National Swine Nutrition Guide

factsheet

Pork Information Gateway

Feed Additives for Swine-Conjugated Linoleic Acid (CLA)

Authors
Brian T. Richert, Purdue University
Mickey Latour, Purdue University

Reviewers
Bryon Wiegand, University of Missouri
Eric van Heugten, North Carolina State University
Joel M. DeRouchey, Kansas State University

Introduction

A major challenge in the pork industry is to produce lean pigs without compromising pork quality. Pork quality includes both lean (e.g. color, intramuscular fat, drip loss or purge) and fat (e.g. firmness, slice ability of bellies, flavor) quality of the meat products. One of the strongest determinants of carcass fat quality in pigs is the dietary lipid level and composition. Because the efficiency of utilization of dietary fat is very high (90%) in pigs and the transfer of dietary fat to carcass lipid is high (31-40%) [1,2], the carcass lipid composition is often a reflection of the dietary fat fed when pigs shift from de novo synthesis of fatty acids to dietary uptake. Dietary lipids may have different effects on carcass lipid depending on its composition, level, and duration or timing preslaughter during the grow-finish period. Understanding and managing the factors that control carcass fat quality is a challenge for swine producers given several feedstuffs may be very economical (e.g. DDGS), but may be detrimental to carcass fat quality. Conjugated linoleic acid (CLA) is a fatty acid that may be one tool to help producers manage pork carcass quality. CLA refers to a group of linoleic acid (18:2) isomers that have several biological effects. When fed to finishing pigs, CLA has been reported to reduce backfat, improve feed conversion, carcass leanness, loin marbling, and carcass fat firmness.

Objectives

- Describe dietary fat effects on carcass fat quality
- Describe the FDA approved use of CLA for swine
- Describe the effects of CLA on pig performance and carcass traits

Dietary Fat Sources and Carcass Lipid Quality

Dietary fat composition plays a major role in determining adipose tissue composition. Swine , especially lean genetics, directly incorporate a significant amount of their dietary fatty acids into tissue lipid deposits [3,4]. Therefore, to manipulate carcass lipid quality, it is important to understand the effects dietary fat sources can have on the final carcass composition. Because unsaturated dietary fatty acids are minimally modified before deposition into swine adipose stores, carcass fatty acid profile closely mimics dietary fatty acid profile [3,5]. Dietary fats primarily alter carcass lipid composition by changing the level of saturation in the carcass fatty acid profile [3].

Fatty acid composition of fat tissue is important because different fatty acids have varying melting points which will affect carcass fat firmness. In addition, unsaturated fatty acids are more prone to lipid oxidation, because their double bonds are subject to free radical attack [6]. The ability of unsaturated fatty acids, especially polyunsaturated fatty acids, to rapidly oxidize affects shelf life of the meat products and creates an off-flavor and odor. Fat quality can also be measured by saturated to unsaturated fatty acid ratios or iodine value (IV) which is a measure of double bonds in the fatty acids [3,7]. Increased IV [7] and decreased saturated to unsaturated fatty acid ratios [3] indicate a potential decrease in carcass quality due to decreased fat firmness.

The level of saturation and IV of the feed lipid source will be reflected in the carcass fatty acid profile. Vegetable oils are typically high in linoleic acid (C18:2), have an unsaturated to saturated fatty acid ratio of 12:1 [4] and an IV greater than 100 [3]. Diets high in unsaturated vegetable oils will result in oily, soft carcass fat [3]. Conversely, beef tallow, which is high in palmitate (C16:0) and stearate (C18:0), has a saturated to unsaturated fatty acid ratio of 1:1 [4], an IV of 40 or 45 [3], and will result in firmer carcass fat when fed in the diet.

Acceptable fat quality standards for pork carcasses vary between processors and researchers according to IV, ratio of saturated to unsaturated fatty acids, belly firmness, and percent lean in bacon. Many processors utilize IV as numerical evaluation of carcass quality and thus have target IV values. An IV greater than 65 for some processors may be unacceptably high [8], while an IV greater than 72 may be the threshold for other processors.

Conjugated Linoleic Acid

Conjugated linoleic acids (CLA) are a group of polyunsaturated fatty acids that are positional and geometric isomers of linoleic acid (C18:2). Because CLA is naturally produced during bacterial fermentation in the rumen of ruminant animals, the main sources of CLA in human nutrition are dairy products and ruminant meat products [9,10]. There are numerous isomers of CLA though the main isomers are cis-9, trans-11(c9t11) and trans-10, cis-12 (t10c12), shown in Figure 1. The main isomer produced by ruminants is c9t11. Commercially available products commonly contain equal proportions of c9t11 and t10c12 [9,10]. Research in rodents, pigs, and humans has shown beneficial effects of CLA on obesity, cancer, atherosclerosis, and diabetes, some of which are isomer specific [9,10,11]. Many studies have shown CLA is able to reduce adipose tissue depots in rodents, pigs, and humans and that this effect is specific to the t10c12 isomer or a mixture containing greater than 50% t10c12 [9,11].

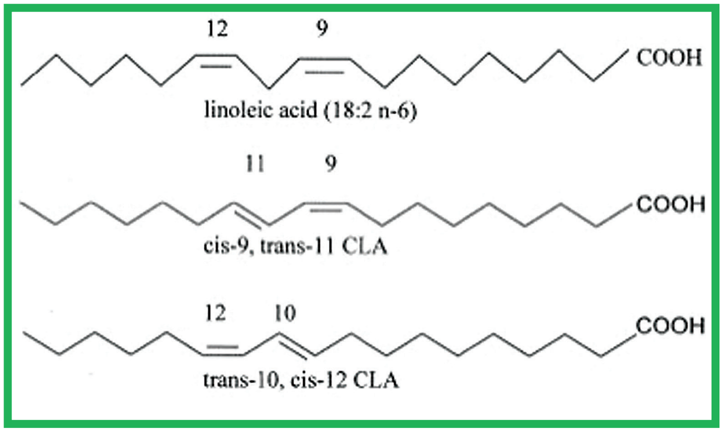

Figure 1. Structure of linoleic acid, cis-9, trans-11 CLA and trans-10, cis-12 CLA, adapted from Evans et al., 2002 [33].

FDA approved use of CLA for swine

The use of CLA in swine diets was published as a final approval in the FDA registry on October 29, 2008 (Vol. 73:No. 210; pg 64197-64199) based on the application of BASF Corp. The approval states: "The additive (CLA) is used or intended for use in the feed of growing and finishing swine as a source of fatty acids at levels not to exceed 0.6% in the finished feed". The approval also indicates that the CLA source must contain a minimum of 28% of each isomer, cis-9, trans-11(c9t11) and trans-10, cis-12 (t10c12) as methyl esters derived from sunflower oil. There are no claims made of what CLA may or may not do beyond serving as a source of fatty acids and there are no weight restrictions other than for growing and finishing swine. BASF's current product name for CLA in swine diets in the U.S. is Lutalin® and is currently commercially available in 385 lb drums. Other volumes of the product maybe available in the future as product development and demand are fully assessed.

Feeding CLA in Swine Production

Feeding CLA to pigs resulted in decreased feed intake while growth rate was unchanged, thus improving feed efficiency. A summary of CLA swine research through 2004 evaluated 18 studies and growth rate was rarely improved (only 1 study) however, most of the studies reported an average of 6.5% improvement in feed efficiency [12]. A majority of these studies also reported slight reductions in carcass fat and small increases in carcass lean. Feeding CLA has minimal effects on most fresh pork quality measures [12].

However, CLA does increase intramuscular fat (marbling) content in the loin anywhere from 8 to 31% (See PIG factsheet 12-02–02; Nutritional effects on pork quality).

There may be some synergistic effects for feeding CLA with betaine. When pigs were fed both 1% CLA and 0.5% betaine during the grower period ADG and gain:feed were significantly improved, more than by either product fed by itself [13]. In addition, carcass protein and lean deposition increased and carcass fat tended to decrease with the combination of betaine and CLA. The use of CLA with Paylean™ results in a similar CLA response with or without Paylean™ in the diet, providing improved feed efficiency and carcass fat quality [14].

CLA and Carcass Fat Quality

The belly has become one of the most valued primal cuts of the carcass, thus, the quality of bacon produced from the belly is linked to overall carcass value. The industry has shifted to genetically lean lines with decreased backfat resulting in the bellies of these pigs also being thinner, leaner, and softer [15,16]. Thinner bellies are typically softer, produce fewer premium grade one slices, and have increased problems with processing, tissue separation, and storage stability [15,16]. Furthermore, high levels of unsaturated fatty acids in the diets also produce bacon which is smeary, separates and causes processing difficulties [17]. Providing dietary fat from a more saturated source has been shown to increase belly thickness and improve belly firmness [15]. In addition, feeding CLA has been shown to improve belly firmness in finishing pigs [8,14,15].

The effects of including CLA in livestock diets have been examined in numerous studies to elucidate its effect on fat quality [18]. When CLA was included in a grower-finisher diet at 0.75% inclusion rate, barrows fed CLA had decreased backfat, and improved loin marbling and firmness when compared to controls [19]. Weber et al., (2006) [14] also noted an increase in saturated fatty acids and decrease in unsaturated fatty acids of the belly tissue. Several studies have also shown that CLA feeding increases fatty acid saturation, and firmness in back fat and belly fat [12,20,21]. The duration and level of CLA required to elicit the changes in carcass fatty acids appears to be dose and time dependent. Gilts fed 1% CLA for 7 weeks prior to slaughter had firmer bellies, higher levels of saturated fatty acids, lower levels of unsaturated fatty acids and decreased IV compared to control pigs [8]. Feeding CLA for the last 123 lbs of weight gain prior to slaughter achieved the majority of the fatty acid shifts in the loin but fatty acid changes continued through the last 192 lb of gain in the backfat tissue [24]. With an 8 week feeding duration prior to slaughter, belly fatty acid profiles achieved a 7 IV unit reduction when feeding 0.60% CLA [14] and a 10 IV unit reduction when feeding 0.75% CLA [25]. Feeding 0.6% CLA for 10 days prior to slaughter reduced belly fatty acid IV by an average of 2 IV units and backfat by 3 IV units [26].

These changes in the degree of saturation and attributes of fat deposited with CLA feeding appear to be associated with changes in expression of key genes for lipid metabolism. Specifically, decreased expression of Δ9-desaturase activity and stearoyl CoA desaturase enzyme activity likely increases the saturated fatty acid levels in adipose tissue of pigs, leading to increased firmness of fat associated with feeding CLA [22,23].

CLA and Dried Distillers Grains with Solubles

Due to the rapid increase in corn ethanol production, large quantities of dried distillers grains with soluble (DDGS) have been utilized by the swine industry in nearly all phases of swine production in the last few years. Besides the variability of DDGS, the two most limiting factors for including DDGS in swine diets are the high level of unsaturation in the dietary fatty acid profile and the high fiber content [27,28, 29]. These two factors have been shown to result in both decreased feed intake and greatly increase the unsaturated content of adipose tissue.

The primary fatty acid of corn oil is concentrated in DDGS (linoleic acid; C18:2n6), a primary contributor of soft pork fat [8,30]. Inclusion of 20 to 30% DDGS in corn-soybean meal based diets can result in pork carcasses with less saturated, softer fat [31,32]. However, the feeding of 0.6% CLA for the last 10 days prior to slaughter can improve the carcass fat by 4.3 IV units when fed in combination with 20% DDGS and 3.1 IV units when fed in combination with 40% DDGS, due to increased saturated and decreased unsaturated fatty acids in the carcass and belly fat tissues [26].

Summary

CLA is naturally present in ruminant meats and milk products at much higher concentrations than it is in pork, and has received considerable attention as a protective agent against cancer and heart disease. Thus, CLA is likely to become a selling point for other meat industries – an advantage which may be neutralized, as several trials have demonstrated the ability to create CLA-enriched pork through feeding 0.6% CLA for 4 to 8 weeks prior to slaughter. In addition to the marketing advantages of CLA-enriched or "heart-healthy" pork, CLA has the potential to directly increase profitability to both producers and processors. Feeding CLA-supplemented diets may provide a means by which backfat in average lean gain genetics can be decreased and percent lean can be increased with improved feed efficiency and carcass fat quality. As pork-processing plants become increasingly mechanized, CLA may provide a nutritional tool to counteract carcass fat and belly firmness problems from feeding dietary unsaturated fats and may enhance the overall value of extremely lean carcasses.

References

1. Freeman, C. P. 1983. Fat supplementation in animal production -- monogastric animals. Proc Nutr Soc. 42:351-359.
2. Kloareg, M., J. Noblet, and J. van Milgen. 2007. Deposition of dietary fatty acids, de novo synthesis and anatomical partitioning of fatty acids in finishing pigs. Brit J Nutr. 97:35-44.
3. Azain, M. J. 2001. Fat in swine nutrition. In: Swine Nutrition, 2nd Ed., A.J. Lewis and L.L. Southern, ed. CRC Press, Boca Raton. Pg 95.
4. Wiseman, J. 2006. Value of fats and oils in pig diets. In: Whittemore's Science and Practice of Pig Production. 3rd ed. I. Kyriazakis and C.T. Whittemore, ed. Blackwell Publishing, Oxford, UK. Page 368.
5. Allen, C. E., D. C. Beitz, B. A. Cramer, and R. G. Kauggman. 1976. Biology of fat in meat animals. Research Division, College of Agricultural and Life Sciences, University of Wisconsin-Madison.
6. Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fisher, M. M. Campo, E. Kasapidou, P. R. Sheard, and M. Enser. 2003. Effects of fatty acids on meat quality: a review. Meat Science. 66:21-32.
7. Madsen, A., K. Jakoben, and H. P. Mortensen. 1992. Influence of dietary fat on carcass fat quality in pigs. A review. Acta Agric Scand, Sect. A., Animal Sci. 42:220-225.
8. Eggert, J. M., M. A. Belury, A. Kempa-Steczko, S. E. Mills, and A. P. Schinckel. 2001. Effects of conjugated linoleic acid on the belly firmness and fatty acid composition of genetically lean pigs. J Anim Sci. 79:2866-2872.
9. Wang, Y. W. and P. J. H. Jones. 2004. Conjugated linoleic acid and obesity control: efficacy and mechanisms. Int J Obes. 28:941-955.
10. House, R. L., J. P. Cassady, E. J. Eisen, M. K. McIntosh, and J. Odle. 2005. Conjugated linoleic acid evokes de-lipidation through the regulation of genes controlling lipid metabolism in adipose and liver tissue. Obes Rev. 6:247-258.
11. Belury, M. A. 2002. Dietary Conjugated Linoleic Acid in Health: Physiological Effects and Mechanisms of Action. Annu Rev Nutr. 22:505-531.
12. Dugan, M.E.R., J.L. Aalhus, and J.K.G. Kramer. 2004. Conjugated linoleic acid pork research. Am. J. Clin. Nutr. 79:1212S-1216S.
13. Fernandez-Figares, I., J.A. Conde-Aguilera, R. Nieto, M. Lachica, and J.F. Aguilera. 2008. Synergistic effects of betaine and conjugated linoleic acid on the growth and carcass composition of growing Iberian pigs. J. Anim. Sci. 86:102-111.
14. Weber, T. E., B. T. Richert, M. A. Belury, Y. Gu, K. Enright, and A. P. Schinckel. 2006. Evaluation of the effects of dietary fat, conjugated linoleic acid, and ractopamine on growth performance, pork quality, and fatty acid profiles in genetically lean gilts. J. Anim Sci. 84:720-732.
15. Gatlin, L. A., M. T. See, J. A. Hansen, D. Sutton, and J. Odle. 2002. The effects of dietary fat sources, levels, and feeding intervals on pork fatty acid composition. J Anim Sci. 80:1606-1615.
16. Morgan, J.B. G.C. Smith, J. Cannon, F. McKeith, and J. Heavner. 1994. Pork distribution channel audit report. In: Pork Chain Quality Audit-Progress Report. D. Meeker and S. Sonka, ed. NPPC, Des Moines, IA.
17. Person, R. C., D. R. McKenna, D. B. Griffin, F.K. McKeith, J. A. Scanga, K. E. Belk, G. C. Smith, and J. W. Savell. 2005. Benchmarking value in the pork supply chain: Processing characteristics and consumer evaluations of pork bellies of different thicknesses when manufactured into bacon. Meat Science. 70:121-131.
18. Cox, A. D. 2005. Added dietary fat effects on market pigs and sows. M.S. Thesis, Purdue University, West Lafayette.
19. Wiegand, B. R., F. C. Parrish, Jr., J. E. Swan, S. T. Larsen, and T. J. Baas. 2001. Conjugated linoleic acid improves feed efficiency, decreases subcutaneous fat, and improves certain aspects of meat quality in Stress-Genotype pigs. J Anim Sci. 79:2187-2195.
20. Ostrowska, E., M. Muralitharan, R. F. Cross, D. E. Bauman, and F. R. Dunshea. 1999. Dietary conjugated linoleic acids increase lean tissue and decrease fat deposition in growing pigs. J Nutr. 129:2037-2042.
21. Aalhus, J. L., and M. E. R. Dugan. 2001. Improving meat quality through nutrition. Advances in Pork Production. 12:145.
22. Martin, D., T. Antequera, E. Gonzalez, C.Lopez-Bote, and J. Ruiz. 2007. Changes in the fatty acid profile of the subqutaneous fat of swine throughout fattening as affected bu dietary conjugated linoleic acid and monounsaturated fatty acids. J. Agric. Food Chem. 55:10820-10826.
23. Smith, S.B., T.S. Hively, G.M. Cortese, J.J. Han, K.Y. Chung, P.Castenada, C.D. Gilbert, V.L. Adams, and H.J. Mersmann. 2002. Conjugated linoleic acid depresses the 9 desaturase index and searoyl coenzyme A desaturase enzyme activity in porcine subcutaneous adipose tissue. J. Anim. Sci. 80:2110-2115.
24. Wiegand, B. R., J. C. Sparks, F. C. Parrish Jr., and D. R. Zimmerman. 2002. Duration of feeding conjugated linoleic acid influences growth performance, carcass traits, and meat quality of finishing barrows. J Anim Sci. 80:637-643.
25. Larsen, S.T., B.R. Wiegand, F.C. Parrish, Jr., J.E. Swan, and J.C. Sparks. 2009. Dietary conjugated linoleic acid changes belly and bacon quality from pigs fed varied lipid sources. J. Anim. Sci. 87: 285-295.
26. White, H.M., B.T. Richert, J.S. Radcliffe, A.P. Schinckel, J.R. Burgess, S.L. Koser, S.S. Donkin, and M.A. Latour. 2009. Feeding conjugated linoleic acid partially recovers carcass quality in pigs fed dried distillers grains with solubles. J. Anim. Sci. 87:157-166.
27. Newland, H. W., and D. C. Mahan. 1990. Distillers By-Products. Page 161 in Nontraditional Feed Sources for Use in Swine Production. P.A. Thacker and R.N. Kirkwood, ed. Butterworths, Stoneham,MA.
28. Rausch, K. D., and R. L. Belyea. 2006. The future of coproducts from corn processing. Appl Biochem Biotechnol. 128:47-86.

29. Shurson, G., M. Spiehs, and M. Whitney. 2004. The use of maize distiller's dried grains with solubles in pig diets. Pig news and information. 25(2):75N-83N.
30. Prescott, N.J. 1998. The influence of dietary linoleic on backfat firmness in bacon weight pigs. Anim. Prod. 46:502 (Abstr.).
31. Whitney, M. H., G. C. Shurson, L. J. Johnston, D. M. Wulf, and B. C. Shanks. 2006. Growth performance and carcass characteristics of grower-finisher pigs fed high-quality corn distillers dried grain with solubles origininating from a modern Midwestern ethanol plant. J Anim Sci. 84:3356-3363.
32. Stein, H. H. and G. C. Shurson. 2008. Board Invited Review: The use and application of distillers dried grains with soluble (DDGS) in swine diets. J. Anim. Sci. 87:1292-1303.
33. Evans, M.E, J.M. Brown, and M.K. McIntosh. 2002. Isomer-specific effects of conjugated linoleic acid (CLA) on adiposity and lipid metabolism. J. Nutr. Biochem. 13:508-516.

Frequently asked questions

What does the current FDA approval of CLA allow?

The current U.S. FDA approval for CLA in swine diets indicates that CLA is intended for use in the feed of growing and finishing swine as a source of fatty acids, not to exceed 0.6% in the finished feed and must contain a minimum of 28% of each isomer, cis-9, trans-11(c9t11) and trans-10, cis-12 (t10c12) as methyl esters derived from sunflower oil. There are no body weight range restrictions other than it is approved for growing and finishing swine and the only claim made is to serve as a dietary fat source for swine.

What is the minimum duration of CLA feeding needed to elicit an effect in the pork carcass?

The duration and level of CLA required to elicit the changes in carcass fatty acids appears to be dose and time dependent. Only 0.6% CLA is currently approved for feeding to swine. An 8 week feeding duration at 0.60% CLA prior to slaughter can reduce carcass fatty acid IV between 7-10 IV units. While feeding 0.6% CLA for 10-14 days prior to slaughter may reduce carcass fatty acid IV by approximately 2-4 IV units.