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## Addition of Fat to Diets of Lactating Sows. II. Effects on Energy Intake, Meal Patterns, and Blood Hormones and Metabolites

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also supported by the small amount of backfat lost during lactation, or in the case of the second parity sows fed the 10% tallow diet, an increase in backfat thickness during lactation.

Milk fatty acid composition was altered (Table 5). The increase in oleic (C18:1) and linoleic (C18:2) acid in the milk is a direct response to increased dietary intake of these fatty acids. However, the amount of palmitic acid (C16:0) in the milk decreased even though dietary palmitic acid content increased. In addition, there is a reduction in the percentages of short-chain fatty acids in the milk of sows fed the high tallow diet. This is also indicative of a reduction in fatty acid synthesis in the mammary glands of sows that consumed the high tallow diet. Therefore, more milk fat was derived from dietary origin in gilts or sows fed the 10% tallow diets. The ability to manipulate milk fatty acid content nutritionally is not surprising because the pig is thought to utilize fat proportionally to what is consumed. In addition, it has been shown that dietary fatty acid content has a significant effect on milk composition.

In summary, the addition of 10% tallow to lactation diets resulted in an alteration of milk fat and fatty acid profiles, without significantly altering sow and pig performance during the lactation period. The increase in milk energy observed in sows and gilts consuming the tallow diets has important research applications for investigating the effects of energy intake on litter performance and sow weight loss during lactation.

<sup>1</sup>Scott L. Tilton and Paul M. Ermer are graduate students, Austin J. Lewis is a Professor, Phillip S. Miller is an Assistant Professor, and Cynthia K. Wolverton is a Research Technologist, Department of Animal Science.

<sup>2</sup>Two sows were removed from the experiment on d 19 due to a technical error. Data from these animals appear only in the initial litter information, and milk yield and composition data.

## Addition of Fat to Diets of Lactating Sows. II. Effects on Energy Intake, Meal Patterns, and Blood Hormones and Metabolites

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Suboptimal feed intake during lactation is associated with reduced litter weight gain and increased sow weight loss. This weight loss may lead to a prolonged weaning-to-estrus interval and decreased embryo survival in subsequent parities. Feed intake is a particular concern in primiparous sows, which consume 15% less feed than multiparous sows.

The consequences of low feed intake and excess body weight loss during lactation have received considerable attention. However, little research has focused on the mechanisms that regulate feed intake in the lactating sow. Furthermore, the progress being made in increasing litter size will continue to increase milk production and nutrient demands during lactation.

Numerous researchers have found that adding relatively large amounts of fat to the diet of lactating sows (e.g., 10% of the diet) results in increased

energy intake, increased milk fat and energy, and increased litter weight gain. At these levels of fat addition, energy intake is increased by approximately .8% for every 1% addition of fat to the diet. However, adding fat seems to have little effect on reducing lactation weight loss.

Our research sought to identify possible physiological mechanisms whereby energy intake is increased when tallow (fat) is added to the diets of lactating sows.

### Methods

Two experiments were conducted using 18 second parity sows and 16 first parity sows (gilts). Sows and gilts were assigned to dietary treatment after parturition. Weights postpartum were 469 and 375 lb for sows and gilts, respectively. A complete description of experimental methods and diets is presented in the preceding article.

Sow and litter weights were recorded weekly throughout the 28-day lactation. Feed intake was determined daily for 21 days. On days 7 and 20 of lactation, meal patterns of 24 sows (12

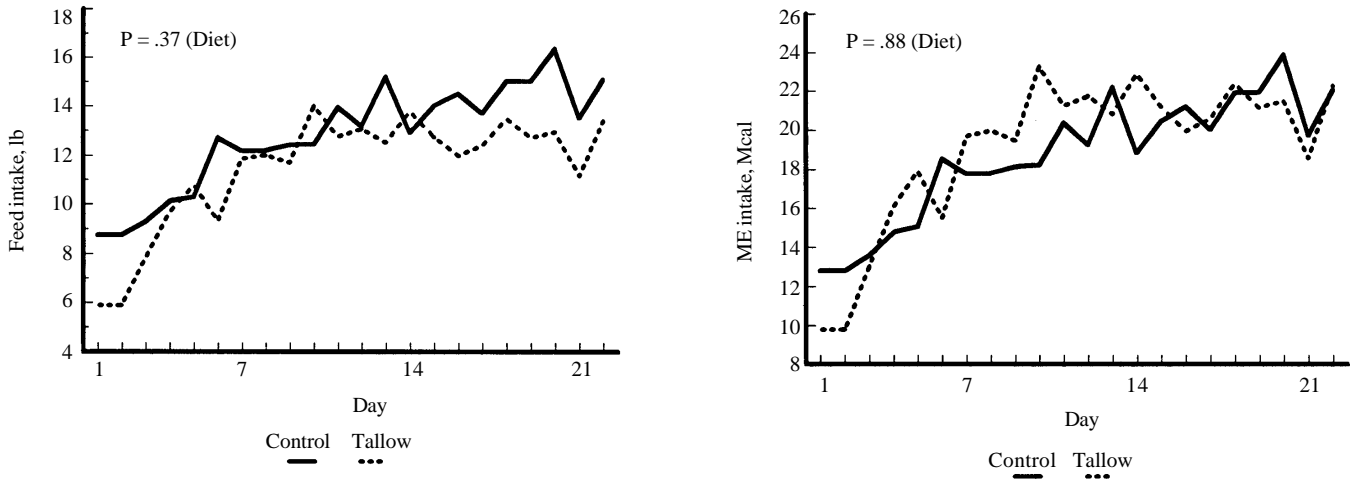


Figure 1. Feed and energy intake of gilts fed either a corn-soybean meal diet or a corn-soybean meal-10% tallow diet throughout a 21-d lactation (n = 16).

sows and 12 gilts) were examined continuously for 24 hours. Time spent eating and time between feedings were recorded and feeders were weighed to determine the amount of feed consumed. Sows were considered to be feeding when observed with their head in the feeder and chewing feed.

For each sow during each 24-hour period, periods of feeding were characterized into meals. Meals were considered to be periods of feeding separated by intervals of relatively short duration (usually 20 minutes or less). These brief and frequent intervals generally represented drinking and other activi-

ties associated with the meal. Longer (30 minutes to several hours), and less frequent intervals represented sleeping or other activities. Statistical methods were used to establish whether an interval was categorized as occurring during the course of a meal or between meals.

Feed consumption rate was calculated by dividing intake during the 24-hour observation period by the duration of time spent consuming feed. Similarly, the percentage of time spent consuming feed was obtained by dividing the duration of time spent consuming feed by the total length of the observa-

tion period (24 hours).

Fasting (overnight) concentrations of hormones and metabolites were measured on venous blood drawn from all sows on day 109 of gestation and days 9 and 23 of lactation. Blood plasma was analyzed for glucagon (gilts only), insulin, glucose, and nonesterified fatty acids (NEFA).

## Results

Daily feed and energy intakes are presented in Figures 1 and 2. There were no differences ( $P > .3$ ) in either

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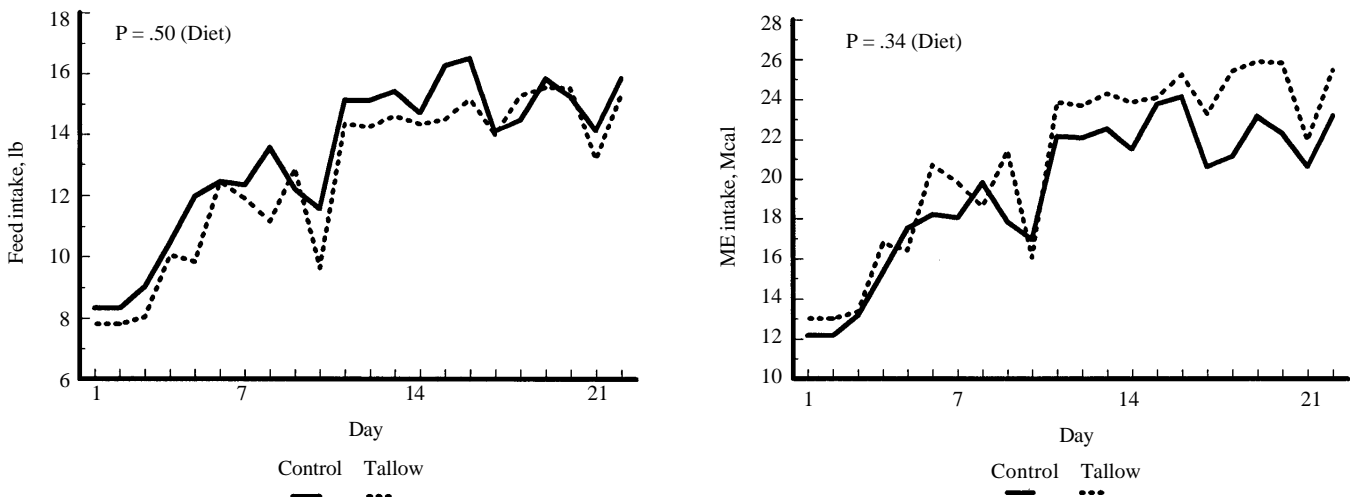


Figure 2. Feed and energy intake of sows fed either a corn-soybean meal diet or a corn-soybean meal-10% tallow diet throughout a 21-d lactation (n = 18).

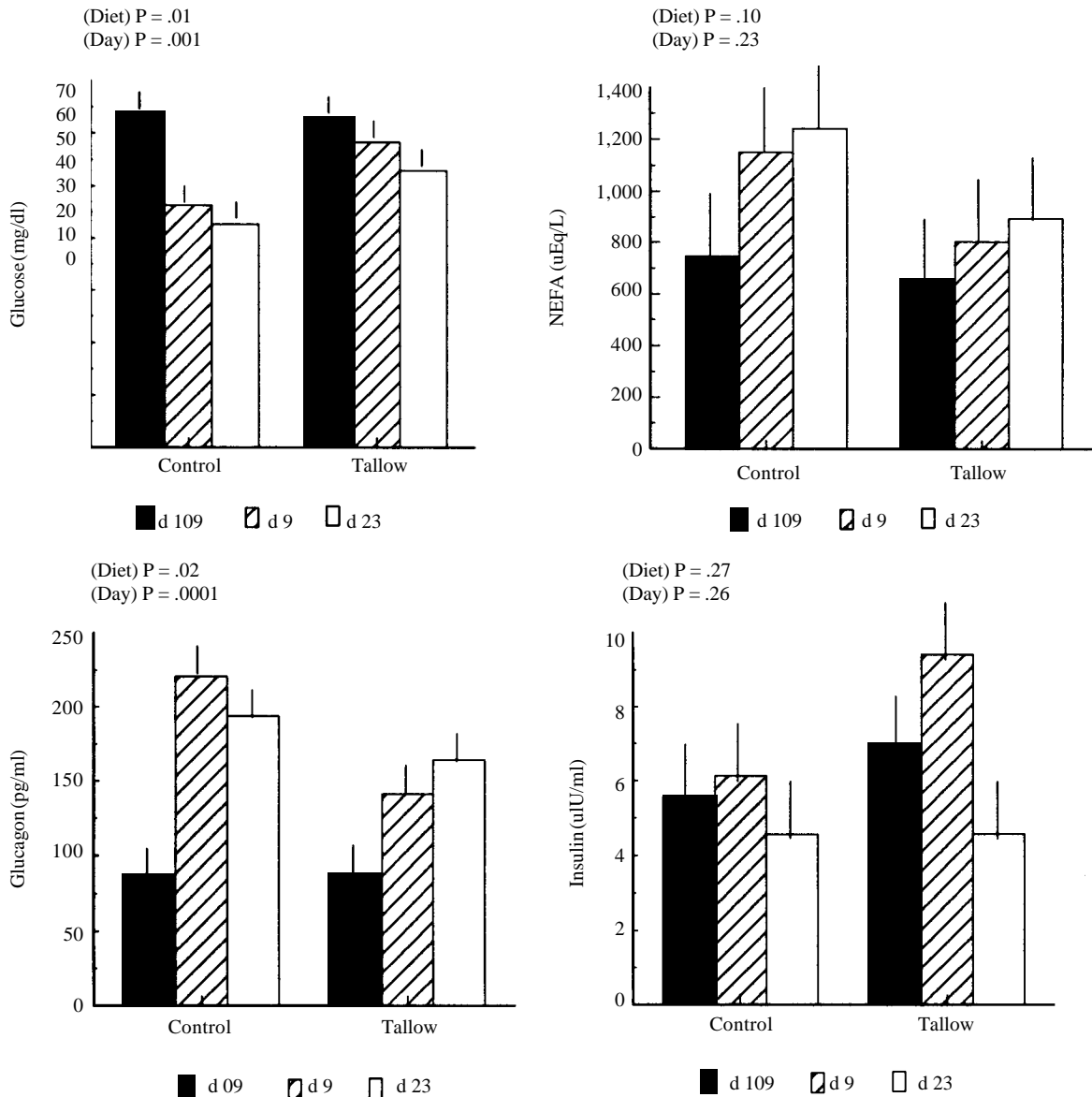


**Table 1. Meal patterns of gilts fed either a corn-soybean meal or a corn-soybean meal-10% tallow diet**

Response	Day	Corn-SBM	Tallow	P (Diet)	P (Day)	P (Diet×Day)	SE <sup>b</sup>
Meal size, lb	7	1.68	1.81	.92	.23	.75	.07
	20	2.20	2.12				
Number of meals	7	7.50	7.83	1.00	.34	.69	.44
	20	7.07	6.67				
Rate of consumption, oz/minute	7	1.71	2.45	.08	.93	.44	4.01
	20	1.91	2.19				
Percentage of time consuming feed, %	7	8.92	6.09	.05	.57	.98	.67
	20	9.88	7.00				

<sup>a</sup>n = 22

<sup>b</sup>SE = standard error



**Figure 3. Concentrations of glucose, nonesterified fatty acids (NEFA), glucagon, and insulin in gilts fed either a corn-soybean meal diet or a corn-soybean meal-10% tallow diet throughout a 21-d lactation (n = 16).**



**Table 2. Meal patterns of sows fed either a corn-soybean meal or a corn-soybean meal-10% tallow diet**

Response	Day	Corn-SBM	Tallow	P (Diet)	P (Day)	P (Diet × Day)	SE <sup>b</sup>
Meal size, lb	7	2.76	1.48	.01	.17	.10	.06
	20	2.67	2.31				
Number of meals	7	5.67	8.17	.16	.77	.15	.43
	20	7.17	7.17				
Rate of consumption, oz/minute	7	1.68	2.30	.002	.90	.79	2.68
	20	1.65	2.38				
Percentage of time consuming feed, %	7	10.03	5.86	.0001	.05	.62	.50
	20	12.64	7.44				

<sup>a</sup>n = 24

<sup>b</sup>SE = standard error

feed or energy intake in either sows or gilts. However, in both sows and gilts, adding tallow to the diet resulted in a numerical reduction in feed intake. Sows fed the tallow diet consumed 8% more energy than sows fed the corn-soybean meal diet. In gilts, adding tallow to the diet resulted in a 3% increase in energy intake.

Meal pattern data for gilts and sows are presented in Tables 1 and 2. The addition of tallow to the diet resulted in reduced meal size in sows on day 7 of lactation (Table 2). There were no differences in meal size on day 20 for either gilts or sows. Both sows and gilts

that received the tallow diet spent less time ( $P < .05$ ) consuming feed and had greater rates of feed consumption than those that received the corn-soybean meal diet. ( $P < .08$ ; Tables 1 and 2).

Blood hormone and metabolite data are presented in Figures 3 to 5. In gilts, feeding the 10% tallow diet resulted in increased ( $P < .01$ ) fasting concentrations of glucose, reduced ( $P < .10$ ) NEFA, and reduced ( $P < .05$ ) glucagon. There were no diet effects ( $P > .10$ ) on the concentrations of metabolites in sows. However, glucose concentration decreased as lactation advanced in sows fed both the corn-soybean meal

and tallow diets. No effects ( $P > .10$ ) of diet on fasting insulin concentration were observed in either sows or gilts. Although not statistically significant, the insulin to glucagon ratio was higher in gilts fed tallow on d 9 of lactation.

## Discussion

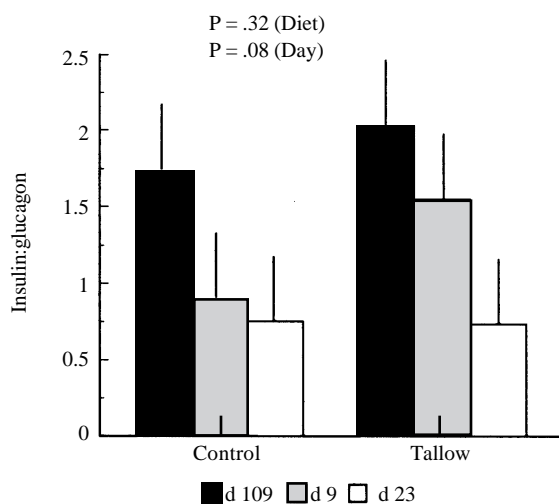
The lack of significant differences in either feed or energy intake may have resulted from the thermoneutral environment in these studies. Adequate feed intakes of sows and gilts fed both diets was reflected by minimal weight and backfat loss. The energy intake response to added fat is probably greatest under conditions of heat stress and reduced feed intake.

Although effects of added tallow on meal size and meal frequency were variable, there was a consistent effect of fat on reducing the amount of time spent consuming feed and increasing rate of consumption. Diets that are very palatable are usually consumed more rapidly than diets that are less palatable. The effect of added tallow on diet palatability in lactating sows is still unknown.

Insulin and glucagon are two major metabolic hormones that regulate nutrient flux after the ingestion of meals as well as during fasting. In conjunction with their effects on metabolite utilization, both insulin and glucagon have pronounced effects on feed intake.

An increase in glucagon concentration and a decrease in insulin concentration reflects a fasted state or increased nutrient demand. Previous researchers have observed a reduction in insulin concentration and an increase in glucagon concentration during lactation in sows. In the present study, glucagon concentration was increased during lactation in gilts, but there was no consistent effect of lactation on insulin concentration in either sows or gilts.

The addition of 10% tallow did numerically increase energy intake by 8% in lactating sows. Although there were inconsistent effects of diet on meal



**Figure 4. Molar ratio of insulin to glucagon in gilts fed either a corn-soybean meal diet or a corn-soybean meal-10% tallow diet throughout a 21-d lactation (n = 16).**

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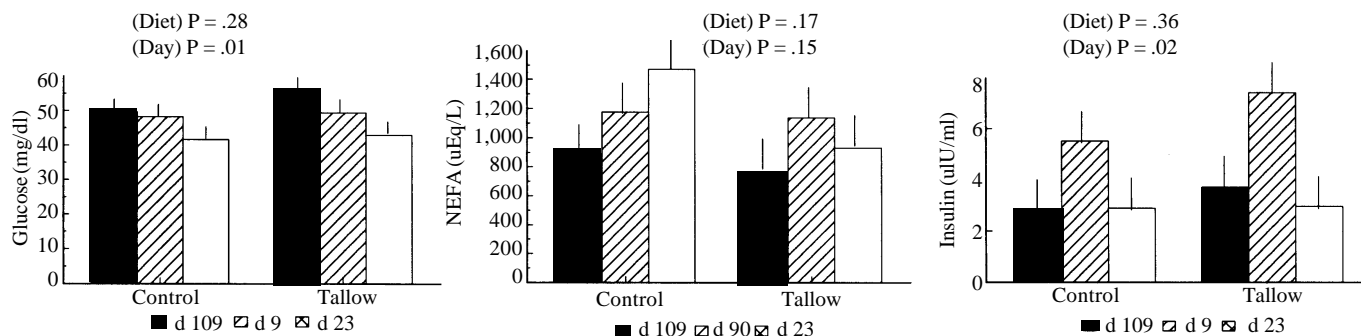


Figure 5. Concentrations of glucose, nonesterified fatty acids (NEFA), and insulin in sows fed either a corn-soybean meal diet or a corn-soybean meal-10% tallow diet throughout a 21-d lactation (n = 18).

size and the number of meals, the addition of fat reduced the percentage of time spent consuming feed and increased the rate of feed consumption.

Because of the importance of insulin and glucagon in the regulation of

nutrient utilization and feed intake, further research is warranted. In particular, the effects of dietary energy density on feed intake as mediated by changes in insulin and glucagon will be investigated in future studies.

<sup>1</sup>Paul M. Ermer and Scott L. Tilton are graduate students, Phillip S. Miller is an Assistant Professor, Austin J. Lewis is a Professor, and Cynthia K. Wolverton is a Research Technologist, Department of Animal Science.

## Are There Benefits in Adding Fat to Sow Lactation Diets?

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### Introduction

Lactation is a metabolic challenge to the sow. Some high-producing sows can produce as much as 30 lb of milk/day during peak lactation. Unfortunately, most sows are unable to consume sufficient dietary energy to fuel the processes of milk synthesis and must mobilize body stores of fat and protein. This problem is accentuated as the number of pigs nursed increases (milk production is increased). Therefore, nutritional programs for lactating sows must incorporate strategies to maximize energy intake and avoid excessive weight loss that may contribute to longer rebreeding intervals or increased culling from the sow herd.

Research conducted at the University of Nebraska in the late 1970s and early 1980s examined the relationship

between dietary energy intake and sow productivity. These experiments used high fat (tallow; 8 to 10%) additions to create diets that when limit fed would result in different daily energy intakes. Subsequently, the benefits of maximizing energy intake during lactation observed in these studies have been attributed to fat itself. However, because of practical and economic considerations, additions of fat in commercial sow lactation diets are considerably lower than 8% (i.e., 1 to 4%). Therefore, the objective of this study was to examine the effects of practical additions of fat (tallow) on sow energy intake and litter performance during lactation.

### Methods

One hundred twenty-two first parity sows raised and bred at the University of Nebraska Swine Research Center at Mead were used in this study. Three dietary treatments (Table 1) were formulated to contain either 0, 2, or 4% added tallow. The

Table 1. Composition of experimental diets<sup>a</sup>

Ingredient, %	Dietary tallow, %		
	0	2	4
Corn	65.90	62.90	59.90
Soybean meal, 44% CP	19.75	20.75	21.75
Beet pulp, dried	10.00	10.00	10.00
Dicalcium phosphate	2.75	2.75	2.75
Salt	.50	.50	.50
Trace mineral premix	.10	.10	.10
Vitamin premix	1.00	1.00	1.00
Tallow	0.00	2.00	4.00
Analyses, calculated (%)			
ME, Mcal/lb	1.43	1.47	1.51
Crude protein	15.2	15.4	15.5
Lysine	.80	.82	.84
Calcium	1.01	1.02	1.02
Phosphorus	.83	.83	.83

<sup>a</sup>As-fed basis

corn:soybean meal ratio was adjusted between the three dietary treatments to maintain a constant lysine:metabolizable energy (ME) ratio. Concentrations of other nutrients were formulated to meet or exceed recommendations provided in the