).

TABLE 4. Concentration of ruminal volatile fatty acids.

Group	Acetate	Propionate	Butyrate	Isovalerate	Valerate	Acetate: propionate ratio	Total acids
	(molar %)						(meq/100 ml)
			Experiment 1				
Pre-experimental							
1	61.7	22.3	14.1	.5	1.4	2.77	10.5
2	62.2	22.7	13.1	.8	.9	2.74	11.4
3	60.6	24.2	13.2	.7	1.1	2.50	12.1
4	61.3	23.8	12.6	.6	1.7	2.57	10.3
Experimental							
1	44.4	35.7[a]	16.2	.8	3.0	1.24	10.0
2	53.2	30.3**,*	13.9	.9	1.6	1.75	8.8
3	50.2	31.7**,*	14.8	1.3	2.1	1.58	10.7
4	59.0	22.7**	15.3	1.5	1.5	2.60	8.5
			Experiment 2				
Pre-experimental							
1	65.9	17.2	13.2	1.9	1.8	3.83	9.0
2	65.6	17.7	13.3	1.6	1.8	3.71	9.6
3	67.8	16.0	12.8	1.7	1.7	4.24	10.2
Experimental							
1	52.8*	29.2*	14.3	2.2	1.6*	1.81*	8.7
2	56.3*	25.9*	14.3	2.0	1.4*	2.17*	7.8
3	63.5**	18.5**	14.7	2.2	1.1**	3.43**	6.9

[a] Means within the same column having different superscripts are significantly different ($P < .05$).

most effective in maintaining fat test.

Although differences in milk production were not significant between treatments, apparently all treatments reduced milk yield more than could be accounted for by advancing stage of lactation. Based on prediction values for incomplete lactation records, Groups 1 and 4 decreased 2.4 and 1.6 kg more in daily milk yield during the 6-wk experimental period than would have been predicted, and Groups 2 and 3 maintained production .4 and .5 kg higher than would have been predicted. Although this is a crude approach in appraising milk persistency, it suggests that persistency of milk production was below normal for Groups 1 and 4.

Concentrations of ruminal volatile fatty acids are in Table 4. The molar percentages of acetate, propionate, and butyrate were approximately 61, 23, and 13% for all groups during the pre-experimental period. The proportion of acetate decreased and propionate increased during the experimental period for all groups except the 30% aspen group. The acetate-to-propionate ratios were 1.24, 1.75, 1.58, and 2.60 for Groups 1 through 4, compared to an average of 2.62 during the pre-experimental period. The 10% aspen ration with sodium bentonite and sodium bicarbonate increased the ruminal acetate-to-propionate ratio over that of the same ration without bentonite and bicarbonate (1.75 vs. 1.24) and was similar to the 20% aspen ration (1.75 vs. 1.58). A pelleted ration of 30% aspen sawdust is as effective as 50% long hay to maintain normal ruminal acetate-to-propionate ratios.

Times of rumination and eating are in Table 5. During the pre-experimental period all cows spent about 6 h ruminating and slightly less than 4 h eating. When fed the all-pelleted ration, times for ruminating were 2.0, 1.6, 3.2, and 4.1 h for Groups 1 through 4. Time for eating was approximately halved for all groups. Rumination time was linearly related to aspen content of the ration. The slight reduction in rumination time of the bentonite and bicarbonate group was not significant. The tendency for bentonite to reduce rumination time has been observed (1), and Welch (6) has noted that bicarbonate in large quantities can completely stop rumination.

TABLE 5. Effect of aspen sawdust on rumination and eating time.

Group	Pre-experimental		Experimental	
	Rumination time	Eating time	Rumination time	Eating time
	—(h/day)—		—(h/day)—	
	Experiment 1			
1	5.8	3.2	2.0	1.4
2	6.1	4.0	1.6	1.9
3	5.8	3.6	3.2	1.5
4	6.6	4.3	4.1	2.2
	Experiment 2			
1	7.3	2.4	5.1	2.4
2	7.3	2.7	6.3	2.7
3	7.5	2.4	5.1	2.4

Rumen pH of samples obtained by stomach tube averaged 6.3 for both the pre-experimental and the experimental periods, with no differences between treatments. A reduction of rumen pH to 5.5 to 6.0 was expected during the experimental period. Samples of rumen fluid relatively free of saliva were obtained, so the high rumen pH values of treatment groups on the all-pelleted ration were surprising, Rumen pH values determined from stomach tube samples tend to be biased upward, however, due to saliva contamination.

Experiment 2. The effect of aspen sawdust on changes in feed intake and body weight are in Table 2. Feed intake did not differ between groups during the pre-experimental period. Of the two groups with aspen sawdust during the experimental period, the group supplemented with sodium bentonite and sodium bicarbonate had the lowest intake (14.3 vs. 16.5 kg) of concentrate; this compared to 14.9 kg consumed by the control group. These differences were not significant. All groups were limited to 2.3 kg hay/cow per day during the experimental period; they consumed this eagerly. In contrast to feeding an all-pelleted ration in Experiment 1 during which about 40% of the cows were severely off feed at least once during the period, cows receiving 2.3 kg of hay and a coarsely cracked concentrate had less fluctuation in feed intake. Body weight changes during the experimental period were + 1.4 + 20.7, and —8.4kg/cow for the control, the aspen, and the aspen-bentonite-bicarbonate groups.

Production and composition of milk are in Table 3. Milk production was not significantly affected by treatment but trended lower with the aspen treatments. Percent milk fat for control, aspen, and aspen-bentonite-bicarbonate treatments were 3.4, 3.5, and 3.6%; differences were not significant. A decrease in percent milk fat was anticipated when the cows were changed from the pre-experimental to the experimental period, particularly for the control group, but this did not materialize. Since

the control group was not depressed in the fat test, the value of aspen sawdust in maintaining fat test could not be assessed. An explanation for the failure of fat to depress in this group is not readily apparent. The concentrate did have a rather coarse texture, but 2.3 kg of hay/cow per day is well below the recommended level for maintaining a normal fat test. Milk protein content was not affected by treatment.

The effect of the treatments on concentration of ruminal volatile fatty acids is in Table 4. The molar percentages of acetate for the control, the aspen, and the aspen-bentonite-bicarbonate groups were 52.8, 56.3, and 63.5%; for propionate, 29.2, 25.9, and 18.5%. Aspen alone increased the acetate-to-propionate ratio, but not enough to be significant. The combination of aspen, bentonite, and bicarbonate increased ($P < .05$) the acetate-to-propionate ratio from the control of 1.81 to 3.43. Molar percentages of butyrate. isovalerate, and valerate were not affected by treatment. The pattern of the ruminal fatty acids of the control group was similar to that of Group 2 and 3 in Experiment 1, both of which had depressed milk fat test.

Times of rumination and eating are presented in Table 5. Neither time of ruminating nor of eating differed between treatments, although both tended to be increased in the aspen group.

In summary, aspen sawdust may be used as a roughage extender or as a partial roughage substitute in high-concentrate dairy rations. The sawdust does maintain fat test and diminishes off-feed problems when constituting about 30% of the ration dry matter in high- or all-concentrate dairy rations. The dry matter digestibility of aspen sawdust is about 31% (2). The cows apparently compensate for this by eating more of the aspen-containing ration; thus, they maintain total digestible energy intake. Whether high-producing cows already at maximum feed intake could do this is questionable.

Aspen sawdust has useful roughage characteristics, but using it as the only roughage in high-concentrate dairy rations cannot be recommended. Approximately 30% of the ration dry matter would have to be sawdust; that is too high to be practical. Even when fed at this level, the challenge to the cow of an otherwise all-concentrate, pelleted ration is too great to maintain stability of appetite. Sodium bentonite and sodium bicarbonate apparently have an additive effect toward maintaining fat test when combined with aspen sawdust. In combination with bentonite and bicarbonate, smaller quantities of sawdust would probably be sufficient to maintain a given fat content of milk.

As little as 2.3 kg of ha /cow per day is effective in stabilizing feed intake. To supplement the hay, adding 10 to 15% of the high-concentrate diet as aspen sawdust, 5% as sodium bentonite, and 2% as sodium bicarbonate might extend limited forage supplies. Since aspen sawdust does not serve well as the sole source of roughage in a complete, all-concentrate ration, its potential appeal as a forage substitute is reduced.

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