INFLUENCE OF CARNICHROME® ON ENERGY BALANCE OF GESTATING SOWS[1]

M.G. Young, M.D. Tokach, J. Noblet[2], F.X. Aherne[3], S.S. Dritz[4], R.D. Goodband, J.L. Nelssen, J. van Milgen[2], and J.C. Woodworth[5]

Summary

Twelve multiparous sows were utilized in a randomized complete block design to determine the effects of feeding diets with or without Carnichrome® (50 ppm carnitine and 200 ppb chromium picolonate) on the components of heat production (HP) in early, mid and late gestation. All sows were fed dietary treatments for the 28 d lactation, and the subsequent weaning to estrus and gestation periods. The kinetics of HP and its partitioning (basal or resting HP, activity HP, and short term thermic effect of feeding (TEF_{st})) were determined during three stages of gestation, early (weeks 5 or 6), mid (weeks 9 or 10) and late (weeks 14 or 15) for each block. Feeding allowances were based on modeled calculations of energy and nutrient requirements to achieve a target sow maternal weight gain of 44 lb and remained constant throughout gestation. On d 111 of gestation sows were slaughtered and total uterus, individual fetal, placenta and empty uterus weights were recorded. Organic matter and energy digestibility for the Carnichrome® diet was greater (*P*<0.05) and fecal N excretion was lower (*P*<0.05), which resulted in the DE and ME content of the Carnichrome® diet being greater (*P*<0.05) compared to the control diet. Carnichrome® had no effect on total HP, energy retained as protein or lipid or maternal energy retention in early, mid or late gestation. Increased HP in late gestation was associated with increased uterine energy requirements. The ME intake on d 110 of gestation was 6.9 Mcal/d, but to prevent sows from mobilizing maternal tissues ME intake would need to be increased to 8.4 Mcal/d. This equates to a 21.5% increase in ME intake or an additional 1 lb/d of a corn soybean meal diet on d 110 of gestation than fed in the present experiment. Energy requirements for maintenance averaged 91 kcal/kgBW$^{0.75}$/d, and was greater in late compared with mid-gestation in the present experiment. On average 20% of ME intake was utilized for physical activity but ranged from 11.6 to 37.1%. Each 100 minutes of standing time/day represented an additional requirement of 0.38 lb/d of a standard corn soybean meal diet (1485 kcal/lb). The results of the present experiment indicate that improvements in reproductive performance found in previous experiments with carnichrome do not appear to be due to changes in heat production or improvements in energy retention. In con-

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[1]Appreciation is expressed to Lonza, Inc., Fair Lawn, New Jersey, for partial financial support of this experiment.
[2]Institut National de la Recherche Agromique, Unite Mixte de Recherches sur le Porc, 35590 St Gilles, France.
[3]Alberta Pig Company, 9189 Lochside Drive, North Saanich, British Columbia, Canada V8L 1N2.
[4]Food Animal Health and Management Center.
[5]Lonza, Inc., Fair Lawn, New Jersey.

clusion, Carnichrome® had no effect on the components of heat production and maternal weight gain during early-, mid- or late-gestation, but did improve energy and organic matter digestibility of the diet.

(Key Words: Sows, Carnichrome®, Heat Production, Gestation)

Introduction

Carnitine is a vitamin-like compound that is essential for the transport of long- and medium-chain fatty acids across the mitochondrial membrane for B-oxidation. Chromium is a trace mineral that is essential for activating specific enzymes and stabilizing proteins and nucleic acids. Both carnitine and chromium have been shown to improve reproductive performance of sows. In previous trials, we have observed the total number of pigs produced over two parities was greater when sows were fed diets with carnitine or chromium compared to sows fed control diets, with the greatest improvement observed from feeding a diet containing both carnitine and chromium. In other studies, sows gained more weight and backfat during gestation when fed diets containing carnitine. Sows fed chromium tended to gain more body weight during gestation compared to sows fed diets without chromium. These observations would suggest that the sows fed diets with carnitine or chromium retained more energy than the sows fed the diets without carnitine and chromium. The objective of the present study was to quantify the effect of the addition of carnitine and chromium (Carnichrome®) on heat production (HP) and its components and energy gain during early, mid- and late gestation of multiparous sows.

Procedures

A total of fifty-four Large White × Landrace sows were assigned to one of two dietary treatments post farrowing, control and Carnichrome® (50 ppm of L-carnitine and 200 ppb of chromium), based on parity and weight on entry to the farrowing house. All sows were fed dietary treatments for the 28-day lactation, the following weaning to estrus period, and to day 28 of the subsequent gestation. Once confirmed pregnant on day 28 of gestation, 12 sows (6 blocks with 2 sows per block) were selected for indirect calorimetry measurements. Sows were selected for indirect calorimetry measurements based on parity, weight entering the farrowing house, weight loss in lactation, and weaning to estrus interval. Energy balance was measured during three stages of gestation, early (weeks 5 or 6), mid (weeks 9 or 10) and late (weeks 14 or 15) for each block. Sows were housed for 7 days in the metabolism cage that was in a respiration chamber, where digestibility and energy balance measurements were taken simultaneously. Day 1 was used to allow the sow to adapt to the respiration chamber. Collection of urine and feces, and gas exchange measurements commenced on day 1. On the morning of day 8, the energy balance and digestibility measurements were terminated and sows were weighed. All sows on which indirect calorimetry measurements were taken were slaughtered at the end of pregnancy (day 111 on average) and total uterus, individual fetal, placenta, and empty uterus weights were recorded.

Two respiration chambers with a volume of 12 m^3 were available for measurement of gas exchange in individual sows. Metabolism cages were equipped with two infra-red (i.r.) beams located at the front and rear of the cages to detect standing or sitting activity of the sow. Interruption of an i.r. beam for at least 20 seconds was considered to represent a standing activity (i.e., sitting or standing). In addition, the metabolic cage was mounted on force sensors, which produced an electric signal assumed to be proportional to the physical activity of the animal. The temperature in the respiration chamber was maintained at 72^{o}F.

A standard lactation diet, with 1.0% lysine, 0.80% calcium and 0.75% phosphorous was fed for the 28-d lactation. The experimental gestation diet was corn-soybean meal-based and formulated to contain 0.65% lysine, 0.80% calcium and 0.75% phosphorous (Table 1). The control diet had 0.05% of a corn-soy blend added, while the Carnichrome® diet had 0.05% of Carnichrome® 10% added to provide 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.

Table 1. Composition of the Experimental Diet

Item, %	Gestation Diet
Corn	80.07
Soybean meal (47% crude protein)	14.50
Dicalcium phosphate	2.58
Limestone	0.80
Soy oil	1.00
Salt	0.50
Corn-soy blend[a]	0.05
Vitamin and trace mineral	0.50
Calculated analysis	
Crude protein, %	13.6
Lysine, %	0.65
Calcium, %	0.90
Phosphorous, %	0.80
ME, kcal/lb	1499

[a]Corn-soybean meal blend (50:50) for the Carnichrome® treatment was replaced with Carnichrome® 10% blend which provided 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.

During the experiment, sows received their diet in one meal per day (9 a.m.) in pellet form. Feed allowances were based on modeled calculations of energy and nutrient requirements to achieve a target maternal weight gain during gestation of 44 lb. The gestational energy requirements were determined by calculating the daily energy requirement for maintenance (ME_M) multiplied by 115 days, plus energy for target weight gain, and energy for products of conceptus and uterine gain, and summing these to give the total gestation energy requirement. The calculations are:

ME_M (Mcal) = $0.107 \times BW^{0.75}$

Energy maternal gain (Mcal) = $(9.7 \times$ BW gain, kg $+ 54 \times$ P2 gain, mm$) \div 4.184$

Energy uterus gain (Mcal) = $((4.8 \times$ fetus BW gain, kg$) \div 0.5) \div 4.184$

BW is average body weight of the sow, which is calculated as weight at service plus one half targeted weight gain plus one half products of conceptus and uterine gain in gestation. Feeding level was kept constant over pregnancy.

Sows were weighed at the beginning, at the end of each collection period, and every two weeks between collections. Representative samples of feed, feces, and urine were collected during each measurement period. Feed and feces were analyzed for DM, ash, crude protein, crude fiber, diethyl ether and gross energy. Nitrogen in the urine was analyzed on fresh material, whereas the energy content was obtained after freeze-drying approximately 50 ml of urine in polyethylene bags.

Concentrations of O_2, CO_2 and CH_4 in the respiration chamber were measured continuously. Measurements of gas concentrations, signals of the force sensors and weights of trough and water-tank were averaged over 10 seconds and stored on a microcomputer for further analysis. Apparent digestibility coefficients of energy and the different chemical fractions were calculated. Daily heat production (HP) was calculated from gas exchanges. The retained energy (RE) corresponded to the difference in ME intake and HP. Energy retained as protein was calculated from the N balance, whereas retained energy as lipid corresponded to the difference between RE and energy retained as protein. Animals in the fed state were assumed to have a constant basal HP (kJ/d). Ingestion of a meal and associated short-term physiological events such as digestion and absorption cause a temporary increase of HP (TEF_{st}). The daily HP due to physical activity was calculated as the product of unitary HP (kJ/unit of force) and total force detected over a day.

The distribution of daily activity HP between eating (i.e. instability of the trough), standing (i.e., the difference between total duration of standing and the duration of eating) and lying periods was calculated as the production of activity HP (kJ/unit of force) and the total force measured during these periods. The RQ was calculated as the ratio CO_2 production:O_2 consumption. Model variables of HP were estimated for each day of measurement. In the subsequent statistical analysis, the mean of daily variables was used for each sow at each stage of pregnancy. There was a total of 36 experimental periods (12 sows and three stages of gestation).

The results were analyzed as a randomized complete block design with repeated measures over time using the MIXED procedure of SAS (SAS Inst., Carry, North Carolina). Sow was the experimental unit of analysis, with block included as a random effect. Heat production from day 93 to 111 of gestation was modeled as a function of day of gestation and adjusted for the sow effect to determine the increased daily heat production.

Results and Discussion

Both the control and Carnichrome® diets were analyzed for L-carnitine. The control and Carnichrome® diets contained 1.4 and 57.1 ppm of free L-carnitine, respectively. Average parity and sow weight at weaning, d 35, 70, 103 and 111 (slaughter) of gestation was not different between the control and Carnichrome® treatments (Table 2). Maternal weight gain in gestation averaged 47.5 lb, but no effect of Carnichrome® on maternal weight gain was observed. Metabolizable energy intake was targeted for sows to achieve a moderate weight gain throughout gestation, as it was hypothesized that the effects of Carnichrome® would be more prevalent at low energy intake levels. In mid-gestation when energy was retained in maternal tissues and in late gestation when sows mobilized lipid to meet the increased requirement for uterine growth, no effect of Carnichrome® was evident on any of the measured parameters. The prolificacy of the sows utilized in the present experiment was very high, with sows on average producing 16.5 total pigs with no difference between the two treatments. In the present experiment Carnichrome® had no effect on total number of fetuses produced, average fetal weight, total uterus, placenta or empty uterus weights. But it should be mentioned that the number of observations in the present experiment was very limited for such reproductive criteria.

Digestibility coefficient of organic matter and energy were greater for the Carnichrome® compared with control fed sows (*P*<0.05; Table 3). Dry matter digestibility coefficients increased with stage of gestation, while methane production decreased with stage of gestation. The energy content of the urine averaged 3.7%, and was greater in mid- compared with early- or late- gestation. The DE and ME value for the Carnichrome® diet was greater (*P*<0.05) than the control diet. The reduced (*P*<0.05) fecal N excretion for the Carnichrome® fed sows supports these data. Metabolizable energy value was greater (*P*<0.05) in early- and late- compared with mid-gestation. The digestibility of energy reported in the current experiment for a typical corn-soybean meal diet (92%) was greater than that predicted from DE values of corn and soybean meal proposed by the NRC (1998) or more recent values reported for growing pigs (88%). Digestibility coefficient for DM of the experimental diet was determined for growing pigs to be 88% compared with 90.2% for sows. This is in agreement with the recent data from the University of Illinois that digestibility values for complete feeds were greater for sows compared with growing pigs and that diets should be assigned two energy values: one for growing pigs and one for sows.

Nitrogen losses in the feces were greater ($P < 0.02$) for the control compared with the Carnichrome® fed sows (Table 4). Losses of N in the urine were lower ($P < 0.01$) in early- and late-gestation compared with mid-gestation and N retention was greater ($P<0.01$) in early- and late-gestation compared with mid-gestation. The increased N retention in late-gestation was a result of the exponential fetal growth in late-gestation, which is mainly protein.

Heat production was greater ($P<0.01$) in late- compared with early- and mid-gestation and energy in gain was then lower ($P<0.01$) in late- compared with early- and mid-gestation (Table 4). The combination of the higher HP and higher protein (N) retention in late-gestation compared with early- and mid-gestation resulted in a decrease ($P<0.01$) in lipid deposition, with sows in late-gestation mobilizing lipid reserves. The lower ($P<0.01$) RQ in late- compared to mid-gestation confirms this result. As gestation progressed the composition of weight gain changed with lipid deposition decreasing and protein deposition increasing. Virtually all of the protein gains in late-gestation were deposited in the uterine tissues.

The efficiency of energy use for maternal gain averaged 67.9% for gestation in the present experiment, but was lower in late- compared with early and mid-gestation. The lower efficiency values reported in late-gestation are a result of the higher protein and lower lipid content of weight gain, as energy for protein deposition is utilized with a lower efficiency (60%) compared with lipid deposition (80%). Fetal and uterine energy retention increased ($P<0.01$) with stage of gestation especially between mid- and late-gestation. Increased HP and increased energy retained in the uterine tissues in late-gestation resulted in a decrease and negative maternal energy retention in late-gestation. Maintenance energy requirement as a percentage of ME intake averaged 76.4%, but was higher in late- compared with early- and mid-gestation.

Heat production in late-gestation increased 0.95 Kcal/kg $BW^{0.75}$ per d from d 93 to 111 (Figure 1). This is equivalent to an additional 23 g/d of a standard corn-soybean meal gestation diet (1,485 Kcal/lb ME) for a 500 lb sow. This is equivalent to an additional 23 g/d for each day from d 93 to 111 of a standard corn-soybean meal gestation diet (1,485 Kcal/lb ME) for a 500 lb sow. For example, on d 90 the additional feed requirement is 23 g/d which increases to 460 g/d (or lb/d) on d 110 of gestation. The increased HP can be explained mainly by the exponential fetal growth with energy retained in the uterus increasing from 0.52 to 0.79 Mcal/d and also the increased maintenance energy requirement associated with the additional weigh gain (Table 5). The large increase in HP in late-gestation in the present experiment can also be attributed to the high prolificacy of the sows used in the present experiment, with sows having on average 16.5 total pigs born. Maternal energy retention decreased from d 90 to 110 and sows were mobilizing maternal tissues on d 110 of gestation to meet the increased fetal energy requirements in late-gestation. The ME intake on d 110 of gestation was 6.9 Mcal/d, but to prevent sows from mobilizing maternal tissues ME intake would need to be increased to 8.4 Mcal/d (Table 5). This equates to a 21.5% increase in ME intake or an additional 1 lb/day of a standard corn-soybean meal diet on d 110 of gestation than fed in the present experiment.

The average time required to consume daily feed allowance was 20 minutes/d with an average rate of feed consumption of 100 g/minute (Table 6). Duration of total standing activity averaged 273 minutes/d and values ranged from 80 to 511 minutes/d. Activity HP (Mcal/d) while lying was greater (*P*<0.01) in late- compared with early- and mid-gestation. Irrespective of sow behavior, the energy cost of standing averaged 3.9 Kcal/minute or 0.07 Kcal/kg $BW^{0.75}$ per minute standing activity and was not affected by treatment or stage of gestation. Activity HP averaged 23.7% of total HP, but ranged from 14.2 to 41.5%, with large variation between individual sows. On average 22% of ME intake was used for physical activity. For sows standing for 150 minute/d or less AHP was similar to APH sows that are lying at approximately 9.6 Kcal/kg $BW^{0.75}$/d, but AHP was 3 times greater for sows that stood for approximately 500 minutes per d at 28.7 Kcal/kg $BW^{0.75}$/d (Figure 2). The higher duration of standing time in the present experiment compared to other experiments may be partly attributable to the low feeding level and low fiber content of the diet utilized in the present experiment. Physical activity can be quite variable and represent a major factor causing differences in maternal weight and backfat gains in gestation. For a 500 lb sow standing for an extra 100 minutes/d the additional feed requirement of corn-soybean diet (1485 kcal/lb) is 0.38 lb/d. A highly active sow that stood for 500 minutes/d requires an additional 1.9 lb/d to meet the energy requirement of the high activity.

In summary, organic matter and energy digestibility was greater and N excretion was lower for sows fed the Carnichrome® diet, which resulted in greater DE and ME values for the Carnichrome® compared to the control diet. When sows were fed Carnichrome® in gestation no effects were observed on HP or energy retention as protein or lipid in early-, mid- or late-gestation. Increased HP in late-gestation was associated with the increased uterine energy requirements and was determined as an additional 29 g/d of a standard corn-soybean meal diet (1,485 kcal/lb ME) from d 90 to 110 of gestation. ME intake on d 110 of gestation would need to have been increased 20% or 1 lb/day to prevent the sows from mobilizing maternal tissues. Energy requirement for maintenance averaged 76.4% of ME intake and was higher in late- compared with early- and mid-gestation in the present experiment. On average, 20% of ME intake was utilized for physical activity but there was large variation between individual sows in activity levels. For each additional 100 minutes/d standing an additional 0.38 lb/day of feed was required with highly active sows requiring as much as 1.9 lb/d more feed than low activity sows.

Table 2. Effect of Carnichrome® and Stage of Gestation on Sow whole Body and Uterine Growth

	Treatment			
	Control	Carnichrome®[a]	SED	P<
Number of sows	6	6		
Average parity	1.8	1.8		
Sow weight, lb				
Weaning	400.1	400.5	12.36	0.98
Day of gestation				
35	398.1	401.1	13.32	0.84
70	457.7	454.7	15.58	0.86
103	489.8	495.5	13.88	0.71
111 (slaughter)	499.4	505.9	15.16	0.69
Daily maternal weight gain (d 36-111), lb	0.61	0.67	0.09	0.54
Maternal weight gain, lb[b]	44.1	51.0	11.59	0.58
Weight, lb				
Total uterus	76.7	75.2	5.33	0.78
Fetuses	45.7	44.9	3.43	0.82
Placenta	9.5	9.5	1.00	0.99
Empty uterus	16.4	15.5	1.18	0.49
Total number of fetuses	17.3	15.7	1.74	0.34
Average fetal weight, lb[c]	2.67	2.91	0.25	0.37

[a]Provided 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.
[b]Slaughter weight – total fetal weight – placenta weight – weaning weight.
[c]At slaughter (d 111 on average of gestation).

Table 3. Effect of Carnichrome® and Stage of Gestation on Digestibility and Energy Values of the Dietary Treatments

	Treatment			Stage of gestation				P<		
Stage of gestation	Control	Carnichrome®[a]	SED	Early	Mid	Late	SED	Treat.	Stage	T×S
No. of observations	18	18		12	12	12				
Day of gestation	69	69		36	69	102				
Mean body weight, lb	446.5	450.8	12.69	398.2[b]	455.3[c]	492.5[d]	2.72	0.75	0.01	0.12
DM intake, lb/d[e]	3.90	3.90	0.06	3.87	3.91	3.92	0.02	0.99	0.23	0.79
Apparent digestibility, %										
DM	89.9	90.6	0.39	91.0[b]	89.5[c]	90.1[bc]	0.58	0.10	0.04	0.22
Organic matter	93.0	93.7	0.28	93.9	92.9	93.3	0.41	0.05	0.08	0.24
Crude protein	87.9	89.2	0.53	88.7	87.8	89.1	0.67	0.06	0.19	0.14
Energy	91.8	92.7	0.32	92.9	91.7	92.2	0.45	0.03	0.06	0.27
Energy of CH4 (% DE)	0.95	0.92	0.06	1.01[b]	0.97[b]	0.77[c]	0.06	0.65	0.04	0.11
Energy of urine (% DE)	3.72	3.69	0.10	3.61[b]	3.94[c]	3.57[b]	0.14	0.77	0.04	0.80
ME:DE (%)	95.5	95.4	0.17	95.3[b]	95.3[b]	95.9[c]	0.16	0.76	0.01	0.50
Energy values (Mcal/kg DM)										
DE	4.03	4.07	0.01	4.08	4.03	4.05	0.02	0.03	0.06	0.27
ME	3.84	3.88	0.01	3.89[b]	3.83[c]	3.87[b]	0.02	0.03	0.03	0.21

[a]Provided 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.
[bcd]Means with different superscripts differ (*P*<0.05).
[e]Dry matter content of the diet increased (*P*<0.05) with stage of gestation, 88.1, 88.5 and 88.9%.

Table 4. Effect of Treatment and Stage of Gestation on Nitrogen and Energy Balance of Sows

	Treatment			Stage of Gestation				P<		
Item	Control	Carnichrome®[a]	SED	Early	Mid	Late	SED	Treat.	Stage	T×S
Number of observations	18	18		12	12	12				
Day of gestation	69	69		36	69	102				
Nitrogen balance, g/d										
Intake	44.4	44.5	0.72	44.2	44.5	44.7	0.22	0.93	0.12	0.86
Losses										
Feces	5.3	4.8	0.20	5.0	5.4	4.9	0.29	0.02	0.21	0.14
Urine	21.2	21.5	0.84	20.5[b]	23.7[c]	19.9[b]	0.83	0.72	0.01	0.52
Evaporation	1.4	1.4	0.20	1.3	1.4	1.4	0.31	0.87	0.95	0.87
Retention	16.3	16.4	0.89	17.0[b]	13.9[c]	18.3[b]	0.94	0.89	0.01	0.31
Energy balance, Mcal/d										
ME intake[e]	6.79	6.87	0.11	6.84[bc]	6.78[b]	6.89[c]	0.05	0.52	0.03	0.10
Heat production	5.73	5.75	0.21	5.39[b]	5.52[b]	6.31[c]	0.11	0.93	0.01	0.70
Energy gain	1.06	1.13	0.16	1.44[b]	1.26[b]	0.58[c]	0.12	0.69	0.01	0.94
Energy gain as										
Protein	0.58	0.59	0.03	0.61[b]	0.50[c]	0.65[b]	0.03	0.89	0.01	0.31
Lipid	0.48	0.54	0.14	0.84[b]	0.76[b]	-0.08[c]	0.13	0.66	0.01	0.93
Energy gain in										
Fetal tissues	0.26	0.25	0.03	0.01[b]	0.18[c]	0.57[d]	0.03	0.71	0.01	0.90
Uterine tissues	0.35	0.34	0.03	0.10[b]	0.30[c]	0.63[d]	0.03	0.69	0.01	0.91
Maternal tissues	0.75	0.86	0.18	1.36[b]	1.01[c]	-0.03[d]	0.14	0.57	0.01	0.85
Maintenance % ME intake	76.8	75.9	2.97	70.0[b]	73.8[b]	85.3[c]	2.06	0.79	0.01	0.88
Respiratory quotient	1.00	1.00	0.01	1.02[b]	1.01[b]	0.97[c]	0.01	0.62	0.01	0.28

[a]Provided 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.
[bcd]Means with different superscripts differ (*P*<0.05).
[e]Dry matter content of the diet increased (*P*<0.01) with stage of gestation, 88.1, 88.5 and 88.9%.

Table 5. Effect of Day of Gestation on Heat Production, Uterine and Maternal Energy Retention

	Day of Gestation		
Item	90	110	110[a]
Body weight, lb	474	507	507
Mcal/d			
ME intake	6.90	6.90	8.37[b]
HP	5.65	7.20	7.58
Uterine energy retention	0.52	0.79	0.79
Maternal energy retention	0.72	-1.09	0

[a]Increased energy intake on d 110 of gestation to result in 0 maternal energy retention.
[b]ME intake for 0 energy retention, using an efficiency of energy retention for gain of 74%.

Table 6. Effect of Treatment and Stage of Gestation on Standing and Physical Activity of Sows

Item	Treatment		SED	Stage of Gestation			SED	P<		
	Control	Carnichrome®[a]		Early	Mid	Late		Treat.	Stage	T×S
No. of observations	18	18		12	12	12				
Day of gestation	69	69		36	69	102				
Behavior, min/d										
Eating	24	19	2.52	22	22	21	0.83	0.10	0.48	0.77
Standing not eating	240	265	69.80	271	251	235	24.03	0.73	0.49	0.45
Total standing	263	284	71.49	290	273	257	19.49	0.79	0.28	0.48
Percent of day spent standing	18.2	19.7	4.83	20.3	18.9	17.7	1.71	0.77	0.49	0.47
Activity HP, Mcal/d										
Total	1.41	1.58	0.28	1.35	1.48	1.65	0.14	0.57	0.20	0.96
Standing and/or eating	0.11	0.09	0.02	0.09	0.10	0.11	0.01	0.55	0.43	0.48
Standing and/or not eating	0.77	0.95	0.19	0.89	0.85	0.84	0.09	0.39	0.89	0.44
While lying	0.54	0.54	0.16	0.37[b]	0.53[b]	0.71[c]	0.10	0.99	0.04	0.78
Standing HP, kJ/min	15.9	16.7	1.64	15.4	16.9	16.4	1.20	0.99	0.66	0.21
Standing HP, kJ/kgBW$^{0.75}$ per min	0.29	0.31	0.03	0.31	0.30	0.28	0.02	0.99	0.73	0.26
Rate feed consum., g/min.	90	111	11.2	99	99	103	3.90	0.10	0.52	0.52

[a]Provided 50 ppm of L-carnitine and 200 ppb of chromium from chromium picolonate.
[bc]Means with different superscript letters differ ($P<0.05$).

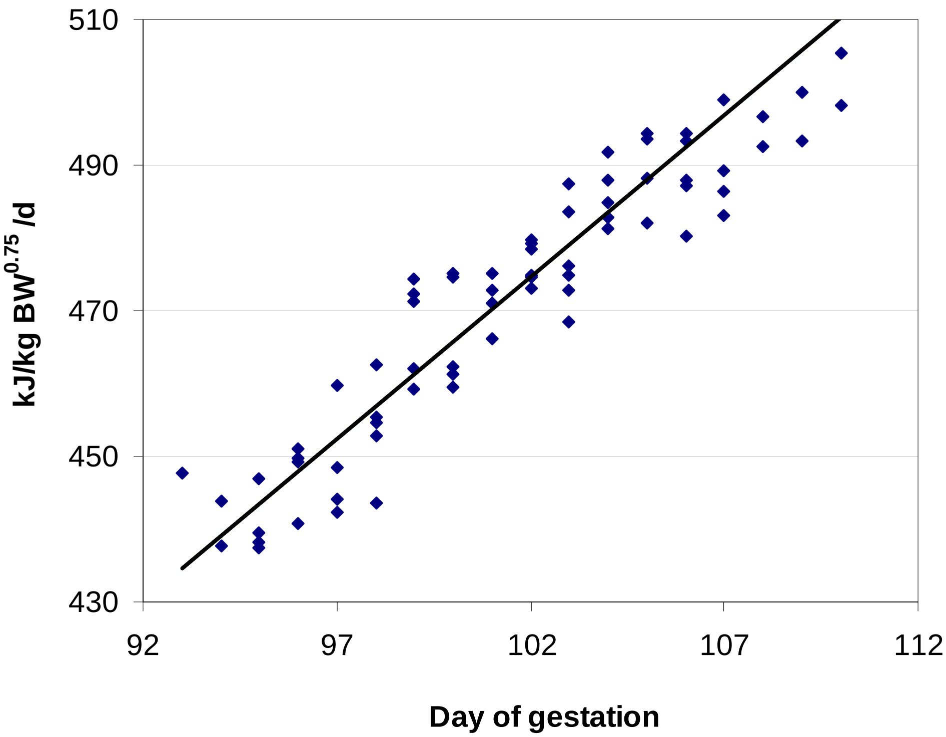

Figure 1. The relationship between day of gestation and heat production (HP). HP (kJ/kg $BW^{0.75}$/d) = 4.5(day of gestation) + 20; adjusted for the sow effect. R^2 = 0.85.

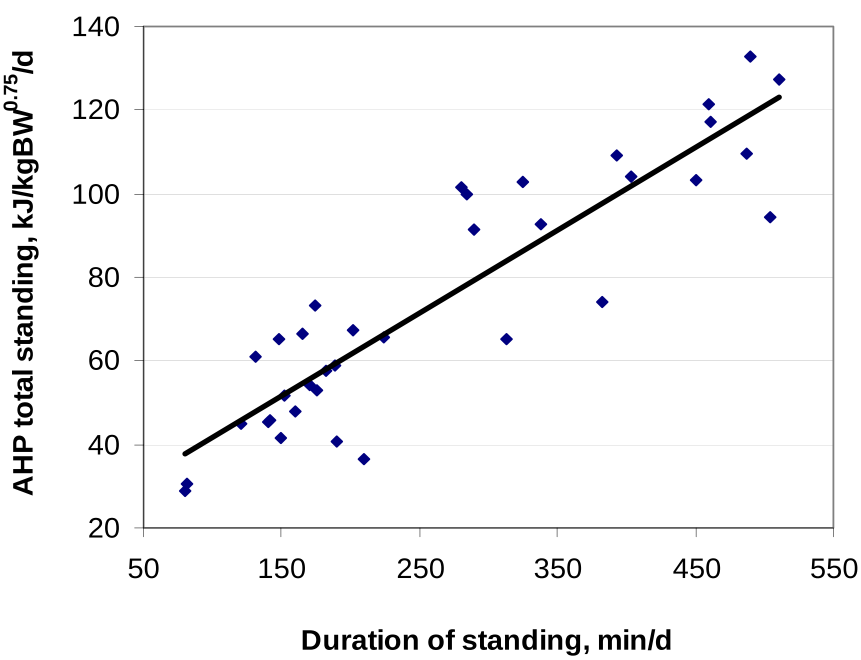

Figure 2. The relationship between duration of standing (min/d) and AHP during total standing time (kJ/kg$BW^{0.75}$/d). AHP (kJ/kg$BW^{0.75}$/d) = 0.2(duration of standing, minutes/d) + 22; R^2=0.81.