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Director's Digest

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INFLUENCE OF DIETARY FAT ON SWINE CARCASS QUALITY

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In the early 1900's the pork industry became aware of carcass quality problems associated with increased levels of unsaturated fat that has been commonly refer too as "soft pork". The USDA supported studies beginning in 1919 on the relationship between different fat sources and carcass firmness. It was shown in numerous studies that the use of ingredients containing high levels of unsaturated fat (corn germ meal, flaxseed, peanuts, cooked or raw soybeans, sunflower seed, and sesame seed) produced soft carcasses. (Carroll and Krider, 1956; Hanson et al, 1970).

The fatty acid composition of lean and fat tissue is directly related to the type of fat fed. Fatty acids are important precursors to pork flavor. The use of supplemental dietary fat to increase energy level in the diets of growing finishing pigs has become common place. Especially to combat the effects of heat stress (Coffey et al, 1982).

It has been assumed that carcass firmness concerns are primarily associated with the use of vegetable oils and the feeding of seeds containing high levels of unsaturated fats. Further, there has been interest in increasing the proportion of polysaturated fat in pork meat. Studies have shown linoleic acid (18:2) to be the most

influential dietary fatty acid in regard to carcass fat composition and fat quality due to it's rapid incorporation into tissues. Schoenherr et al, (1988) reported significant variation in the carcass quality of pigs feed either 5% prime steam lard or 5% rendered poultry fat. Pigs fed poultry fat were softer and had lower muscle pH, color score and total estimated lean meat ($P < .01$). The most noticeable difference in the composition of those fat sources was the linoleic acid content. Unsaturated fatty acids, particularly linoleic acid are more susceptible to oxidation. This can have a negative effect on quality by altering flavor and oxidative stability of pork meat. Therefore, two experiments were conducted to 1) evaluate the influence of dietary linoleic acid concentration and 2) evaluate common feed fats in relation to their linoleic acid concentration on carcass quality of swine (Schoenherr et al. 1991).

In the first experiment 80 pigs (60 kg) were allotted to one of four treatments containing similar levels of lysine (.90%) and added fat (6%) from varying amounts of either edible tallow or safflower oil to provide linoleic acid at either 1.76, 3.20, 4.60 or 6.10% of the diet (treatment 1-4, respectively). Safflower oil was either 0, 33, 66 or 100% of the added dietary fat. Pigs were slaughtered at 100 kg. Carcass composition and quality factors were determined including volatiles released during heating to estimate the effects of linoleic acid content of the diet on flavor components.

Growth performance and carcass data are shown in Table 1. As expected, growth and carcass data were not altered by dietary fat source. Increasing the level of dietary linoleic acid resulted in a linear increase in the linoleic acid (18:2) and 20:2 concentration in adipose tissue (Table 2) and the linoleic acid concentration of the lean tissue (Table 3). In adipose tissue, increasing the level of linoleic acid via safflower oil replacement of tallow resulted in decreased concentration of 14:0, 16:0 and 18:1. A regression equation was developed to estimate the influence of dietary linoleic acid level on tissue concentration of linoleic acid. For adipose the relationship was: tissue concentration of linoleic acid (mg/100 g fat) = 6833.8 + 1267.9 (% dietary linoleic acid); $R^2 = .51$. For lean the relationship was: tissue concentration of linoleic acid (mg/100

g lean) = 165.2 + 13.9 (% dietary linoleic acid); R^2 = .16. As expected the relationship for the adipose tissue is much stronger since the dietary fat is preferentially stored in adipose tissue upon digestion and absorption.

The effect of treatment on head space volitiles released from lean tissue during heating is show in Table 4 (Larick et al. 1991). There were differences due to dietary treatment and release of the aldehyde's pentanal and hexanal which are major components unique to autoxidative decomposition increased with increasing levels of dietary linoleic acid; however, a trained taste panel was unable to detect any flavor differences between the treatments.

Carcass firmness, a subjective measure of lean and fat firmness, decreased as the unsaturation of the fatty acids in the fat source increased. A penetrometer was used to objectively measure the firmness of the lean tissue. The penetrometer drops a standard weight from a set distance over a same time period and measures the deflection of the tissue. Data from the penetrometer indicated that as lean tissue increased in linoleic acid content the tissue became less firm. Linoleic acid was the only unsaturated fatty acid changed enough that carcass firmness was directly related to linoleic acid level. These results indicated that the dietary linoleic acid concentration may need to be considered in formulation of swine diets and limited to a maximum of 3.5 - 4.0%

In the second experiment common feed fats including lard, poultry fat, soy oil and animal vegetable blend were used to determine if linoleic acid content of each fat was the major fatty acid impacting carcass quality of pigs. Diets contained .90% lysine and 0 or 5% added fat and were fed to pigs from 60 to 100 kg body weight. The fatty acid composition of each of the fats fed is shown in Table 5.

Growth and carcass data for the second experiment are shown in Table 6. A diet not supplemented with fat was used as a control in this experiment. Pigs fed fat added diets grew faster and with greater efficiency than those fed diets without supplemental fat. There was little difference in feed intake among treatments. Pigs fed an animal-vegetable blend grew faster than those fed lard. No differences were found among fat-added diets for efficiency of feed

utilization. Carcass length, loin area and percent muscle were not different among treatments but tenth rib backfat was increased in those pigs fed additional fat when compared with a diet not supplemented with fat.

Review of the fatty acid composition of the carcass backfat in this experiment (Table 7) showed trends similar to that in the first experiment. The addition of high levels of linoleic acid significantly increased the amount of 18:2 in adipose tissue and appeared to be well correlated to dietary levels. The increase in linoleic acid in the adipose appeared to be at the expense of oleic and stearic acid.

These data also indicated that linoleic acid had a major influence on carcass firmness for the fats added except poultry fat. Carcass firmness measurements were influenced by diet and fat source but not all measurements were correlated with a single fatty acid (Table 6 and 7). What was evident in this trial was that poultry fat is a unique fat. In trying to establish a relationship of linoleic acid to carcass firmness by including all fats in the model, linoleic acid accounted for 11% of the variation in carcass firmness. If pigs fed poultry fat were dropped from the model, linoleic acid accounted for 45% of the variation. This approached the degree of influence linoleic acid had in the previous experiment. The question this experiment generated was what makes poultry fat so different from other fats. From the fatty acid composition of the fat one would not expect it's large negative effect on carcass quality. Further studies will be required to clarify the impact of the composition of supplemental fat on swine carcass quality.

References

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Table 1. Growth Performance and Carcass Data, Experiment 1.

Criterion	Treatment 1	2	3	4
Initial wt., lb	132.3	131.1	131.9	132.1
Daily gain, lb/d	1.89	1.86	1.82	1.86
Feed intake, lb/d	5.93	5.77	5.89	5.96
F:G	3.13	3.09	3.22	3.19
Hot carcass wt., lb	161.5	163.1	162.9	162.6
Carcass length, in[a]	31.2	31.2	31.3	31.5
Loin area, sq. in[a]	4.18	4.10	4.13	4.09
10th rib backfat, in[a]	1.62	1.57	1.52	1.58
% muscle	43.8	44.1	44.6	44.1
Carcass firmness[b,c]	2.57	2.46	3.31	3.77
Penetrometer depth, mm[c]	49.57	51.45	57.30	60.05

[a] Hot carcass weight used as a covariate to adjust means.
[b] Subjective score on a scale of 1 to 5 (1=very firm, 5=very soft).
[c] Linear effect of dietary fat source (P<.001).

Table 2. Fatty Acid Composition of Adipose Tissue

Fatty acid (mg/100g fat)	Treatment 1	2	3	4
12:0	67.2	54.1	67.9	74.2
14:0[a]	1396.2	1439.6	1368.9	1316.5
14:1	0.0	4.9	13.3	0.0
16:0[a]	18589.4	17777.4	17482.4	17327.4
16:1	1592.7	1488.3	2006.5	1330.0
18:0	9359.1	8399.1	8495.3	8343.4
18:1[a]	28054.5	25034.0	24687.9	24282.9
18:2[b]	9238.6	10254.2	13387.1	14272.7
18:3	328.9	291.6	295.6	303.6
20:0	108.1	76.7	102.7	88.1
20:1	511.6	476.9	489.5	521.7
20:2[b]	298.6	305.1	461.7	508.1
20:3[a]	10.0	7.0	16.4	16.9
20:4	95.9	104.4	75.1	81.1
22:0	0.0	0.0	18.4	0.0
22:4	8.6	2.6	11.7	10.4
24:0	3.3	0.0	17.9	2.1
Total Fatty Acid	71089.0	66986.4	70442.2	69741.1

[a] Linear effect of fat source ($P<.05$).
[b] Linear effect of fat source ($P<.0001$).

Table 3. Fatty Acid Composition of Lean Tissue

Fatty acid (mg/100g fat)	Treatment 1	2	3	4
12:0	2.0	2.4	2.5	2.3
14:0	27.8	33.5	33.5	30.7
14:1	0.1	0.2	0.2	0.1
16:0	426.6	485.7	483.1	451.4
16:1	55.6	60.8	60.0	57.6
18:0	199.1	226.4	216.9	204.4
18:1	623.9	684.1	665.7	615.1
18:2[a]	185.2	210.1	241.1	241.2
18:3[b]	3.9	3.9	3.5	2.7
20:0	2.5	3.0	2.8	2.7
20:1	8.9	11.0	10.3	9.8
20:2	4.5	4.9	5.4	5.5
20:3	3.7	4.1	3.7	3.3
20:4	37.3	37.6	34.8	35.5
22:0	0.0	0.0	0.0	0.0
22:4	3.9	4.6	4.3	3.8
24:0[b]	2.8	2.7	1.6	1.6
22:6	0.1	0.1	0.1	0.2
Total Fatty Acid	1653.4	1842.6	1834.0	1746.0

[a] Linear effect of fat source ($P<.0001$).
[b] Linear effect of fat source ($P<.05$).

Table 4. Effect of Diet on Head Space Volitiles From Lean

Compound	Treatment 1	2	3	4
Pentanal*	88393[a]	117201[ab]	143549[b]	138220[b]
Hexanal*	315974[a]	410308[ab]	481412[b]	476239[b]
T-2-heptenal	2264[a]	3496[b]	4227[bc]	5059[c]
2-pentylfuran	12524[a]	16504[ab]	18645[b]	19102[b]
2-ethyl - 1-hexanal	1217[a]	1932[ab]	1949[ab]	2462[b]

* Major components unique to autoxidation decomposition
Means with different superscripts are different ($P < .05$)

Table 5. Fat Composition, Experiment 2.

Fatty Acid, %	Soy Oil	AV-Blend	Poultry	Pork Lard
12:0	.10	.09	.22	.05
14:0	3.09	1.44	1.49	1.42
16:0	10.34	16.23	21.14	26.45
16:1	3.21	2.67	6.40	2.45
18:0	4.00	9.33	6.91	12.67
18:1	22.09	43.67	38.52	44.52
18:2	51.50	21.23	22.59	10.12
18:3	6.73	2.11	1.00	.64
Unsaturated:Saturated	4.66	2.53	2.30	1.42

Fat analysis by Woodsen-Tenent, Goldston, NC.
Poultry fat and AV-Blend supplied by Carolina By-Products, Greensboro, NC.

Table 6. Growth Performance and Carcass Data, Experiment 2.

	Treatment				
Fat added:	None	Soy Oil	AV-Blend	Poultry	Pork Lard
Criterion					
Initial wt., lb	144.0	143.8	143.5	143.4	143.3
Final wt., lb	231.5	235.5	237.4	233.2	235.5
Daily gain, lb/d[ab]	1.97	2.05	2.10	1.98	1.88
Feed intake, lb/d	6.36	6.43	6.53	6.06	6.06
F:G[a]	3.56	3.31	3.27	3.30	3.32
Hot carcass wt., lb	175.7	179.0	180.0	179.1	178.5
Cold carcass wt., lb	171.5	175.1	175.6	175.2	174.6
Carcass length, in[c]	31.8	32.1	31.6	31.7	31.9
Loin area, sq. in[c]	5.79	5.60	5.67	5.77	5.59
10th rib backfat, in[cd]	1.05	1.20	1.30	1.12	1.19
% muscle	54.9	53.4	52.6	54.4	53.5
Carcass firmness[ae]	2.93	2.22	2.48	2.22	2.72
Penetrometer depth, mm	71.08	69.48	60.96	72.25	71.24

[a] Fat versus no fat added diets ($P < .005$).
[b] Treatment effect ($P < .001$).
[c] Hot carcass weight used as a covariate to adjust means.
[d] Fat versus no fat added diets ($P < .05$).
[e] Subjective score on a scale of 1 to 5 (1=very firm, 5=very soft).

Table 7. Fatty Acid Composition of Adipose Tissue, Experiment 2.

	Treatment				
Fat added:	None	Soy Oil	AV-Blend	Poultry	Pork Lard
Fatty acid, % of total					
14:0	1.43	1.42	1.19	1.38	1.42
16:0	26.11	23.94	23.54	24.59	25.22
16:1	2.42	2.06	2.50	2.91	2.35
18:0	14.94	12.56	13.32	13.12	13.90
18:1	42.86^{b}	36.59^{a}	42.96^{b}	43.37^{b}	43.68^{b}
18:2	9.31^{d}	19.16^{a}	12.87^{b}	11.10^{c}	10.25^{cd}
18:3	.37	1.47	.57	.41	.41
20:0	.23	.31	.28	.23	.27

Mean with different superscripts are different ($P < .05$).