Title: Predicting the iodine value of pork carcass fat from the iodine value of dietary fat supplied by different fat sources at different levels of inclusion in the diet – **NPB #10-021**

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Industry summary: With input costs continuously rising, the industry has been resourceful in using alternative ingredients to remain profitable. However, some of these feedstuffs contain unsaturated fat, which has brought the issue of pork fat quality to the forefront. Due to this, the industry is currently searching for a method to quantify the issue of pork fat quality and to further the understanding of how dietary fat influences the fat that is deposited in the pig.

A measurement known as iodine value (IV) has become the focal point of this conversation. Iodine value is used as a predictor of pork fat quality and can be measured two different ways: through an equation calculated from the concentration of six different unsaturated fatty acids, or directly by titrating the quantity of iodine that binds to double bonds or unsaturation in the fatty acid chain. The packing industry is looking at adopting this measurement as a standard of quality. However, despite its potential implementation throughout the industry, little research has been done on this measurement.

Additionally, understanding how dietary fat content affects the deposited fat in the pig throughout the growth cycle needs to be analyzed using a more definitive approach. Simply feeding alternative ingredients and measuring their impact on the final carcass iodine value is too simplistic, due to constant changes in the composition of alternative ingredients and due to the fact that excessive – and unnecessary – restrictions on the use of these alternative ingredients result in higher feed costs for pork producers. This, in turn, compromises the competitiveness of individual pork producers, as well as the industry as a whole.

Key takeaways from this project: dietary fat regardless of source increases feed efficiency and barn throughput, deposited fat becomes more reflective of the dietary fat source as the fat inclusion level is increased as de novo synthesis fat (saturated in comparison) becomes diluted, there is a significant difference in the degree of unsaturation as you move from the front to the back of the pig if the dietary fat inclusion level is less than or equal to 3%, which means that fat samples from the jowl will be higher than samples from the belly or loin, and as the pig matures and grows deposited fat becomes more saturated if the dietary fat source is not highly saturated. This research proves that dietary fat sources with an iodine value under 66 can be fed “limitless” without concern of impacting pork fat quality, but if a dietary fat source with iodine value greater than 122 is included at high levels carcass iodine values will be increased over the preffered packer standard of 74.

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Keywords: dietary fat, carcass fat, iodine value, pigs

Scientific abstract: The inclusion of unsaturated fats in pig diets has raised issues related to pork carcass lipid quality. The objective of this experiment was to develop a more comprehensive understanding of how dietary fat affects the composition of body fat during the finishing period and at market. A total of 42 gilts and 21 barrows (PIC 337 X C22/29) with an average initial weight of 77.8±3.06 kg were allotted based on sex and weight to 7 treatments: 3 and 6% of each of tallow (TAL; iodine value (IV)=41.9), choice white grease (CWG; IV=66.5) or corn oil (CO; IV=123.1), and a control (CNTR) corn-soy based diet with no added fat. Pigs were individually housed to allow accurate measurement of individual feed intake and thus daily dietary fat and energy intake. Pigs were weighed and adipose samples were collected from the jowl, belly, and loin on days 0, 18, and 35 and at harvest. Iodine value was determined on diet and carcass lipid samples. Belly weights were recorded at harvest along with a subjective belly firmness score (1-3 with 1 firmest and 3 least firm) 24 h post-mortem. Data were analyzed using PROC MIXED and PROC CORR. Carcass lipid IV was affected by source (TAL=66.8, CWG=70.3, CO=76.3, CNTR=65.4; $P<0.0001$). Carcass lipid IV for TAL and CWG was not affected by inclusion level; however, carcass lipid was affected by CO level (3%=72.6, 6%=80.0; $P<0.0001$). Carcass lipid IV was also affected by sex (barrows=69.1, gilts=71.5; $P<0.001$). The correlation between carcass lipid IV and dietary lipid IV was $R^2=0.592$. Belly weight was increased by inclusion level (CNRT=8.3 kg, 3%=8.8 kg, 6%=9.4 kg; $P<=0.02$). Belly firmness score was affected by source (CNTR=1.8, TAL=1.7, CWG=2.0, CO=2.2; $P<0.05$) and sex (barrows=1.6, gilts=2.3; $P<0.0001$). ADG was increased by inclusion level (CNTR=0.93 kg, 3%=1.04 kg, 6%=1.10 kg; $P<0.02$). G:F was also improved by inclusion level (CNTR=0.301, 3%=0.337, 6%=0.358; $P<0.01$). In conclusion, an increase of dietary fat can improve feed efficiency and performance. Inclusion of a fat source with an IV less than of 66 can be used without repercussions. Inclusion of a fat source with an IV greater than 122 should be limited when possible, this applies to dietary ingredients high in unsaturated fat, such as DDGS, and it's important to know sampling site and procedure used for IV.

Introduction: The issue of pork fat quality has become a trending topic in the United States pork industry over the past five years. With commodity markets becoming elevated, pork producers had to search for options to lower input costs. One solution was the addition of co- or by-products in the substitution of traditional cereal gains such as corn. The problem is some of these alternative ingredients such as distillers dried grains with solubles (DDGS) have higher levels of unsaturated fatty acids than corn, resulting in increased occurrence of "soft fat" in pork carcasses. "Soft fat" tends to decrease shelf life due to oxidation, and to negatively affect the slicing quality of the belly. However, economic loss to the packer does not end there, as "soft fat" will continue to negatively impact production down the line other products such as coloring crayons, and soaps.

While the packer wishes to minimize the use of alternative ingredients such as distillers grains, there is a very strong motivation for pork producers to use them in abundance because they lower feed costs. Depending on the relative market for corn and DDGS, the savings can be in the range of $3 to $5 per pig sold! Consequently, there is a need to balance the interests of the packer with that of the producer, to ensure that pork quality is maintained and produced at the lowest possible cost. Previous research studying levels of DDGS or other ingredients added to the diet on carcass fat quality is insufficiently precise. This approach is also inadequate because by-product ingredients are constantly changing in composition; for example, an increasing number of producers of DDGS are finding ways to lower the fat content. This obviously changes the impact of DDGS on carcass fat quality (Stein and Shurson, 2009). Since constantly re-running growth studies to understand the impact of co-products on carcass fat quality, it makes more sense to study specific fats. The results of such studies can be extrapolated to the use of the ingredients containing fats in a much more dynamic fashion.

Iodine value (IV) is a measurement or estimate of the degree of unsaturation in a lipid sample. There are two ways of obtaining the value: "direct" by titration or "calculated" by an equation containing the concentration of different unsaturated fatty acids the most common equation and the equation used in this experiment is: $(IV) = [C16:1] \times 0.95 + [C18:1] \times 0.86 + [C18:2] \times 1.732 + [C18:3] \times 2.616 + [C20:1] \times 0.785 + [C22:1] \times 0.723$; brackets indicate concentration (AOCS, 1998).

In an effort to quantify this problem, many packers have investigated the use of iodine value to assist in marking poor quality carcass fat. However, little research has been done on the use of iodine value, what factors affect iodine value, and can iodine value be altered over time to maximize economic performance for all parties involved.

Objectives: The overall objective was to provide specific recommendations to pork producers on the use of dietary fat in finishing diets to ensure that carcass fat quality criteria are being met, while still using as much fat as possible to achieve animal and financial performance objectives in the barn. The specific objectives were:

1. To develop a better and essential understanding of how the composition of dietary fat affects the composition of carcass depot fat
2. To determine if the iodine value (IV) of dietary fat, supplied by a diversity of fat sources, can be used to predict the IV of carcass fat, measured in the jowl, belly and backfat. In other words, is the relationship robust across different <u>types</u> of dietary fat
3. To determine if the iodine value (IV) of dietary fat, supplied at two different levels in the diet, can be used to predict the IV of carcass fat, measured in the jowl, belly and backfat. In other words, is the relationship robust across different <u>levels</u> of fat in the diet
4. To define how the fatty acid composition of backfat changes during the course of growth from 75 kg to market, based on feeding different dietary fat sources and different levels of fat inclusion in the diet. This information can be used to further develop feeding programs that optimize the use of dietary fat
5. Determine, using INRA equations, net energy values for the diets and the three dietary fat sources.
6. Provide carcass fat samples of diverse fatty acid composition to strengthen Raman technology being developed to rapidly assess iodine value in carcass fat

Materials & Methods: A single experiment, conducted in two sequential replications with a total (n = 63) pigs was undertaken at the Iowa State University Swine Nutrition Farm. Forty-two gilts and 21 barrows were placed on test for 55 days: from 75 kg to market, providing 9 pigs per treatment. Treatments included a control (a corn soybean meal control diet, designed to replicate that used by the commercial industry today, with the exception of no added fat), plus 6 additional treatments, arranged in a 2 by 3 factorial, incorporating 2 levels of added fat (3% or 6%) and 3 different fat sources (choice white grease, corn oil or beef tallow). These fat sources were selected to provide a diverse range of fatty acid composition and resulting dietary iodine value, while still keeping in mind practical choices for producers. These fat sources were analyzed for iodine value through titration (Barrow-Agee Labs, Memphis, TN). The dietary fats used in this experiment had the following iodine values (Tallow = 41.9, Choice White Grease = 66.5, Corn Oil = 123.1). The final experimental diets were assayed for total fatty acid profile by gas chromatography (AOAC, 2002) and iodine value was calculated (AOCS, 1998). Dietary fatty acids were extracted by a one-step direct transesterification procedure (Lepage and Roy, 1986), in addition crude fat % (Experiment Station Chemical Laboratories, UMC – Columbia, MO) was analyzed to determine concentration of dietary fat in the experimental diets. The calculated iodine values and the concentration of fat for the experimental diets are listed below (Table A).

Table A. Dietary iodine value with crude fat %

	Iodine Value[1]		Crude Fat %[2]	
Treatment	Phase 1[3]	Phase 2[4]	Phase 1[3]	Phase 2[4]
Control	130.0	121.8	2.43	3.24
Tallow 3%	93.2	85.1	5.33	6.3
Tallow 6%	66.3	67.6	7.52	8.74
Choice White Grease 3%	104.6	99.1	5.28	5.85
Choice White Grease 6%	87.3	94.3	8.08	8.67
Corn Oil 3%	133.1	132.6	4.86	5.67
Corn Oil 6%	134.8	134.5	8.00	8.54

[1] Iodine value calculated by: (IV) = [C16:1] X 0.95 + [C18:1] X 0.86 + [C18:2] X 1.732 + [C18:3] X 2.616 + [C20:1] X 0.785 + [C22:1] X 0.723; brackets indicate concentration (AOCS, 1998)
[2] Crude Fat % W/W%=grams per 100 grams of sample (Experiment Station Chemical Laboratories, UMC – Columbia, MO)
[3] Phase 1 diets fed from day 0 to day 27
[4] Phase 2 diets fed from day 27 to day 55 (market)

Pigs were housed individually, so daily feed intake was recorded which means that daily fat intake was also known. Diets contained titanium dioxide as a digestibility marker. Feces were collected throughout the finishing period, at the mid-point of each carcass fat collection period (75 to 90 kg; 90 to 105 kg; 105 to market) to determine the total tract digestibility of the dietary fat sources. While information on the digestibility of the fat sources was critical to understanding the relationship between dietary fat and carcass fat, the digestibility of other dietary components will be determined to support calculation of the digestible, metabolizable and net energy content of the experimental diets. Because the control diet has no added fat, the net energy value of the three fat sources can be estimated by difference.

Subcutaneous fat samples were collected at 75 kg, 95 kg and 115 kg by biopsy and assayed for total fatty acid profile. Following approved IACUC sedation and adipose tissue collection guidelines, small incisions with a cork bore were made in the jowl, in the loin between the sixth and twelfth rib, and the scribe side of the belly between the sixth and twelfth ribs. Adipose tissue collected from the biopsies were snap-frozen using liquid nitrogen and then stored in a controlled minus 80 °C freezer until analyzed. Fatty acids were extracted by a one-step direct transesterification procedure (Lepage and Roy, 1986). These samples were then assayed for total fatty acid profile by gas chromatography (AOAC, 2002) to calculate iodine value (AOCS, 1998). These data allowed us to follow the time course of the fatty acid profile as the pigs grew and deposition of fat increased and accumulated. At 130 kg, the pigs were marketed at the JBS Swift plant in Worthington, MN, where samples of jowl, belly and backfat were collected. All of these carcass fat samples were assayed for total fatty acid profile by gas chromatography (AOAC, 2002) and iodine value calculated (AOCS, 1998), as well as for iodine value by titration (Barrow-Agee Labs).

The right side belly from each pig was collected and measured for: weight, temperature, and thickness. Thickness or depth was measured in two locations in the center of the belly for middle thickness (MT) and at the center of the scribe edge of the belly for edge thickness (ET).

Data were analyzed by using PROC MIXED (SAS 9.2) with fat source, fat level, interaction, sex treated as fixed effects. Replication was the random affect and sample date was a repeated measure. Alpha less than 0.05 is considered significant. Effects were analyzed across the seven treatments, the three fat sources, the three fat inclusion levels, sex, and the interaction between the fat source and the fat inclusion level.

Results: Average daily gain (Table 1) was affected by treatment (P=0.0002), sex (P=0.0371) and was improved by fat inclusion level (P=0.016). There was a fat source by fat inclusion level interaction (P=0.038), but there were no significant differences between fat sources (P=0.548). Average daily feed intake (Table 1) was affected by sex (P<0.0001), and there was a fat source by inclusion level interaction (P=0.031). There were also feed intake increase trends for treatment (*P*=0.0707) and fat source (*P*=0.0778). Fat inclusion level did not increase or decrease average daily feed intake (*P*=0.7654). Gain to feed (Table 1) was affected by treatment (P<0.0001) and sex (*P*<0.0001) and was improved by fat inclusion level (*P*=0.0015). There was no feed efficiency improvement seen across fat sources (*P*=0.3605) or fat source by fat inclusion level interaction (*P*=0.4487).

Final carcass iodine value measured via direct titration averaged across the three sample sites (Table 2) was affected by treatment (*P*<0.0001), sex (*P*=0.0002), fat source (*P*<0.0001), and fat inclusion level (*P*<0.0001). There was also a fat source by fat level inclusion interaction (*P*<0.0001). Jowl IV was significantly higher than belly IV or loin IV with the Control (*P*=0.0058), Tallow 3% (*P*<0.0001), CWG 3% (*P*=0.0032), and Corn Oil 3% (*P*=0.0415) treatment diets (Table 3). However across all fat sources, the 6% fat inclusion level resulted in no significant differences in IV across sampling sites (*P*>0.32). When iodine value was analyzed over time (Table 4), it showed that there were no significant differences across treatments at day 0 (*P*=0.8152), and that treatments were significantly different at day 18, 35, and 55 (*P*<0.0001).

Belly weight (Table 5) was affected by treatment (*P*=0.0393), sex (*P*=0.0007), and was improved by fat inclusion level (*P*=0.0228). There were no differences seen across fat sources (*P*=0.941) and no interaction between fat source and fat inclusion level was evident (*P*=0.2637). Belly firmness (Table 5) measured by a subjective score of 1, 2, or 3 with 1 being the firmest (Table 5) was affected by sex (*P*<0.0001), and was altered by fat source (*P*=0.0322). There was a treatment effect trend on belly firmness (*P*=0.0715), and no difference was seen across fat inclusion level (*P*=0.7646), and there was no significant evidence of a fat source by fat inclusion level interaction (*P*=0.142). Belly middle thickness (Table 5) was affected by sex (*P*=0.0002) and a statistical trend in fat source (*P*=0.0935), but was not affected by treatment (*P*=0.4071), or fat inclusion level (*P*=0.4207), and there was no evidence of a fat source by fat inclusion level interaction (*P*=0.7646). Belly edge thickness (Table 5) was affected by sex (*P*<0.0001) and by fat source type (*P*=0.0249). It was not affected by treatment (*P*=0.177), fat inclusion level (*P*=0.8998), and not interaction between fat source by fat inclusion level was evident (*P*=0.6646).

Hot carcass weight (Table 6) was affected by treatment (*P*=0.017), sex (*P*=0.0007) and a trend in fat inclusion level (*P*=0.0907), but was not affected by fat source (*P*=0.5348). No interaction of fat source by fat inclusion level was detected (*P*=0.5349). Loin muscle depth (Table 6) showed a significant interaction between fat source and fat inclusion level (*P*=0.0177), and there was evidence of a trend for treatment effect (*P*=0.0742). There was no significant sex (*P*=0.1043), fat source (*P*=0.7627), or fat inclusion level effect (*P*=0.4628). Backfat (Table 7) was affected by sex (*P*<0.0001) and showed a significant treatment by sex interaction (*P*=0.0095); however, backfat was not affected by treatment (*P*=0.2788), fat source (*P*=0.9819), fat inclusion level (*P*=0.8473), and no fat source by fat inclusion level interaction was evident (*P*=0.9769). Fat free lean % (Table 7) was affected by sex (*P*=0.0001) and showed a significant treatment by sex interaction (*P*=0.0214); however, fat free lean was not affected by treatment (*P*=0.1897), fat source (*P*=0.9962) or fat inclusion level (*P*=0.684), and no fat source by fat inclusion level interaction was evident (*P*=0.5757).

Discussion: Growth and efficiency was improved by increasing the fat inclusion level as expected. There were no differences seen among the fat sources, which again stresses the importance dietary fat has regardless of source on barn throughput and feed efficiency, as reported by others (De la Lata et al., 2001; Weber et. al. 2006). However translating these performance data into other scenarios should be carried out with caution due to the three different sedations applied to the pigs during this experiment, which impacted feed intake for three days out of the fifty-five day experiment. However, all pigs were uniformly affected by the sedation in this trial and did not confound the experiment.

Final carcass iodine value was altered by fat source and showed a dose response increase in the corn oil treatments. This shows that negative affect of feeding a fat source or feed ingredient that is unsaturated in content (iodine value greater than 120) on carcass iodine value is reflective of the inclusion level and should be limited when possible. If we assume that an acceptable IV is 74 g/100 g, then both CWG and tallow can be fed without concern up to 6% of the diet. However, IV for CWG can vary widely; the product used in this experiment had an IV of 66.5 g/100 g, but can be much higher or lower depending on the supplier (Weber et. al., 2006; Benz et. al., 2011). Carcass lipid IV was also affected by sex; this can be attributed to the growth and concurrent fat deposition differences between the two sexes. Previous experiments have shown a significant increase in iodine value between gilt and barrows (Benz et. al., 2011; Averette-Gatlin et. al., 2002). However, this difference in iodine value is correctable if gilts are marketed with more days on feed than their barrow counterparts or marketed at the same weight.

The difference seen between sample sites shows that when additional dietary fat is limited at equal to or less than 3%, the pig deposits more unsaturated fat from front to back. The assumed rule of thumb is that there is a two point difference between sampling fat from the jowl when compared to the belly or loin. However, our research shows that it can be significantly greater or less than this assumption depending on the fat inclusion level, regardless of source. Thus, producers need to be aware of where fat is being sampled from on the carcass. For example, if a production system with similar feed budgets and market weight targets is marketing to several different packing plants, a difference in iodine value between plants may simply be due to the sampling location.

This research also saw a significant impact on iodine value within the first 18 days of treatment. In addition, as the pig increases fat deposition at heavier weights the degree of saturation also increases, which may support withdrawal techniques from unsaturated fat sources late in the finishing stage of growth, and the importance of marketing at heavier weights. Previous research supports these findings as fat from soybean oil (unsaturated in content) has significantly increased iodine value within the first period of BW gain, and remained elevated above those of that of pigs fed the diets that contained saturated sources or no added fat, at each subsequent slaughter weight (Apple et. al., 2009).

Overall fat deposition in the pig greatly reflects the dietary fat content, and as dietary fat an inclusion level increase de novo fat synthesis is diluted or inhibited (Bee et. al. 2002) which is known to be mostly saturated in content. So as fat level increases de novo synthesis deposition decreases in content, causing that fatty acid profile and the iodine value to be more reflective of the dietary fat source and this reflection was evident within the first 18 days of treatment.

Differences were seen in bellies from the seven different treatments including trends in softness as the unsaturation of the dietary fat source increased. Sex was a significant fixed effect for all four belly measurements; and this may also be attributed to growth and fat deposition differences between the sexes. Belly weight increased with fat inclusion level, and differences between fat sources for belly thickness at the edge of the scribe side were evident as well. Overall the 3% corn oil bellies were numerically the poorest in our four belly measurements. Differences in other carcass measurements were mainly attributed to sex, with a treatment effect shown for hot carcass weight. Previous results have shown significant differences between no additional dietary fat, choice white grease and beef tallow in backfat and carcass weight, but no significant differences in belly firmness and dressing percentage (Weber et. al., 2006).

In summary, these results indicate the importance of knowing IV of fat source in the diet and the level at which it is fed. This helps producers determine how much corn oil, fed directly or as DDGS, can be fed while still producing a good-quality product. This report sums up the research completed to this point on further understanding the relationship between dietary fat and carcass fat. Research will be continued on this data set to further our understanding the relationship between the two over time by looking at: net energy of experimental diets, correlating daily fat intake to deposition of fat in the pig, and furthering information for on-line sampling of iodine value in packing plants which will allow us to complete objectives five and six. This completed experiment will allow us to give producers a science backed set of recommendations to maintain fat quality without sacrificing barn throughput and economic targets.

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Table 1. Effects of dietary fat on growth performance

	Treatments							Sex		Pooled SEM		*P-Value*				
Item	Control	Tallow		CWG		Corn Oil		B	G	Trt	Sex	Trt	Sex	Source	Level	S X L
Level	0	3	6	3	6	3	6									
ADG, kg	0.93^{b}	1.09^{a}	1.07^{ab}	0.99^{b}	1.11^{a}	1.04^{ab}	1.12^{a}	1.08	1.03	0.044	0.038	0.0002	0.0371	0.548	0.016	0.038
ADFI, kg	3.11	3.26	3.10	2.96	3.12	3.11	3.08	3.31	2.90	0.130	0.121	0.0707	<.0001	0.0778	0.7654	0.031
G:F, kg	0.301^{d}	0.337^{c}	0.347^{abc}	0.336^{c}	0.360^{ab}	0.339^{bc}	0.367^{a}	0.326	0.356	0.0077	0.0044	<.0001	<.0001	0.3605	0.0015	0.4487

^{a,b,c} Superscript indicates treatment effect of ($P<0.05$)

Table 2. Effects of dietary fat on carcass iodine value via titration[1]

	Treatments							Sex		Pooled SEM		*P-Value*				
Item	Control	Tallow		CWG		Corn Oil		B	G	Trt	Sex	Trt	Sex	Source	Level	S X L
Level	0	3	6	3	6	3	6									
Dietary Fat IV, g/100 g	-	41.9		66.5		123.1										
Carcass Fat IV[2], g/100 g	65.4^{d}	66.3^{d}	67.2^{d}	70.2^{c}	70.3^{c}	72.6^{b}	80^{a}	69.1	71.5	0.73	0.4	<.0001	0.0002	<.0001	<.0001	<.0001
Belly Fat IV, g/100 g	63.3^{e}	64.0^{e}	65.9^{de}	67.9^{cd}	69.1^{c}	72.0^{b}	79.1^{a}	66.7	70.8	1.06	0.59	<.0001	<.0001	<.0001	0.0002	0.0137
Back Fat IV, g/100 g	63.9^{c}	64.3^{c}	66.4^{c}	70.3^{b}	70.0^{b}	70.9^{b}	81.4^{a}	68.6	70.6	1.19	0.66	<.0001	0.0423	<.0001	<.0001	<.0001
Jowl Fat IV, g/100 g	69.3^{d}	70.9^{cd}	69.6^{d}	72.6^{c}	72.0^{c}	75.6^{b}	79.6^{a}	72.2	73.4	1.04	0.85	<.0001	0.0531	<.0001	0.2244	0.0012

[a,b,c] Superscript indicates treatment effect of ($P<0.05$)

[1] Iodine value assayed via titration (Barrow-Agee Labs)

[2] Carcass Fat IV was averaged across the three sampling sites: belly fat IV, back fat IV, and jowl fat IV

Table 3. Effects of dietary fat on iodine value via titration by sample site[1]

	Sample Site IV g/100 g				
Treatments	Belly	Loin	Jowl	SEM	*P*-Value
Control	63.3^{b}	63.9^{b}	69.3^{a}	1.28	0.0058
Tallow 3%	64.0^{b}	64.3^{b}	70.9^{a}	0.81	<0.0001
Tallow 6%	65.9	66.4	69.6	1.61	0.3412
CWG 3%	67.9^{b}	70.3^{ab}	72.6^{a}	0.77	0.0032
CWG 6%	69.1	70	72	0.96	0.3643
Corn Oil 3%	72.0^{ab}	70.9^{b}	75.6^{a}	1.11	0.0415
Corn Oil 6%	79.1	81.4	79.6	1.08	0.3212

^{a,b,c} Superscript indicates treatment effect of ($P<0.05$)

[1] Iodine value assayed via titration (Barrow-Agee Labs)

Table 4. Effects of dietary fat on iodine value over time

	Treatments								
Item	Control	Tallow 3%	Tallow 6%	CWG 3%	CWG 6%	Corn Oil 3%	Corn Oil 6%	SEM	P-Value
d0[1]	72.6	73.2	72.5	74.5	73.6	73.5	73.3	1.72	0.8152
d18[1]	67.1^{e}	68.5^{de}	68.2^{de}	71.3^{bc}	70.5^{bcd}	71.6^{b}	75.1^{a}	0.85	<.0001
d35[1]	63.4^{d}	65.0^{d}	65.6^{cd}	68.0^{bc}	68.4^{b}	70.4^{b}	74.1^{a}	0.82	<.0001
d55[1]	64.0^{d}	63.9^{d}	63.1^{d}	68.1^{bc}	67.6^{c}	70.6^{b}	78.6^{a}	1.03	<.0001

[a,b,c] Superscript indicates treatment effect of ($P<0.05$)

[1] Iodine value calculated by: (IV) = [C16:1] X 0.95 + [C18:1] X 0.86 + [C18:2] X 1.732 + [C18:3] X 2.616 + [C20:1] X 0.785 + [C22:1] X 0.723; brackets indicate concentration (AOCS, 1998)

Table 5. Effects of dietary fat on belly weight, depth, and firmness

	Treatments							Sex		Pooled SEM		*P-Value*				
Item	Control	Tallow		CWG		Corn Oil		B	G	Trt	Sex	Trt	Sex	Source	Level	S X L
Level	0	3	6	3	6	3	6									
Dietary Fat IV, g/100 g	-	41.9		66.5		123.1										
Belly Weight, kg	8.3^{c}	9.2^{ab}	9.2^{ab}	8.7^{abc}	9.5^{a}	8.6^{bc}	9.5^{a}	9.41	8.58	0.44	0.37	0.0393	0.0007	0.941	0.0228	0.2637
Belly Firmness[1]	1.78	1.65	1.65	1.78	2.31	2.42	2.05	1.56	2.34	0.228	0.126	0.0715	<.0001	0.0322	0.7646	0.142
Belly MT[2], cm	2.62	2.73	2.78	2.59	2.76	2.50	2.50	2.82	2.45	0.177	0.148	0.4071	0.0002	0.0935	0.4207	0.7646
Belly ET[3], cm	3.70	4.14	4.03	3.86	3.83	3.46	3.67	4.30	3.33	0.187	0.104	0.177	<.0001	0.0249	0.8998	0.6646

^{a,b,c} Superscript indicates treatment effect of (*P*<0.05)

[1] Measured by a subjective score of 1, 2, or 3 with 1 being the firmest

[2] Measured in the middle of the belly

[3] Measured on the middle scribe side edge of the belly

Table 6. Effects of dietary fat on hot carcass weight and loin muscle depth

	Treatments							Sex		Pooled SEM		*P-Value*				
Item	Control	Tallow		CWG		Corn Oil		B	G	Trt	Sex	Trt	Sex	Source	Level	S X L
Level	0	3	6	3	6	3	6									
HCW, kg	95.2^{b}	102.1^{a}	102.7^{a}	100.0^{ab}	105.1^{a}	103.1^{a}	106.0^{a}	105.0	99.0	2.33	1.55	0.017	0.0007	0.5348	0.0907	0.5349
LM Depth, mm	680	630	630	670	620	590	680	630	660	70	67	0.0742	0.1043	0.7627	0.4628	0.0177

^{a,b,c} Superscript indicates treatment effect of ($P<0.05$)

Table 7. Effects of dietary fat on backfat and fat free lean %

	Treatments							Pooled SEM			*P-Value*					
Item	Control	Tallow		CWG		Corn Oil		Trt	Sex	T X S	Trt	Sex	T X S	Source	Level	S X L
Level	0	3	6	3	6	3	6									
Backfat, mm																
Barrows	223	274	213	292	295	220	213	15.4	10.6	20.1	0.2788	<.0001	0.0095	0.9819	0.8473	0.9769
Gilts	183	190	199	182	175	215	201									
Fat Free Lean, %																
Barrows	52.9	49.6	52.9	48.7	48.3	52.4	54.7	1.6	1.4	1.85	0.1897	<.0001	0.0214	0.9962	0.684	0.5757
Gilts	56.3	55	54.6	56.2	55.9	53.1	54.7									