In this experiment, pigs fed corn-whey-yeast at 14.4 percent protein and .9 percent dietary lysine had 35, 40 and 65 percent greater rate of gain, gain: feed ratio and gain: protein ratio, respectively, than those pigs fed the corn-soybean meal diet at 0.9 percent lysine and 17.9 percent crude protein. At 1.0 percent lysine (14.3 percent protein), the corn-whey-yeast diet produced 25, 35 and 59 percent greater average daily gain, feed efficiency and protein efficiency ratio over the 17.9 percent protein corn-soybean meal diet.

The results of this study indicate that whey-yeast protein is consistently superior to soybean meal protein for baby pigs. The reasons for this are unclear; however, whey-yeast protein contains higher levels of most indispensible amino acids than soybean meal protein. The possibility of whey-yeast lysine being more readily available to the pig than soybean meal lysine is suggested in this study.

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Influence of Protein Intake, Energy Intake and Stage of Gestation on Protein Status of the Gestating Gilt

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Story in Brief

Thirty-six crossbred gilts were fed three levels of protein (8, 14 and 20 percent protein diets) and two levels of energy (approximately 6200 kcal DE/day and 6200 kcal DE/day + 20 percent) throughout gestation. Five-day nitrogen balance studies were conducted at early (0-30 days), mid (30-60 days) and late (60-90 days) gestation. At slaughter (90 days gestation), reproductive tracts were evaluated for reproduction performance and samples of the reproductive tract and semimembranosus muscle were analyzed for crude protein.

The results of this experiment suggest that an 8 percent protein ration during gestation is just as effective as the higher levels of crude protein intake for litter size or storage of protein in the reproductive tissue. However, storage of protein in muscle tissue increased as protein level was increased to levels from 14 to 20 percent crude protein. No advantage for the higher energy diets for these traits was noted.

Introduction

Several recent studies have been unable to establish a relationship between protein or energy intake on subsequent litter size or pig weight at birth. This suggests that the gestating gilt or sow is able to utilize tissue stores for the normal development of the fetus to parturition even under conditions of suboptimum energy and/or protein nutrition. However, more recent studies have shown that the depletion of stores during gestation does have an adverse effect on lactation performance as measured by litter size and litter weight at weaning.

The amount of tissue stores needed to optimize subsequent lactation performance has not been adequately determined. The fate of this stored muscle nitrogen at parturition and its role is subsequent lactation and rebreeding performance is an unanswered question.

The objectives of this study were to examine nitrogen retention in the pregnant gilt as affected by protein intake, energy intake and stage of gestation. Concurrent evaluation of reproductive performance, growth rate and tissue protein content were conducted.

Materials and Methods

Thirty-six crossbred (two and three breed crosses of Hampshire, Yorkshire and Duroc) gilts were fed three levels of protein (8, 14 or 20 percent crude protein) and two levels of energy (moderate (M) and high (H)). The M20 percent crude protein corn-soybean meal diet was extended with corn starch to give the M8 percent and M14 percent crude protein rations. The moderate energy rations were further extended with corn starch to increase the digestible energy content of the moderate energy rations by 20 percent to yield the high energy rations (Table 1). Thus, amino acid rations across protein levels were maintained.

Gilts were randomly assigned to one of four dirt lots at approximately 270 days of age. Gilts were fed once daily in individual feeding stalls and had access to drinking water and shelter. Gilts were observed daily for signs of estrus by introducing a teaser boar into the pens and were bred on the second estrus after initiation of the trial. After breeding, gilts were changed from 5.0 lb of a 16 percent crude protein diet to 4.0 lb (moderate energy rations) or 4.75 lb (high energy rations) of the experimental diets. On days 25, 55 and 85 of gestation, urine and feces were collected for four days.

Gilts were slaughtered on day 90 of gestation. Reproductive tracts were recovered as quickly as possible after slaughter and uniformly trimmed. The reproductive tracts were weighed and evaluated immediately for reproductive status. Corpora lutea counts were recorded for each ovary and each uterine horn was dissected from the cervical end to obtain embryo numbers.

All solid tissues including the uterus, ovaries, placenta, and fetuses were ground twice in a Hobard Model 4332 grinder and a ground sample was quickly frozen for subsequent nitrogen analysis. Volumes were recorded for freely draining uterine fluids

Table 1. Calculated composition of experimental diets.

Item	M 8%	H 8%	M 14%	H 14%	M 20%	H 20%
Corn (9%)[a]	24.75	20.81	44.76	37.70	64.77	54.64
Soybean meal (44%)[a]	12.31	10.35	22.25	18.74	32.20	27.17
Corn starch (0.6%)[a]	59.24	65.73	29.62	40.72	- - - - -	15.63
Dicalcium phosphate	1.94	1.63	1.33	1.12	0.71	0.60
Calcium carbonate	0.76	0.64	1.04	0.88	1.32	1.11
Vitamin T.M. premix[b]	0.50	0.42	0.50	0.42	0.50	0.42
Salt	0.50	0.42	0.50	0.42	0.50	0.42

[a]Estimated percent protein given in parentheses.

[b]Vitamin-trace mineral premix supplied 2004 IU Vitamin A, 150 IU Vitamin D_3, 5 IU Vitamin E, 2.0 mg riboflavin, 10 mg d-pantothenic acid, 15 mg niacin, 400 mg choline chloride, .0075 mg Vitamin B_{12}, 1.0 mg menadione sodium bisulfite per lb of diet and 22 PPM Mn, 100 PPM Zn, .22 PPM I,99 PPM Fe, and 11 PPM Cu. (High energy rations supply 84% of these values).

and a sample was frozen for nitrogen analysis. The liver and the semimembranosus muscle of each left ham was removed as soon after slaughter as possible and weighed. The muscle was quickly ground and samples frozen for subsequent nitrogen analysis.

Carcass weights were obtained and the right side of the carcass was subject to a physical separation of fat, lean and bone.

Body weight, growth data and nitrogen balance data were analyzed as a 3 x 2 x 3 factorial arrangement of treatments in a split plot design. Each animal was a main plot with main plot treatments being level of protein in the diet (8, 14 and 20 percent) and dietary energy level (moderate and high). The subplot treatment corresponded to stages of gestation (30,60 and 90 days). Remaining data variables measured in just one period were analyzed as a 3 x 2 factorial arrangement of treatments in a completely randomized design. The two treatment factors were protein level in the diet (8, 14 and 20 percent) and energy level in the diet (moderate and high).

Results and Discussion

Growth

The initial weight and slaughter weight of gilts are presented in Table 2. There were no significant trends in slaughter weight of gilts due to protein level or energy level of the diet. The mean slaughter weights (lb) were 376, 390.5 and 387.6 for the 8, 14 and 20 percent protein diets and 382.6 and 386.3 for the M (moderate) and H (high) energy levels, respectively.

Reproductive performance

Numbers of corpora lutea were 13.3, 13.9 and 12.6 for protein levels of 8 percent, 14 percent and 20 percent respectively (Table 3). For the M and H energy levels, the mean numbers of corpora lutea were 13.4 and 13.2, respectively. None of these values was significantly affected by level of protein intake or level of energy intake.

The mean embryo numbers were 10.9, 9.8 and 10.4 for the 8 percent, 14 percent and 20 percent crude protein diets, respectively. The embryo numbers for both the M and H energy diets were 10.4. There was no significant trends in these values caused by level of protein intake or energy intake.

Nitrogen balance

As protein level increased, nitrogen retention increased linearly ($P<.005$) with mean values of 10.3, 16.6 and 22.6 g/day for protein levels 8, 14 and 20 percent

Table 2. Body weight and growth data of gilts.[a]

	Protein level			Energy level	
Item	8%	14%	20%	M	H
No. of gilts	12	11	10	17	16
Initial wt, lb	293.5	292.1	293.3	297.0	288.9
Slaughter wt, lb	376.0	390.5	387.6	382.6	386.3

[a]Means

Table 3. Reproductive performance of gilts.[a]

	Protein level			Energy level	
Item	8%	14%	20%	M	H
No. of corpora lutea	13.3	13.9	12.6	13.4	13.2
No. of embryos	10.9	9.8	10.4	10.4	10.4

[a]Means

Table 4. Nitrogen balance of gilts.[a]

Item	Protein level			Days gestation			Energy level	
	8%	14%	20%	30	60	90	M	H
Nitrogen retention (g/day)	10.3	16.6	22.6[b]	13.9	14.6	20.5[b]	14.6	18.0[b]
Retained N (% of digested)	55.3	52.1	48.1[c]	42.0	46.7	67.6[d]	47.1	56.3[e]
Dry matter digestibility (%)	84.3	80.7	78.1[f]	81.6	82.3	79.5	78.5	83.8[f]

[a]Means
[b]Linear effect significant ($P<.005$).
[c]Linear effect approached significance ($P<.10$).
[d]Quadratic effect significant ($P<.05$).
[e]Linear effect significant ($P<.025$).
[f]Linear effect significant ($P<.01$).

respectively (Table 4). This linear relationship is similar to that reported by Miller *et al.* (1969) during early gestation, Jones and Maxwell (1974) in early gestation and Jones (1975) throughout gestation.

As energy level increased, nitrogen retention increased with mean values of 14.6 and 18.0 g/day for M and H energy levels, respectively (significant linear effect $P<.005$). Pike (1970) also showed increasing nitrogen retention with increasing energy levels.

Nitrogen retention increased linearly ($P<.005$) as stage of gestation progressed with mean values of 13.9, 14.6 and 20.5 for 30, 60 and 90 days gestation, respectively. These data agree with earlier work by Elsley *et al.* (1966) and Kline *et al* (1972) which showed increasing retention from a low value early in gestation to maximum retentions in late gestation. These data suggest that nitrogen retention is increasing at levels of protein higher than those commonly recommended for gestating gilts (14 to 16 percent protein).

Protein retention efficiency decreased with increasing protein level (linear effect, $P<.1$). Since amino acid ratios are similar across protein levels, this suggests that protein was being supplied in excess of that needed for growth and reproduction, with catabolism and excretion of the excess protein. Retention efficiency increased linearly ($P<.025$) as energy level increased. Further, there was an increase in retention efficiency as state of gestation progressed, (significant quadratic effect, $P<.05$) with mean values of 42.0, 46.7 and 67.6 for 30, 60 and 90 days gestation, respectively. Changes in retention efficiency suggest changes in protein synthesis as pregnancy progresses.

Dry matter digestibility decreased as protein level increased (significant linear effect, $P<.01$) with mean values of 84.3, 80.7 and 78.1 for the 8 percent, 14 percent and 20 percent protein rations. There was no significant trend in dry matter digestibility as stage of gestation progressed. However, dry matter digestibility increased as level of energy intake increased (significant linear effect, $P<.01$). It appears that energy levels, at least up to the H level of this experiment, can increase dry matter digestibility.

Carcass composition

Carcass weight (Table 5) was not affected by protein level. However, total carcass lean (physically separated) and semimembranosus muscle weight increased as protein level increased from 8 to 14 percent of the diet and no further increase was observed at higher protein levels (significant quadratic effect $P<.001$ and $P<.05$, respectively). Liver weight increased linearly ($P<.01$) as protein intake increased. No significant trends were observed in carcass, semimembranosus muscle on liver weight due to energy.

Table 5. Carcass composition of gilts.[a]

	Protein level			Energy level	
Item	**8%**	**14%**	**20%**	**M**	**H**
Carcass					
Weight (lb)	240.2	253.7	250.1	244	251.7
Lean (lb)	125.6	153.3	146.5[b]	142.1	139.9
Semimembranosus muscle					
Weight (lb)	4.09	4.88	4.60[d]	4.64	4.38
Lean (% of dry wt)	79.6	80.4	80.0	79.4	80.6
Liver					
Weight (lb)	3.39	3.56	4.07[c]	3.53	3.78

[a]Means
[b]Quadratic effect significant ($P<.001$).
[c]Linear effect significant ($P<.01$).
[d]Quadratic effect significant ($P<.05$).

Table 6. Uterine volume, weight and composition.[a]

Item	Protein level 8%	14%	20%	Energy level M	H
Uterine fluid					
Volume (oz)	83.3	74.8	58.9[b]	67.0	72.4
Nitrogen (% of dry matter)	8.2	9.0	9.7[c]	8.8	9.0
Uterine					
Weight (lb)	38.9	35.9	32.3[d]	36.5	35.2

Item	Energy level M, Protein level 8%	14%	20%	Energy level H, Protein level 8%	14%	20%
Uterine						
Dry matter(%)[f]	15.0	13.1	13.3	11.7	16.0	13.4
Nitrogen (%)[eg]	7.7	9.4	9.7	10.2	8.5	9.8

[a]Means
[b]Linear effect significant (P<.05).
[c]Linear effect significant (P<.001).
[d]Linear effect approached significance (P<.10).
[e]Significant (P<.05) energy linear x protein linear interaction.
[f]Significant (P<.01) energy linear x protein quadratic interaction.
[g]Significant (P<.05) energy linear x protein quadratic interaction.

By assuming that the percent protein, percent dry matter and percent lean were the same for the physically separated lean as for the semimembranosus muscle, the total protein content of the carcass was calculated. The average dry ether extract carcass protein values were 23.09, 28.72 and 26.70 lb for the 8, 14, and 20 percent protein levels. Average values for the moderate and high energy levels were 26.11 and 26.23 lb, respectively. These data suggest that total protein stores can be increased by increasing protein levels from 0.32 to 0.56 lb/day.

Uterine weight (Table 6) tended to decrease with increasing protein intake and uterine fluid volume decreased linearly (P<.01) with increasing protein intake. Uterine fluid percent nitrogen increased linearly (P<.001) with increasing protein intake. Total uterine nitrogen was not affected by protein intake, although there was a tendency for uterine protein to increase as protein intake increased at the low energy level but not at the high energy level.

The amount of protein in the uterine tissue (not including nitrogen in the uterine fluid) for the 8, 14 and 20 percent protein levels were 4.31, 4.37 and 3.84 lb, respectively. For the medium and high energy levels, the values were 4.20 and 4.15 lb of protein, respectively. This suggests that the level of protein intake supplied by the 8 percent crude protein diets were as effective as that supplied by the higher levels of nitrogen intake for protein deposition in uterine tissues.

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