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Effect of Particle Size and Physical Form on Digestibility of Sun-cured Alfalfa for Pregnant Sows

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Summary

Sixteen pregnant crossbred sows (second parity) were employed in a digestion trial to evaluate the effect of particle size and physical form of sun-cured alfalfa. The treatment consisted of ¼ inch meal, ¼ inch pelleted, ½ inch meal, and ½ inch meal pelleted. Utilization of dry matter (DM), digestible energy (DE) and fiber components increased (P<.05) with the ¼ inch particle size compared to ½ inch. Nitrogen utilization was not affected by the two particle sizes. Cellulose digestibility increased (P<.05) when pelleted but other digestion coefficients were not affected. During the third trimester,digestibility of DM, energy and fiber components increased (P<.05) compared to the first trimester. Apparent nitrogen digestibility increased (P<.05) in the third trimester but nitrogen balance and nitrogen retention decreased. The results of this study indicate that alfalfa is equally digested as meal or pellets and increased utilization by gestating sows can be expected with decreased particle size.

Introduction

The ability of swine to utilize high fiber feeds was established early in the 1900's. Forages, such as alfalfa, tend to be good sources of vitamins and minerals and have amino acid profiles similar to soybean meal. Nebraska researchers have suggested that high fiber forages may be economically feasible for gestating swine diets. Of the forages in the United States, alfalfa appears to have the greatest potential in swine diets. It has been shown that sun-cured alfalfa fed daily, bi-weekly, or self-fed has no adverse effects on reproductive performance. Dehydrated alfalfa as 25% of the diet and 96.7% of the diet self-fed also have been studied. Recently a study was conducted showing that a gestation diet containing 50% sun-cured alfalfa increased reproductive performance over a corn-soybean meal control diet. These data indicate that alfalfa can be utilized successfully and may be economically competitive with concentrate diets for gestating swine.

In past studies, the amount of alfalfa in the diet has been the main emphasis and very little research has been done on particle size or physical form. This study was conducted to determine effect of particle size and physical form of sun-cured alfalfa for gestating sows.

Experimental Procedure

Sixteen pregnant crossbred sows (second parity) were used in a digestion trial to determine the influence of particle size and physical form of sun-cured alfalfa. Treatments were prepared using baled alfalfa hay ground through a grinder (Bearcat®)[1] with a ½ inch screen opening. Half of the alfalfa was rechopped using a screen with a ¼ inch opening resulting in two particle sizes. A portion of each particle size was pelleted using a pelleter[2] with a 3/8 inch die. Alfalfa was conditioned with steam to 170°F prior to pelleting and cooled across a horizontal pellet cooler with ambient air. The pellets were scalped across a ¼ inch screen to recover fines and packed into 50 lb bags. The alfalfa treatments were designated as ¼ inch, ¼ inch pelleted, ½ inch and ½ inch pelleted. Fifty percent alfalfa was added to a sorghum grain-soybean meal supplement (Table 1). Diets were fed to supply approximately 5000 kcal metabolizable energy (ME) per day (4.4 lbs). For diet formulation, digestibility of 60% was used for alfalfa, as suggested by earlier research. Chemical composition in Table 2 shows the quality of alfalfa used.

After mating, the sows were weighed, and introduced to the treatments. Treatments were hand fed once a day throughout gestation. Five day total collections were initiated at 25 and 80 days postcoitum. Three days prior to the collection period, the sows were reweighed and moved into metabolism crates.

Results and Discussion

Particle Size

The effects of particle size of alfalfa are shown in figure 1. Significant increases in digestibility were observed for DM, energy and the fiber components with decreased particle size (Table 3,4). Digestibility for ½ inch and ¼ inch treatments were DM, 70.6 vs 73.6%, DE, 68.3 vs 73.0%, CF, 32.2 vs 38.0%, ADF, 36.5 vs 43.3%, NDF, 49.3 vs 53.2% and cellulose, 32.2 vs 47.4%, respectively. Dry matter digestibility was correlated (r^2=.92) with DE. Crude fiber digestion was found to correlate with cellulose (r^2=.78) and NDF (r^2=.64) digestion. Lignin and hemicellulose digestibilities were unchanged with particle size as was nitrogen utilization.

Physical Form

Digestibility of cellulose (49.9 vs 46.3%) increased (P<.01) and ADN (67.7 vs 64.2%) decreased (P<.05) with pelleting. The other digestibility coefficients were not significantly different between meal and pelleted treatments (Tables 3, 4).

Due to extreme temperatures and moisture employed in the pelleting process, the pelleted treatments were expected to contain a higher percentage of lignin. The results of the chemical analysis were not different for the meal and the pelleted treatments. However, the results of this study indicate that the digestibility of ADN tended to increase with pelleting (P<.07). Lignin and ADF digestibilities were depressed with pelleting. Lignin digestibility was also found to be highly correlated with nitrogen digestibility (r^2=.80).

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[1] Western Land Roller, Hastings, NE.

[2] California Pellet Mill Co., San Francisco, CA.

Nitrogen balance and nitrogen retention were also decreased by pelleting, whereas nitrogen digestibility was unaffected. These results indicate that pelleting has a tendency to decrease solubility of nitrogen (Table 5).

Period of Gestation

Digestibilities of all feed components studied were significantly affected between trimesters. Digestibilities of DM (69.5 vs 74.8%), DE (66.9 vs 74.3%), CF (23.9 vs 46.9%), ADF (31.2 vs 48.6%), NDF (43.4 vs 59.1%), lignin (31.6 vs 46.6%), cellulose (37.0 vs 50.2%), and hemicellulose (63.0 vs 80.5%) significantly increased from the first to the third trimester of gestation, respectively (figure 2). Nitrogen balance and nitrogen retention decreased significantly from the first to the third trimester while nitrogen digestibility increased ($P<.07$) from 74.7 to 77.1%.

A physical form x period interaction ($P<.05$) was observed for CF, cellulose and NDF. The increase in digestibility of the meal diets were twice that of the pelleted diets from the first to the third trimesters. CF (29.8 vs 16.2%), cellulose (17.9 vs 8.5%) and NDF (20.0 vs 11.4%) increased between periods for meal and pelleted diets, respectively. NDF digestibility also exhibited a particle size x period interaction ($P<.05$). The ¼ inch diets increased 19.5% in NDF digestibility between periods while the ½ inch diets increased 11.9%.

In order for fiber to cause a decrease in apparent N digestibility, it must first be susceptible to microbial degradation in the hindgut resulting in increased microbial nitrogen in the feces unavailable to the host. Adaptation of swine to the high fiber diet is another variable which influences digestibility associated with high fiber diets. Thus, when considering digestibilities of high fiber diets, adequate time must be allotted for optimal populations of microflora to become established in the lower intestinal tract.

Results of this study indicate that grinding alfalfa through a ¼ inch screen increased utilization of DM, GE, and fiber as compared to ½ inch screen and pelleting of alfalfa increased cellulose digestion while other component digestibilities were unchanged.

Table 1. Composition of Diet

Ingredient	%
Alfalfa, sun-cured[a]	50.0
Grain sorghum	41.4
Soybean Meal, 44%	5.5
Monosodium phosphate	1.1
Dicalcium phosphate	.7
Vitamin-trace mineral premix[b,c]	1.0
Salt	.3
Total	100.0.

[a]Assume 60% digestible.
[b]Supplied the following per kg of diet: Vitamin A, 4400 IU; Vitamin D_3, 330 IU; riboflavin, 5.0 mg; calcium pantothenate, 14.3 mg; choline chloride, 507 mg; niacin, 27.5 mg; Vitamin E, 22 IU; Vitamin B_{12}, 24 µg; Mn, 55 mg; Fe, 100 mg; Cu, 11 mg; Zn, 200 mg; I_2, 1.5 mg; Co, 1.0 mg.
[c]Finely ground sorghum grain was used as a carrier.

Table 2. Chemical Composition of Diets[a]

	Alfalfa	Supplement[b]
Dry matter, %	90.1	88.5
Ether Extract, %	2.9	3.6
Ash, %	8.4	7.2
Crude protein, %	20.2	17.9
Crude fiber, %	26.8	2.8
ADF, %	32.1	6.9
NDF, %	40.7	21.4
Lignin, %	8.9	2.2
Cellulose, %	23.3	4.4
Hemicellulose, %	8.7	14.5
Acid detergent insoluble N, %	.23	.39
Hot water insoluble N, %	2.27	2.27
Ca, %	1.64	.61
P, %	.29	1.45
Gross energy, kcal/kg	4524	4194

[a]Values expressed on dry matter basis.
[b]All ingredients excluding alfalfa.

Table 3. Effect of Particle Size and Physical Form of Alfalfa on Dry Matter, Ether Extract, and Energy Digestibility.

Item	Trimester	Particle Size Physical form	6.25mm Meal	6.25mm Pellet	12.5 mm Meal	12.5 mm Pellet
Dry matter(%)[a,b]	1		69.6	72.4	67.1	68.8
	3		76.5	76.0	74.5	72.1
Ether Extract (%)	1		63.4	62.1	60.0	56.5
	3		63.4	54.7	63.2	56.9
Digestible Energy (%)[a,b]	1		68.7	71.2	63.3	64.5
	3		76.5	75.6	74.1	71.2
Digestible Energy (kcal/kg)[a,b]	1		2991	3102	2772	2806
	3		3331	3290	3222	3097

[a]Particle size difference ($P<.01$).
[b]Period difference ($P<.001$).

Table 4. Effect of Particle Size and Physical Form of Alfalfa on Fiber Component Digestibilities.

Item	Trimester	Particle Size Physical form	6.25mm Meal	6.25mm Pellet	12.5 mm Meal	12.5 mm Pellet
Crude fiber[abd]	1		20.7	32.0	19.0	23.9
	3		50.9	50.9	48.5	37.4
ADF[abd]	1		27.7	36.0	28.0	33.0
	3		59.9	49.5	45.8	39.4
Lignin[b]	1		33.0	32.4	29.8	31.1
	3		51.2	39.6	50.9	44.9
Cellulose[abcd]	1		33.2	44.8	30.7	39.4
	3		53.2	58.5	46.5	42.6
NDF[abde]	1		38.4	48.5	41.5	45.2
	3		63.4	62.5	56.5	54.0
Hemicellulose[b]	1		57.0	65.0	65.3	64.8
	3		83.5	81.0	79.8	77.5

[a]Particle size difference ($P<.05$).
[b]Period difference ($P<.05$).
[c]Form difference ($P<.05$).
[d]Form x period ($P<.05$).
[e]Size x period ($P<.05$).

Table 5. Effect of Particle Size and Physical Form of Alfalfa on Nitrogen Utilization

Item	Trimester	Particle Size / Physical form	6.25mm Meal	6.25mm Pellet	12.5 mm Meal	12.5 mm Pellet
N-Intake, g/day	1		49	53	51	54
	3		50	52	52	54
Fecal N, g/day	1		12	13	14	14
	3		11	12	12	13
Urinary N, g/day	1		22	23	22	26
	3		29	31	31	34
N-Balance, g/day[a]	1		15	17	15	14
	3		9	7	13	6
N-Retention (%)[a]	1		32.4	32.3	30.3	26.2
	3		18.4	14.9	26.4	12.8
N-Digestibility (%)	1		76.0	75.8	72.9	74.2
	3		77.4	77.3	77.7	75.3
ADN-Digestibility (%)[b]	1		63.5	65.7	66.7	63.0
	3		71.3	66.9	69.5	62.3
HWIN Digestibility (%)	1		80.8	81.2	80.1	78.8
	3		82.0	80.9	81.4	79.3

[a]Period difference ($P<.01$).
[b]Form difference ($P<.05$).

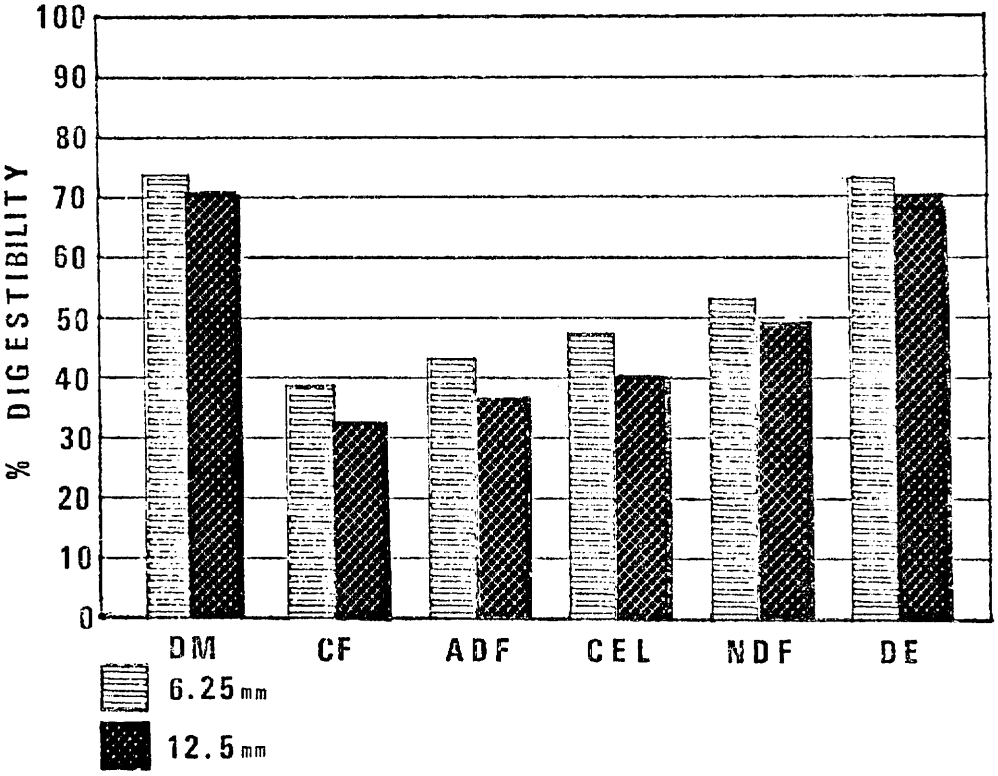

Figure 1. Effect of particle size of alfalfa on digestibility.

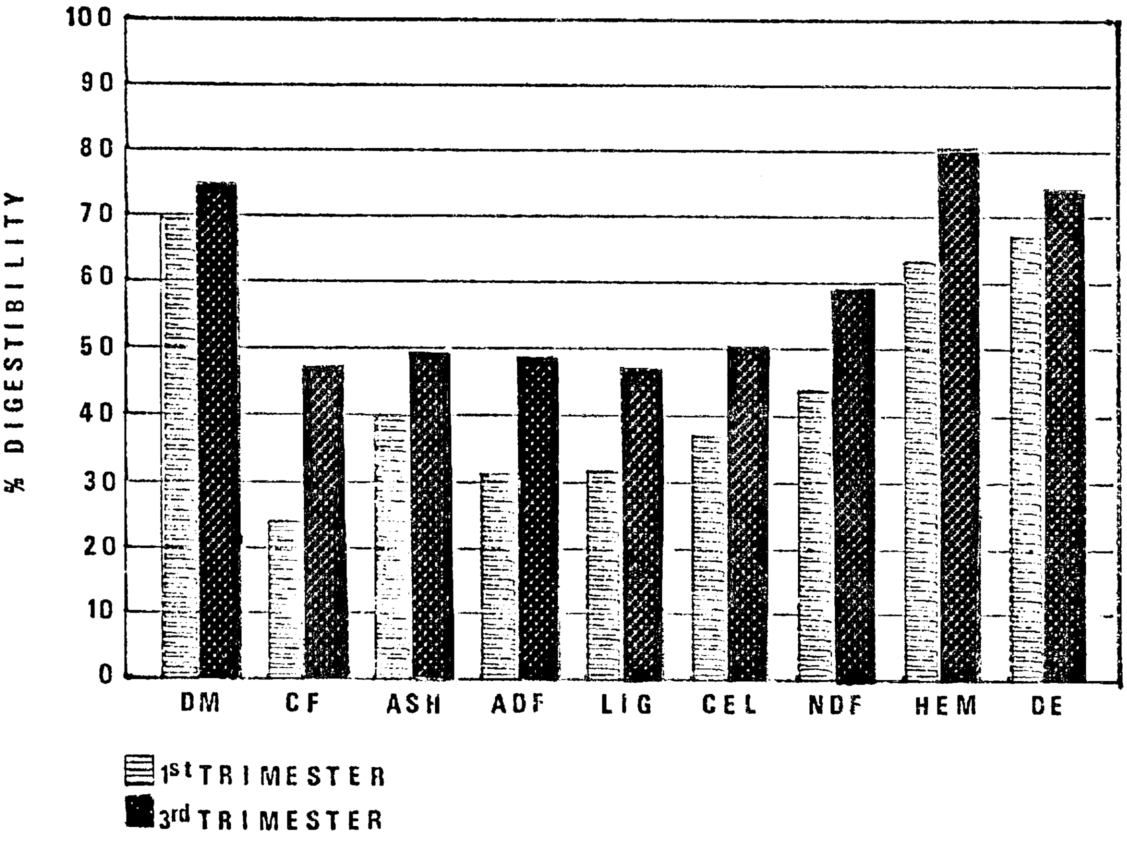

Figure 2. Effect of stage of gestation on nutrient utilization.