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VALUE OF HIGH FIBER DIETS FOR GRAVID SWINE[1]

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SUMMARY

An experiment was conducted to determine the effect of roughages on the utilization of dietary nitrogen, energy and fiber by gravid swine. Water consumption, backfat depletion, pregnancy weight gain, and reproductive performance were used as response criteria.

Metabolism assays, employing 18 crossbred sows (second or third parity), were initiated at days 0 (prior to breeding), 30 and 80 postcoitum. The pelleted experimental diets consisted of a 97% sun-cured alfalfa (Alf), a 66% tall wheatgrass (WG), and a conventional corn-soybean meal diet (CS). The sows were weighed every 2 weeks and changes in backfat thickness were estimated from ultrasonic determinations.

Water consumption was not affected by treatment. The average apparent water intake was 17.5 liters/sow/day with an average spillage of 14.9 liters/day. The CS group gained more weight than those fed high fiber diets during gestation ($P<.001$), with a tendency for the sows in the CS group to have a greater amount of backfat than those fed the high fiber diets.

Metabolizable energy (ME) values were 2,019, 1,874 and 3,733 kcal/kg for Alf, WG and CS diets, respectively. ME value of tall wheatgrass was 597 kcal/kg of dry matter. Sows in the CS group retained more nitrogen (g/day) than those in the Alf and WG groups ($P<.001$). A period × treatment interaction ($P<.05$) was observed for dry matter (DM) digestibility. The sows on the Alf and WG diets showed decreased DM digestibility from day 0 to day 30 and then increased 3.0 and 2.8%, respectively, to day 80 of gestation. Conversely, the CS group showed an increase in DM digestibility slightly above the base at 30 days and then a decrease of 2.7% at 80 days. It appeared that as the digestive system became more accustomed to the fibrous diets, more nutrients from the fiber diets were utilized. A greater amont of hemicellulose was digested after an 80-day adaptation period, but cellulose digestion remained relatively constant during gestation. As fiber content of the diets increased, digestibility of the fiber components, energy and nitrogen decreased.

(**Key Words:** Sows, Roughage, Fiber, Alfalfa, Wheatgrass, Nutritive Value.)

INTRODUCTION

Carroll and Krider (1971) suggested that feed is the largest single factor in the cost of pork produced. It represents 70 to 75% of the total cost of swine production; a major portion of this feed is consumed for maintenance of the breeding herd. The possibility of increasing the use of forages and roughages in swine production was theorized by Carroll (1936). He suggested that sows could make more extensive use of forage materials; however, the forage should be fine stemmed, leafy, tender and succulent. Utilizing forages in the sow diet could result in at least a 50% reduction in grain feeding. Peo (1975) indicated that substituting alfalfa or prairie hay in the diets of dry and gestating sows can reduce feed costs as much as 4 to 10¢ per day while maintaining satisfactory reproductive performance. Forage such as alfalfa has shown its most beneficial effect as a feedstuff for swine during the reproductive phase. Alfalfa in brood sow diets increased ovulation rate (Teague, 1955) and litter size at birth (Cunha *et al.*, 1944; Seerley and Wahlstrom, 1963; Teague, 1955). Danielson and Noonan (1975) fed a 96.75% sun-cured alfalfa diet through three successive gestations and maintained satisfactory reproductive performance. Allee (1977) found that self-feeding a diet containing 96.9% dehydrated alfalfa during gestation had no significant effects on reproductive performance. Since Boyd *et al.* (1976) showed that the metabolizable energy value of sun-cured

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[2] Department of Animal Science. Acknowledgement is made to Alice Teter, Marie Allen, Gerald Walker and Marijane England for their assistance in the conduct, analysis and reporting of this research.

TABLE 1. COMPOSITION OF GESTATION DIETS

Ingredient, %	Internat'l Ref. No.	Diet		
		Alf	WG	CS
Alfalfa hay, S-C, MB	1-00-063	96.75	...	2.5
Wheatgrass, tall, S-C, mature		...	66.0	...
Corn, yellow	4-02-931	...	12.9	77.2
Soybean meal (44%)	5-04-604	...	17.8	15.0
Dicalcium phosphate	6-01-080	...	2.0	3.125
Limestone, ground	6-02-632	...	.275	.875
Sodium phosphate	6-04-208	2.4	...	...
Salt, iodized	6-04-152	.5	.5	.5
Trace minerals[a]		.1	.1	.1
Vitamin premix[b]		.25[c]	.425[d]	.7[e]

[a]Contributed the following per kg diet: Zn, 200 mg; Fe, 100 mg; Mn, 54 mg; Cu, 11 mg; Co, 1.0 mg; I, 1.5 milligrams.

[b]Finely ground corn used as carrier.

[c]Contributed the following per kg diet: Vitamin A, 1512 IU; vitamin D_3, 122 IU; riboflavin, 2.2 mg; calcium pantothenate, 3.7 mg; niacin, 9.9 mg; choline chloride, 11.0 mg; vitamin B_{12}, 11.0 micrograms.

[d]Contributed the following per kg diet: Vitamin A, 1830 IU; vitamin D_3, 148 IU; riboflavin, 2.0 mg; calcium pantothenate, 3.0 mg; niacin, 9.0 mg; choline chloride, 10 mg; vitamin B_{12}, 10 micrograms.

[e]Contributed the following per kg diet: Vitamin A, 3384 IU; vitamin D_3, 274 IU; riboflavin, 1.5 mg; calcium pantothenate, 2.5 mg; niacin, 6.6 mg; choline chloride, 7.3 mg; vitamin B_{12}, 7.3 micrograms.

alfalfa for gilts and sows is 150% higher than reported by NRC (1973), the above observations are not surprising.

This study was conducted to determine the effect of feeding high levels of various roughages during gestation on the utilization of nitrogen, energy, and fiber by pregnant sows.

EXPERIMENTAL PROCEDURE

Metabolism studies, employing 18 crossbred sows (second or third parity), were conducted to determine nutritive value of high fiber diets for gravid sows. The assays were initiated at days 0 (prior to breeding), 30 and 80 of gestation. The pelleted experimental diets (table 1), 97% sun cured alfalfa (Alf), 66% tall wheatgrass (WG) and corn-soybean meal (CS), were initiated the day following breeding. The diets were formulated to equalize vitamin and mineral intakes, except for Ca and P in the Alf diet (table 2). The tall wheatgrass was devoid of head or seed. All females received an estimated 5000 Kcal of metabolizable energy (ME) during gestation until day 110 postcoitum when the lactation diet was started (table 2). To evaluate the effects of pregnancy on nutrient utilization, all sows were subjected to metabolism assessment prior to breeding, using the CS diet to establish a baseline.

Three days prior to the 5-day total collection period, each sow was placed in a metabolism crate in a controlled environment with artificial light supplied continuously and the room tem-

TABLE 2. CHEMICAL ANALYSES OF GESTATION DIETS

Item[a]	Diets		
	Alf	WG	CS
Dry matter, %	90.0	91.9	89.5
Crude protein, %	16.8	11.8	14.0
Ca, %	1.19	.74	.72
P, %	.87	.65	.65
ADF, %	32.0	32.6	5.3
NDF, %[b]	37.3	48.7	9.9
Cellulose, %	24.3	24.2	4.6
Hemicellulose, %	5.3	16.1	4.6
Lignin, %	7.0	4.4	.7
Total fiber, %[c]	36.6	44.7	9.9
Gross energy, Mcal/kg	4.17	4.10	4.17
Calculated ME, Mcal/kg	2.03	2.24	3.05
Daily intake/sow, kg	2.46	2.23	1.64

[a]All anlyses are reported on as-is basis.

[b]Takediastase was used in pre-digestion step to facilitate filtration of NDF.

[c]Cellulose + lignin + hemicellulose.

perature controlled at 25 C. On the day prior to initiation of the collection period, sows were catheterized to facilitate feces and urine separation. Bardex Foley[3] catheters (size 18, 5cc, plug type) were used to avoid contamination of the excreta. Insertion of the catheter was accomplished by passing the fingers of the left hand through the vulva, locating the urethra opening with the tips of the fingers and guiding the catheter from the right hand through the fingers of the left hand into the urethra. The catheter was directed into the bladder and then inflated by injecting 10 cc of warm tap water into the plug. Prior to insertion, a sterile lubricant was coated on the fore-fingers and the catheter to facilitate ease of movement and entry. After insertion was completed, tygon tubing was connected to the catheter to direct the urine collections into a 20-liter plastic container containing 100 ml of concentrated HCl diluted 1:1 with water. Masking tape was used to bind the tygon tubing and catheter to prevent separation.

Urine output per day was weighed and recorded. A 10% aliquot was obtained from the total sample while it was being continually mixed. At the end of the study the aliquots were composited and subsampled. A sample of between 150 and 250 ml of urine was freeze-dried to be used for gross energy and dry matter determinations. A representative sample was saved for nitrogen analysis. Feces, collected three times daily, were placed in plastic bags and frozen. At the end of the collection period, the feces were thawed, mixed and subsampled. Samples of approimately 600 g were frozen and other samples were dried in a forced air oven at 75 C for 24 hours. After drying, the feces were ground through a Wiley mill (1 mm screen), mixed thoroughly, and subsampled.

Acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by methods of Van Soest (1963); neutral detergent fiber (NDF) by the method of Van Soest and Wine (1967). It was necessary to use takediastase in a predigestion step to facilitate filtration of the NDF (Smith *et al.*, 1978) by breaking down the starch, especially in the control diet.

Energy determinations of all samples were made in an adiabatic bomb calorimeter as outlined by Parr (1960). Gross energy of the lyophilized urine was determined using approximately a 1 g sample with .25 g of benzoic acid to facilitate ignition. Gross energy values of the urine were corrected for the addition of benzoic acid. Nitrogen content of feed, urine and dried feces were analyzed by the Kjeldahl method (AOAC, 1975). All pigs had free access to automatic nipple waterers which were equipped with a meter[4] to measure water flow. Water spillage was collected and measured to adjust total water flow for apparent water intake.

The sows were weighed every 2 weeks during gestation. Simultaneously, backfat measurements were taken by ultrasonic[5] determinations at three predesignated locations along the topline approximately 2.5 cm to the left of midline as outlined by Isler and Swiger (1968).

Following parturition, a 16% protein lactation diet was fed *ad libitum* for a 14-day period. Sows were weighed at day 110 of gestation, 1 day postpartum and at weaning. Reproductive parameters were measured at birth and at days 7 and 14 following parturition.

Data were analyzed by least square analysis of variance using the statistical analysis system as implemented by Harvey (1960). Pre-planned comparisons (Alf + WG *vs* CS and Alf *vs* WG) were made (Snedecor and Cochran, 1967). Regression coefficients for pregnancy weight gain and backfat measurements for each sow were calculated and used as a parameter to compare treatments.

RESULTS AND DISCUSSION

Nitrogen Metabolism. Summary of the results of the nitrogen metabolism study is reported in table 3 and figure 1. The concept of nitrogen balance is attractive in theory but difficult to undertake accurately. It is most efficient when isonitrogenous, isocaloric diets containing proteins of different biological values are being compared, and is subject to most error when both nitrogen and energy intakes differ between treatment groups. Nitrogen intake was similar for the CS and WG diets, but it was not feasible to dilute the protein of the Alf diet to comparable levels.

CS-fed sows retained more nitrogen (g N/day) than Alf and WG groups ($P<.05$). Therefore, the nitrogen retention (% of intake) and apparent N-digestibility were also significant ($P<.05$). The sows fed WG had a negative N-balance in both the first and last trimester assays, whereas sows fed CS and Alf had positive balances. The Alf and WG fed groups showed a decrease in N-

[3] C. R. Bard, Inc., Murray Hill, NJ.

[4] American Meter Division, LoFlow Fuel Meter, Nebraska City, NE.

[5] Itha Co Ultra sonic Scanoprobe, Ithaca, NY.

TABLE 3. EFFECT OF ROUGHAGE IN SOW DIETS ON NITROGEN METABOLISM

	Diet						
	CS			WG		Alf	
Day of gestation	0[a]	30	80	30	80	30	80
Intake, g N/day	39.4	35.0	36.2	39.8	38.2	59.7	62.1
Fecal, g N/day	3.2	3.0	4.3	11.5	11.5	18.1	18.3
Urinary, g N/day	28.7	25.3	22.5	28.4	33.2	41.1	41.4
N Balance[b,c]	7.5	6.7	9.4	−.1	−6.4	.5	2.4
N Retention (% of intake)[b,c]	19.0	19.1	26.0	−.3	−16.7	.8	3.9
N Digestibility, %[b]	91.9	91.4	88.1	71.1	70.0	69.7	70.5

[a]Represents average for all 18 sows prior to breeding.

[b]CS *vs* Alf + WG (P<.001)

[c]Alf *vs* WG (P<.05.

retention from the initial collection (0 days) to the 30 or 80 day collections (P<.05).

Elsley and MacPherson (1964) stated that the increase that occurs in nitrogen retention in late pregnancy can only be achieved if the intake of energy is adequate. If energy is limiting, it is inevitable that a proportion of the dietary protein will be used as a source of energy rather than from body protein. It is possible that energy was a limiting factor in this study, especially in the WG group.

The N-balance of the CS-fed sows was higher at the third period than at the first period (7.5 *vs* 9.4). Since Adams *et al.* (1960), Hesby *et al.* (1970) and Allee and Baker (1970) point out that nitrogen retention is dependent of the quality of the protein fed, it is possible that protein quality of the Alf and Wg diets was inferior to the CS diet.

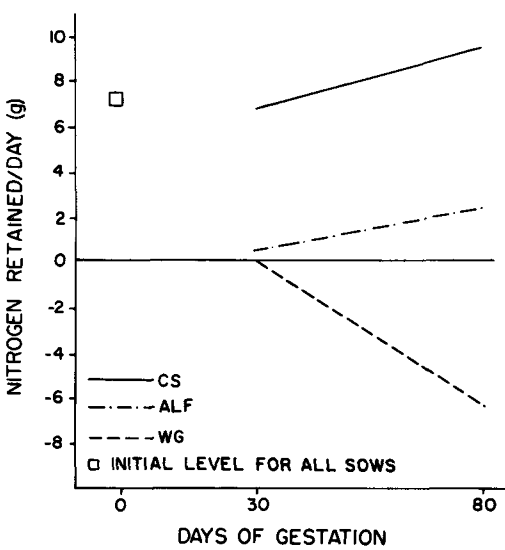

Figure 1. Effect of roughage in sow diets on nitrogen retention, CS = corn-soybean meal; Alf = 97% alfalfa; WG = 66% wheatgrass.

Energy Metabolism. A summary of the energy metabolism data is presented in table 4. Differences (P<.001) in the efficiency of energy utilization existed between CS *vs* Alf and WG. As expected, no statistical differences at day 0 were observed for the digestible energy (DE) or metabolizable energy (ME) values, making it feasible to pool the data to establish a baseline for treatment comparisons. Also, no significant interactions or period effects were observed.

At the beginning of the trial, ME values were estimated in an attempt to feed the diets isocalorically at 5,000 kcal ME/day as shown in table 2. Since mid-term energy metabolism in periods 2 and 3 were not significantly different, the two periods (days 30 and 80) were averaged for discussion purposes. The actual ME levels fed per day for Alf, WG and Cs diets were 4,966, 4,179 and 6,122, respectively. ME values of 1937 kcal/kg of alfalfa (150% higher than NRC (1973) value) as reported by Boyd *et al.* (1976) were used to estimate ME intake. Estimated ME of Alf was similar to the actual value, whereas ME of WG was 85% of the estimate. The actual ME for the CS group was 122% of estimated values, based on NRC (1973) values. The standard DE and ME values from NRC are normally based on digestibility and metabolism studies with growing pigs fed *ad libitum.* Thus, they may not be applicable to sows when a limited-feeding system is used, especially for high fiber ingredients.

TABLE 4. EFFECT OF ROUGHAGE IN SOW DIETS ON ENERGY METABOLISM

	Diet						
	CS			WG		Alf	
Day of gestation	0[a]	30	80	30	80	30	80
DE, %[b,c]	91.2	93.2	91.7	48.2	51.2	52.5	55.0
DE, Kcal/kg[b,c]	3942	3890	3826	1974	2099	2187	2293
ME, %[b]	87.8	90.0	88.9	43.9	47.6	47.6	49.3
ME, Kcal/kg[b]	3766	3756	3710	1799	1949	1981	2056
ME/DE Ratio[b]	95.5	96.6	97.0	91.1	92.9	90.6	89.7
Feed offered, kg/day	1.64	1.64	1.64	2.23	2.23	2.46	2.46
ME/day, Kcal[b,c]	6176	6160	6084	4012	4346	4873	5058

[a]Represents all 18 sows prior to breeding.

[b]CS *vs* Alf + WG ($P<.001$).

[c]Alf *vs* WG ($P<.05$).

ME values as a percentage of DE for Alf, WG and CS, averaged for Periods 2 and 3, were 90.1, 92.0 and 96.8, respectively. It is generally recognized that ME values are approximately 96% of the DE values (NRC, 1973), although individual feed ingredients vary considerably.

Young *et al.* (1977) estimated energy values of corn and soybean meal, using regression analysis, when several ingredients are fed in various combinations. By modifying his methods slightly, as shown below, it is possible to predict the ME value of wheatgrass. The WG and CS diets averaged 1,874 and 3,756 kcal/kg for the combined periods. The WG diet consisted of 66% wheatgrass and the other 34% is assumed to be accounted for by corn and soybean meal. The corn-soy portion of the diet supplies 1277 kcal/kg (.34 × 3756). Thus, the energy supplied by the corn-soy portion subtracted from 1874 kcal/kg of WG diet equals 597 kcal/kg from wheatgrass, which is about 1/3 the value of sun-cured alfalfa.

Dry Matter and Fiber Utilization. Average digestion coefficients of dry matter (DM) and fiber utilization are given in table 5. As expected, no statistical differences at day 0 were observed for the digestion coefficients, making it feasible to pool the data to establish a baseline for treatment comparisons. All digestion coefficients were statistically significant ($P<.05$) between periods 2 and 3. As illustrated in figure 2, a treatment × period interaction ($P<.05$) was observed. DM digestibility of the CS diet increased, but that of the high fiber diets decreased with time. It appeared that as the digestive system became more accustomed to the diets more nutrients were utilized. These results agree with those of Wusson and Weniger (1954) who found that length, as well as weight and volume, in the small and large intestine can be increased

TABLE 5. SUMMARY OF AVERAGE DIGESTION COEFFICIENTS OF SOWS FED ROUGHAGE DIETS

	Diet						
	CS			WG		Alf	
Day of gestation	0[a]	30	80	30	80	30	80
Dry matter[b,c]	89.3	90.1	87.4	46.6	49.4	54.3	57.3
Neutral detergent fiber[b]	72.4	66.2	60.5	26.7	34.0	35.2	39.5
Acid detergent fiber[b,c]	71.0	61.7	33.6	23.2	23.7	36.2	36.4
Cellulose[b,c]	89.0	78.8	78.9	29.0	27.9	47.3	47.8
Hemicellulose[b]	74.7	70.9	84.5	33.6	46.8	28.9	58.1

[a]Represents all 18 sows prior to breeding and other periods represent six sows.

[b]CS *vs* Alf + WG ($P<.001$).

[c]Alf *vs* WG ($P<.05$).

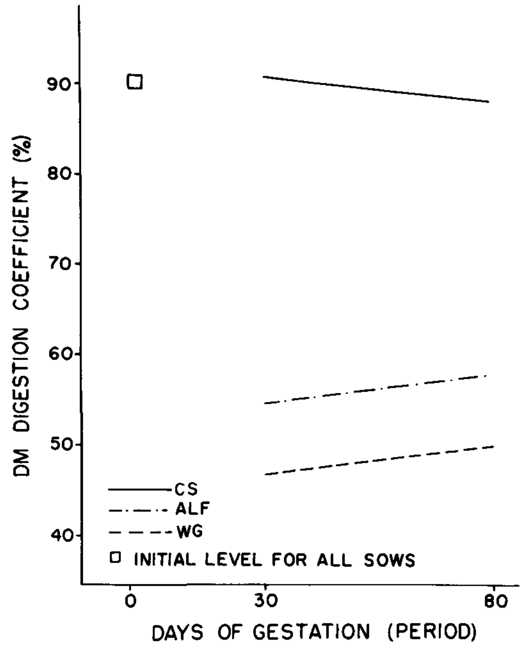

Figure 2. Effect of roughage in sow diets on dry matter utilization, CS = corn-soybean meal; Alf = 97% alfalfa; WG = 66% wheatgrass.

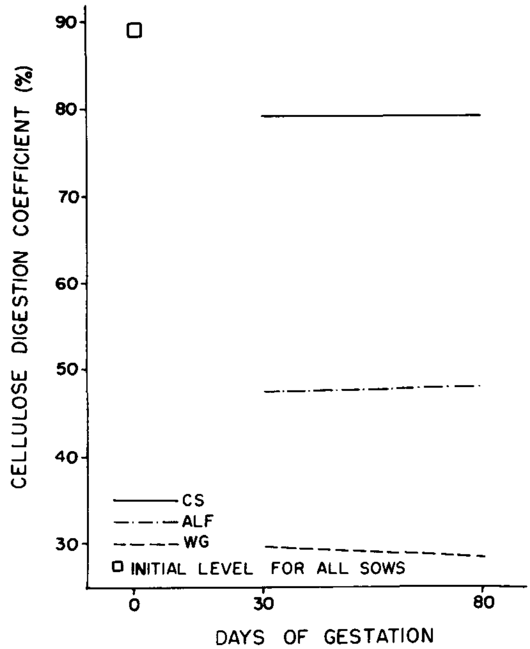

Figure 3. Effect of roughage in sow diets on cellulose utilization, CS = corn-soybean meal; Alf = 97% alfalfa; WG = 66% wheatgrass.

by feeding bulky, fibrous materials to growing-finishing swine.

A consistent positive relationship between DM digestibility and nitrogen and fiber utilization was observed. Significant ($P<.01$) correlations of DM with apparent N-digestibility ($r = .76$), digestible energy ($r= .46$), ADF digestion ($r = .59$), NDF digestion ($r = .57$) and hemicellulose digestion ($r = .46$) were obtained. As expected, DM digestion is a function of fiber and nitrogen utilization.

The digestibility of cellulose and hemicellulose by nonruminants is not well defined. These carbohydrates cannot be digested except by microbial fermentation (Keys *et al.*, 1969). As observed with DM digestion, fiber digestibility was different ($P<.001$) for the CS *vs* the two fiber diets. Digestion coefficients of cellulose and hemicellulose are graphed in figures 3 and 4, respectively. Cellulose digestion after breeding was relatively constant for each treatment. A period effect ($P<.01$) was observed for hemicellulose digestion, which increased dramatically from day 30 to day 80, especially for the Alf group. It is possible that the hemicellulytic microbes had a greater capacity to utilize the cell wall constituents after a 2- or 3-month adaptation period.

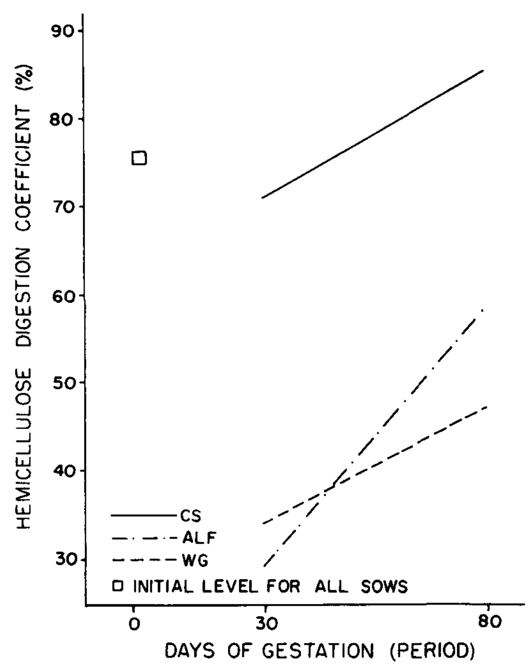

Figure 4. Effect of roughage in sow diets on hemicellulose utilization, CS = corn-soybean meal; Alf = 97% alfalfa; WG = 66% wheatgrass.

TABLE 6. SUMMARY OF WATER CONSUMPTION OF GRAVID SOWS FED ROUGHAGE DIETS MONITORED BY LO-FLOW METERS[a]

	Diet						
	Alf		WG		CS		
Day of gestation	30	80	30	80	30	80	AVG
	(Least square means)						
Total water flow (liter/day)	24.3	37.7	34.1	32.4	39.8	26.4	32.4
Spillage[b]	10.7	18.8	13.5	17.8	16.7	12.1	14.9
Apparent water intake[c]	13.6	18.9	20.6	14.6	23.1	14.3	17.5

[a]Represents 32 observations.

[b]Range of 3.44 to 49.70 liters/day.

[c]Range of 3.44 to 46.22 liters/day.

The digestion coefficients for hemicellulose and cellulose digestion are similar to the values reported by Boyd *et al.* (1976) in open sows and gilts fed a 97% alfalfa diet. The coefficients for cellulose and hemicellulose were 25.7 and 59.0, respectively, for gilts and 34.0 and 56.0 for sows.

Although the site of fiber digestion was not determined, Keys and DeBarthe (1974) observed that 100% of the cellulose and 80% of hemicellulose digestion occurred in the large intestine of swine fed alfalfa, milo or Texas Keingrass. They suggested also that most of the cellulose and hemicellulose of Coastal Bermudagrass appeared to be digested in the small intestine.

The amount of cellulose, hemicellulose and lignin for each diet is given in table 2. These three fractions represent the components of fiber. Total fiber for Alf, WG and CS (as-fed basis) was 36.6, 44.7 and 9.9, respectively. Increasing fiber content of the diet decreased digestibility of the fiber components which also varied with fiber source. Digestibilities of nitrogen and energy followed the same trend as the fiber fractions. These results are in agreement with Scott and Noland (1959) who experimented with utilization of high fiber diets for breeding swine. They concluded that as fiber content of the diet increased (range from 4 to 41% crude fiber) digestion of the nutrients was reduced.

Water Consumption. Water consumption data are summarized in table 6. No statistical significant differences among treatments was observed for water spillage and apparent water intake. A significant correlation (r = .83) between apparent water intake and total urine flow was observed, which indicates that the water consumption measurements were relatively accurate. Approximately the same amount of water was wasted as consumed (14.9 *vs* 17.5 liters/day). Morrison (1956) stated that neither the frequency of feeding, the time of watering, no the quantity of water consumed (within reasonable limits) influences digestibility.

Backfat and Pregnancy Weight Gain. A summary of backfat measurements is shown in table 7. Least-square analysis of variance of regression coefficients showed no significant differences in backfat thickness among treatments. Alf and WG had negative coefficients,

TABLE 7. EFFECT OF ROUGHAGE IN SOW DIETS ON ULTRASONIC DETERMINATIONS OF BACKFAT[a]

	Week of gestation							
Diet	0	2	4	8	10	13	14	Avg regression coefficients
	(mm)							
Alf	17.2	17.3	17.5	17.0	16.0	11.9	15.7	–.0009
WG	19.5	16.8	17.7	17.9	17.2	16.0	15.0	–.0011
CS	16.1	16.5	19.0	20.8	21.3	17.3	19.6	.0023

[a]Measurements represent six sows per treatment probed by ultrasonic determinations on three predesignated locations and averaged.

TABLE 8. EFFECT OF ROUGHAGE IN SOW DIETS ON PREGNANCY WEIGHT GAIN[a]

Diet	Week of gestation 0	2	4	6	8	10	12	14	16	Total gain[b,c]	Avg regression coefficient[b,c]
	(kg)										
Alf	177	173	176	170	175	179	178	194	201	24	.2345
WG	182	176	177	174	179	182	178	184	189	7	.1671
CS	173	171	177	173	183	190	190	200	214	41	.7839

[a]Average weights of six sows per treatment weighed at 2-week intervals.

[b]Alf *vs* WG (P<.05).

[c]CS *vs* Alf + WG (P<.01).

while CS was positive. Adam *et al.* (1971) indicated a positive linear relationship between net sow gain and the change in amont of carcass fat during pregnancy. This suggests that there would be little change in carcass fat if net sow gains in pregnancy were about 10 kilograms. CS is the only diet that prouced a gestation gain of more than 20 kilograms. It appears that the backfat catabolic phase starts about the eighth week of gestation. Fat losses tended to be highest on the lower level of feeding, which is in agreement with Adam *et al.* (1971).

A summary of pregnancy weight gain is shown in table 8 and figure 5. The average regression coefficient is high for CS (P<.001) that for the fiber diets. Figure 5 shows that sows fed the fiber diets started to increase weight during the sixth week. Sows fed the CS diet gained more weight than fiber-fed sows. There was a tendency for the CS group to have more backfat.

Reproductive Performance. Reproductive performance data presented in table 9 indicate that most of the sows had a normal pregnancy and lactation. One sow on the Alf treatment aborted at approximately 100 days of gestation; cause of the abortion was undetermined. The survival rate was higher for pigs from sows fed the CS diet compared to the fiber-fed groups (86.8 *vs* 84.0 and 76.97%). Sows in the CS group

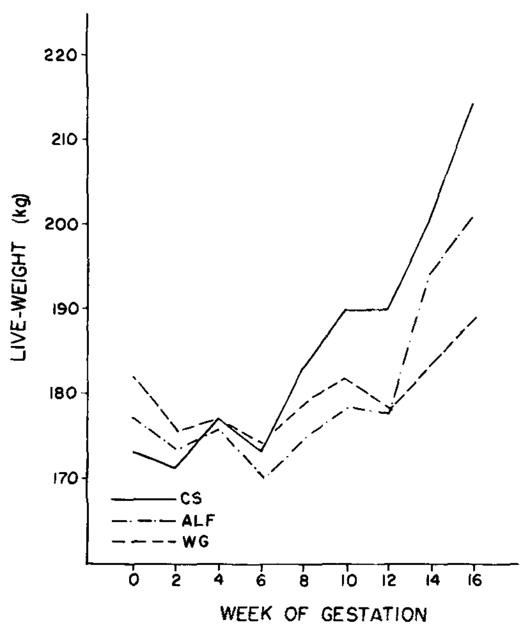

Figure 5. Effect of roughage in sow diets on pregnancy weight gain, CS = corn-soybean meal; Alf = 97% alfalfa; WG = 66% wheatgrass.

TABLE 9 EFFECT OF ROUGHAGE IN DIETS OF SOWS ON REPRODUCTIVE PERFORMANCE

Criterion	Diets Alf	Wg	CS
No. of sows	5[a]	6	6
Farrowing			
Number live	10.0	10.8	11.2
Stillborn	1.0	1.2	.5
Mummified fetus[b]	0	1.0	.5
Avg birth weight, kg	1.32	1.19	1.32
At 7 days			
Number live	8.6	8.7	9.8
Avg weight, kg	2.46	2.28	2.48
At 14 days			
Number live	8.4	8.3	9.7
Avg weight, kg	3.81	3.79	4.40
Survival rate, %	84.0	76.9	86.6
ADFI, kg	4.70	4.76	4.20
Lactation gain, kg[c]	–.3	3.8	–5.5

[a]One sow aborted at approximately 100 days of gestation.

[b]Alf *vs* WG (P<.05).

[c]CS *vs* Alf + WG (P<.01).

lost more weight during lactation (P<.01) than those in the Alf and WG groups. There is conclusive evidence that sow weight change during lactation is directly related to the degree of body stores obtained during gestation and thus related to gestation energy intake. Baker *et al.* (1968, 1969, 1970), Lodge (1969) and Simoneaux and Thrasher (1971) have all shown that sows that gain more during gestation lose more weight during lactation.

LITERATURE CITED

AOAC. 1975. Official Methods of Analysis (12th Ed.). Association of Agricultural Chemists. Washington, DC.

Adam, J. L., I. J. Shearer and K. Hargreaves. 1971. The effects of type and level of feeding of sows during pregnancy. New Zealand Journ. Agr. Res. 14:646.

Adams, C. R., D. E. Terrill, S. W. Norton, H. W. Norton and A. H. Jensen. 1960. Rate of ovulation and implantation in swine as affected by dietary protein. J. Anim. Sci. 19:1245 (Abstr.).

Allee, G. L. and D. H. Baker. 1970. Limiting Nitrogenous factors in corn protein for adult female swine. J. Anim. Sci. 30:748.

Allee, G. L. 1977. Using dehydrated alfalfa to control intake of self-fed sows during gestation. Feedstuffs 49:20.

Baker, D. H., D. E. Becker, H. W. Norton, C. E. Sasse, A. H. Jensen and B. G. Harmon. 1968. Feed restriction of filts during gestation. J. Anim. Sci. 27:1149 (Abstr.).

Baker, D. H., D. E. Becker, H. W. Norton, C. E. Sasse, A. H. Jensen and B. G. Harmon. 1969. Reproductive performance and progeny development in swine as influenced by feed intake during pregnancy. J. Nutr. 97:489.

Baker, D. H., D. E. Becker, A. H. Jensen and B. G. Harmon. 1970. Protein scource and level for pregnant gilts: A comparison of corn, opaque-2 corn and corn-soybean meal diets. J. Anim. Sci. 30:364.

Boyd, R. D., T. D. Creshaw, B. D. Moser, E. R. Peo, Jr. and D. M. Danielson. 1976. Nutritional value of the energy and nitrogen content of sun-cured alfalfa for gilts and sows. J. Anim. Sci. 42:1348 (Abstr.).

Carroll, W. E. 1936. Possibilities of increasing the use of forage and roughage in swine production. Proc. Amer. Soc. Anim. Prod. P. 26. Champaign, IL.

Carroll, W. E. and J. L. Krider. 1971. Swine Production (4th Ed.). McGraw-Hill Book Co., New York.

Cunha, T. J., O. B. Ross, P. H. Phillips and G. Bohstedt. 1944. Further observations on the dietary insufficiency of corn-soybean ration for reporduction of swine. J. Anim. Sci. 3:415.

Danielson, D. M. and J. J. Noonan. 1975. Roughages in swine gestation diets. J. Anim. Sci. 41:94.

Elsley, F. W. H. and R. M. MacPherson. 1964. The effect of feed intake and level of dietary protein upon nitrogen retention of pregnant filts. Anim. Prod. 6:259.

Harvey, W. R. 1960. Least-squares analysis of data with unequal subclass number. USDA Pub. ARS 20-8.

Hesby, J. H., J. H. Conrad, M. P. Plumlee and T. G. Martin. 1970. Opaque-2 corn, normal corn and corn-soybean meal gestation diets for swine reproduction. J. Anim. Sci. 31:474.

Isler, G. A. and L. A. Swiger. 1968. Ultrasonic prediction of lean cut percent in swine. J. Anim. Sci. 27:377.

Keys, J. E. and J. V. DeBarthe. 1974. Cellulose and hemicellulose digestibility in stomach, small intestine and large intestine of swine. J. Anim. Sci. 39:53.

Keys, J. E., Jr., P. J. Von Soest and E. P. Young. 1969. Comparative study of the digestibility of forage cellulose and hemicellulose in ruminants and nonruminants. J. Anim. Sci. 29:11.

Lodge, G. A. 1969. The effects of pattern of feed distribution during the reproductive cycle on the performance of sows. Anim. Prod. 11:133.

Morrison, F. B. 1956. Feeds and Feeding (22nd Ed.). Morrison Publishing Co., Clinton, IA.

NRS. 1973. Nutrient Requirements of Domestic Animals, No. 2. Nutrient Requirements of Swine, Seventh Revised Ed. National Academy of Science —National Research Council, Washington, DC.

Parr Instrument Co. 1960. Oxygen Bomb Calorimetry and Combustion Methods. Technical Manual No. 130. Parr Instrument Co., Moline, IL.

Peo, E. R., Jr. 1975. Hay reduces sow feed cost. Swine Information Service. National Hog Farmer Bull. E9.

Scott, E. W. and P. R. Noland. 1959. Utilization of high-fiber rations for breeding swine. J. Anim. Sci. 18:1161 (Abstr.).

Seerley, R. W. and R. C. Wahlstrom. 1963. South Dakota State College, A. S. Mimeo, Series 63:4-5.

Simoneaux, W. D. and D. M. Thrasher. 1971. Protein and energy requirements of bred sows managed under total confinement. Louisiana State Univ. Eleventh Livestock Producers Day Proc. P. 186-199.

Smith, D. H., G. C. Marten and R. A. Britton. 1978. Use of a diastase pre-digest for determination of cell-wall constituents in corn and sorghum silage. Proc. Amer. Soc. Agron.

Snedecor, G. S. and S. G. Cochran. 1967. Statistical Methods. The Iowa State University Press, Ames.

Teague, H. S. 1955. The influence of alfalfa on ovulation rate and other reporductive phenomena in gilts. J. Anim. Sci. 14:621.

Van Soest, P. H. 1963. Determination of acid detergent fiber and acid detergent lignin. J. Assoc. Official Anal. Chem. 46:829.

Van Soest, P. H. and R. R. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell-wall constituents. J. Assoc. Official Anal. Chem. 50:50.

Wusson, W. and J. H. Weniger. 1954. Development of the stomach and intestinal canal in the pig as affected by diet and in relation to feed utilization. Nutr. Abstr. and Rev. 25:562.

Young, L. G., G. C. Ashton and G. C. Smith. 1977. Estimating the energy value of some feeds for pigs using regression equations. J. Anim. Sci. 44:765.