Influence of Conjugated Linoliec Acid (CLA) on Belly and Bacon Quality From Pigs Fed Various Diets

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Meat Science

ASL-R697

Summary and Implications

A study was initiated to investigate the feeding of conjugated linoleic acid (CLA) to market barrows to achieve improvements of bacon quality characteristics. CLA was fed at 55 kg of body weight to 113 kg of body weight. CLA improved belly firmness ($P<0.05$) for all diets according to the belly bar firmness test but CLA did not improve bacon sliceability. Bacon slabs from CLA-supplemented pigs were firmer according to the compression test. Dietary CLA increased the percentage of saturated fatty acids and CLA isomers in bacon.

Introduction

Diets of market pigs containing high-oil corn can be very beneficial. Improvement of feed efficiency is one way a pork producer can benefit by the use of high-oil corn. Another way high-oil corn could help is that can act as a source of energy for growing pigs. A potential down side, however, to feeding high-oil corn is that it increases soft carcass fat because it has a higher content of unsaturated fatty acids and hence this unsaturated condition makes very soft bellies. Softness is directly proportional to the polyunsaturated fatty acids in high-oil corn diets. The result of soft bellies is reduced sliceability and a lower yield of bacon slices. Moreover, unsaturated fats are very sensitive to lipid oxidation leading to off-flavors. Consequently, a shorter shelf life of bacon is a potential result of feeding pigs high oil corn. Moreover, a decrease in bacon slicing yields and a shorter shelf life can cause a huge impact on the profitability of the pork industry. An alternative to these problems could be by supplementing conjugated linoleic acid (CLA). CLA has been shown to improve belly firmness and increase in shelf life. Consequently, supplementation of CLA could benefit belly firmness and shelf life in diets containing high-oil corn.

Materials and Methods

Forty-seven barrows weighing approximately 55 kg were fed one of six diets. These diets consisted of diet 1, normal corn; diet 2, diet 1 + 1.25% CLA-60 oil; diet 3, high oil corn; diet 4, diet 3 + 1.25% CLA-60 oil; diet 5, diet 1 + choice white grease; diet 6, diet 5 + 1.25% CLA-60 oil. Soy oil replaced CLA to make diets 1 and 2 isocaloric and 3, 4, 5, and 6 isocaloric. Pigs were slaughtered at the ISU meat lab at an average live weight of 113 kg. At 24-h postmortem, carcasses were fabricated into primal cuts and bellies were collected. Spare ribs and skin were removed from the bellies.

Before processing, belly firmness was measured by using a standard bar test. This was measured on each belly by measuring the inside distance between the ends of the belly while the belly was suspended lengthwise across a _-in. diameter stainless steel bar. Those measurements were taken on both the bellies fat side down and the lean side down. They were then weighed to obtain a green belly weight.

Bellies were cured using a brine injection with a Townsend Model 1400 (Townsend Engineering, Des Moines, IA), and then weighed to get a pumped belly weight. The target pump was 12%. The brine consisted of 77.13% water, 12.25% salt, 4.25% sugar, 4.25% phosphate, 0.458% erythorbate, and 0.104% nitrite. Bellies were allowed to equilibrate before being thermally processed in a Maurer (Reichenau, Germany) thermal-processing unit. Immediately after their removal from the Maurer, they were weighed for a hot yield weight. Then they were placed in a cooler ($2^{o}C$) to chill for 24 hours.

After 24 hours, the bacon side was then weighed for a chilled weight, squared, and placed in a Berkel Model 1170 slicer (U.S. Slicing Machine Company, Inc., Laporte, IN). One bacon was completely sliced and the slices were separated by visual quality (e.g., shattered, torn, or not appealing) into either acceptable or unacceptable portions to determine the weights of each group.

Two slices were taken from each end and from the middle section from each bacon side for a total of six slices. These slices were taken for fat and moisture determination along with protein content according to AOAC approved methods. Two methods were used to cook the slices, frying and microwave methods. These slices were cooked beyond the “limp” stage or until the desired crispness was reached. One method cooked the slices by using a standard frying skillet at 177°C. The slices were cooked on the first side for 2 minutes and 30 seconds, and then they were turned and cooked for another 1 minute and 30 seconds, and turned one more time and cooked for 30 seconds. The slices were then blotted dry by using a paper towel. The second method cooked the slices by using a Radarange microwave with 1500 max watts. The slices were placed on a microwavable tray, placed in the microwave and cooked at full power for 2 minutes and 20 seconds, and then rotated 180°, and cooked for another 2 minutes and 20 seconds. The slices were then blotted dry by using a paper towel. Slices were frozen in liquid nitrogen and then ground. Two slices were taken from each end and from the middle section from each bacon side for a total of six slices for lipid oxidation tests (TBA), once a month for five consecutive months. Oxidation products were measured with a mass spectrophotometer at 532 nm. The TBA values are reported as milligrams of malonaldehyde per kilogram of sample. The slices also were frozen in liquid nitrogen and ground prior to doing each TBA. The other bacon side was partially sliced and three 10.16-cm slabs were taken at 25, 50, and 75% of the length of the belly from the shoulder end for compression tests. Compression tests were taken at 25, 50, and 75% of the width from the navel edge of the bacon slab. Two slices were taken from each end and from the middle section from each bacon slab for a total of six slices were taken for lipid analysis. Results were analyzed with the proc GLM procedures of SAS. Means were considered different at a preset P value of 0.05 or less. The means shown in the tables are least-squares means produced by SAS.

Results and Discussion

Belly firmness values according to the belly bar firmness test of fresh bellies are shown in Table 1. As expected, the bellies from CLA-fed pigs had increased belly firmness when measured fat side down according to the belly bar firmness test. Bellies from CLA-fed pigs also increased belly firmness lean side down for the normal corn with choice white grease diet. However, CLA only slightly increased the other two diets, though not significantly.

Belly processing weights (kg), processing yields (%), and sliceability weights (kg) of bellies from pigs fed various diets are shown in Table 2. No differences were observed between any diets according to these observations.

Effects of frying (F), microwave (M) and raw (R) on moisture, fat and protein percentages of bacon from pigs fed various diets using two different cooking methods are shown in Table 3. Significant differences were observed for moisture percentages of raw bacon slices compared with the cooked bacon slices, regardless of cooking method within each treatment. No differences were observed for protein percentages.

TBA values of bacon from pigs fed various diets are shown in Table 4. No differences were observed for TBA values over a 5-month shelf life study.

Data in table 5 shows least squares means for compression values (kg) of bacon slabs from pigs fed various diets. The addition of CLA into the normal corn, high-oil corn and normal corn with choice white grease diets increased bacon slab firmness. Bacon firmness results were also seen in the belly bar firmness test when the bellies were placed fat side down.

Results of the effect of CLA on fatty acid composition and CLA content are shown in Table 6. As expected, CLA increased the percentage of saturated fatty acids, which were palmitic acid (16:0) and stearic acid (18:0). CLA also decreased unsaturated fatty acids, which were oleic acid (18:1) and arachadonic acid (20:4) in every diet. The trans-9, trans-11 isomer was slightly incorporated into the CLA diets, but not at a significant amount. However, the cis-9, trans-11 and trans-10, cis-12 isomers of CLA were significantly increased. The cis-9, trans-11 isomer was incorporated at a higher percentage than the trans-10, cis-12 isomer.

Conclusions

The increase in firmness of bellies and bacon slabs demonstrated by the supplementation of CLA could save dollars for the belly processors in the bacon industry. The incorporation of CLA into bacon slices could have potentially positive impacts on the health of consumers. CLA has beneficial effects such as enhancing immune function, preventing heart disease and cancer, and body compositional differences could improve the health of consumers. These results with supplementation of CLA in swine diets demonstrate a positive effect on some measures of belly quality. Additional research is currently under way at ISU. This will help examine more closely belly quality with regard to diets containing CLA and high-energy diets.

Table 1. Belly bar firmness test (cm) of bellies from pigs fed various diets.

	NC	NC/CLA	HOC	HOC/CLA	NC/CWG	NC/CWG/CLA	SEM
LD[c]	12.32	18.80	11.13	15.98	10.08[a]	18.62[b]	1.73
FD[c]	18.39[a]	28.68[b]	12.85[a]	22.45[b]	12.65[a]	29.21[b]	2.21

[c]Means within a row with different letters are significantly different at P<0.05,
LD, lean side down
FD, fat side down

Table 2. Belly processing weights (kg), processing yields (%), and sliceability weights (kg) of bellies from pigs fed various diets.

	NC	NC/CLA	HOC	HOC/CLA	NC/CWG	NC/CWG/CLA	SEM
Green wt	5.36	5.54	5.53	5.15	5.59	5.72	0.15
Pumped wt	6.05	6.59	6.53	5.90	6.47	6.48	0.23
Pr smokehouse	6.11	6.56	6.49	5.93	6.52	6.51	0.21
Hot wt	5.52	5.79	5.78	5.34	5.79	5.89	0.17
Chilled wt	5.36	5.55	5.59	5.20	5.61	5.71	0.16
Initial loss	9.53	11.68	10.88	10.01	10.93	9.50	0.86
24-hr loss	2.85	4.19	3.23	2.42	3.17	2.96	0.51
Total loss	12.09	15.38	13.75	12.17	13.75	12.17	1.03
Initial wt	5.24	5.30	5.44	5.13	5.34	5.52	0.13
Squared wt	4.02	4.24	4.30	4.09	4.07	4.44	0.12
Acceptable Slices	3.72	3.97	4.05	3.82	3.80	4.05	0.12
Unacceptable Slices	0.30	0.27	0.25	0.27	0.27	0.39	0.05

Pr, weight prior to smokehouse,
Initial loss, 100 – (hot cured weight/weight prior to smokehouse),
24-hr loss, 100 – (cooled cured weight/hot cured weight),
Total loss, 100 – (cooled cured weight/weight prior to smokehouse)

Table 3. Effects of frying (F), microwave (M) and raw (R) on moisture, fat and protein percentages of bacon from pigs fed various diets using two different cooking methods.

	NC			NC/CLA			HOC			
	F	M	R	F	M	R	F	M	R	SEM
Moisture[c]	16.27[a]	12.65[a]	47.02[b]	11.79[a]	12.34[a]	46.35[b]	12.30[a]	12.39[a]	41.89[b]	2.20
Fat[c]	34.15	35.61	36.33	35.89	35.10	35.90	33.33[a]	36.14[a]	42.16[b]	1.82
Protein			14.03			13.84			12.64	0.61

	HOC/CLA			NC/CWG			NC/CWG/CLA			
	F	M	R	F	M	R	F	M	R	SEM
Moisture[c]	13.66[a]	14.29[a]	45.31[b]	12.83[a]	13.85[a]	45.14[b]	10.89[a]	15.96[a]	44.29[b]	2.20
Fat[c]	36.33	33.68	38.06	33.13	34.16	38.08	38.05	35.68	38.79	1.82
Protein			13.24			13.69			13.62	0.61

[c] Means within a row with different letters are significantly different at P<0.05.

Table 4. TBA[a] values of bacon from pigs fed various diets.

Month	NC	NC/CLA	HOC	HOC/CLA	NC/CWG	NC/CWG/CLA	SEM
1	0.158	0.168	0.180	0.156	0.185	0.159	0.133
2	0.150	0.153	0.163	0.140	0.184	0.159	0.009
3	0.161	0.139	0.149	0.156	0.170	0.145	0.128
4	0.143	0.141	0.143	0.134	0.160	0.138	0.009
5	0.155	0.155	0.163	0.148	0.188	0.155	0.011

[a] TBA values expressed as milligrams of malonaldehyde per kilogram sample.

Table 5. Compression values (kg) of bacon slabs from pigs fed various diets.

	NC	NC/CLA	HOC	HOC/CLA	NC/CWG	NC/CWG/CLA	SEM
Force[c]	10.39[a]	11.52[b]	9.17[a]	10.29[b]	8.69[a]	11.67[b]	0.37
Area[c]	63.61	69.32	55.82	61.87	51.98[a]	71.21[b]	2.27

[c] Means within a row with different letters are significantly different at P<0.05.

Table 6. Fatty acid and CLA percentages of bacon from pigs fed various diets.

	NC	NC/CLA	HOC	HOC/CLA	NC/CWG	NC/CWG/CLA	SEM
(16:0) Palmitic[c]	26.09[a]	31.43[b]	24.89[a]	28.52[b]	24.82[a]	29.14[b]	0.757
(16:1) Palmitoleic[c]	2.77[a]	3.40[b]	2.50	2.74	3.01	3.23	0.116
(18:0) Stearic[c]	13.80[a]	16.85[b]	13.15[a]	16.25[b]	12.72[a]	16.20[b]	0.661
(18:1) Oleic[c]	39.72[a]	30.66[b]	37.64[a]	31.31[b]	41.53[a]	33.09[b]	1.427
(18:2) Linoleic[c]	11.82	9.92	16.63[a]	13.65[b]	11.93	9.77	0.723
(18:3) Linolenic[c]	2.83	2.95	2.26[a]	2.62[b]	3.44	3.20	0.100
(20:4) Arachadonic[c]	1.35[a]	1.06[b]	1.41[a]	1.16[b]	1.42[a]	1.18[b]	0.061
CLA Isomers							
t-9, t-11	0	0.06	0	0.05	0	0.03	0.025
c-9, t-11	0[a]	1.22[b]	0[a]	1.18[b]	0[a]	1.18[b]	0.127
t-10, c-12	0[a]	0.95[b]	0[a]	0.93[b]	0[a]	0.91[b]	0.099

[c] Means within a row with different letters are significantly different at P<0.05.
t, trans configuration
c, cis configuration

NC, normal corn; NC/CLA, normal corn with CLA; HOC, high oil corn; HOC/CLA, high oil corn with CLA; NC/CWG, normal corn with choice white grease; NC/CWG/CLA, normal corn with choice white grease with CLA.