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Oxidative changes of fresh loin from pig, caused by dietary conjugated linoleic acid and monounsaturated fatty acids, during refrigerated storage

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ABSTRACT

Three levels (0%, 1% and 2%) of a conjugated linoleic acid enriched oil (CLA) were combined with two levels of monounsaturated fatty acids (MUFA) (19% and 39% average) for pig feeding. Changes in instrumental colour, lipid oxidation (thiobarbituric acid reactive substances, TBARS) and volatile profile of fresh loin chops, as affected by dietary CLA, MUFA and CLA × MUFA, were studied throughout 7 days of refrigerated storage. Lightness (L^*) evolution was conditioned by dietary CLA, whereas changes in redness (a^*) and yellowness (b^*) were unaffected by dietary supplements. Dietary CLA at 2% led to higher TBARS values of loin chops at day 7 of refrigerated storage ($p < 0.05$), while MUFA supplementation and CLA × MUFA interaction did not affect lipid oxidation. Dietary CLA, MUFA or CLA × MUFA did not affect most volatile compounds of loin chops after 7 days of storage.

1. Introduction

Conjugated linoleic acid (CLA) is a collective term to describe positional and geometric isomers of linoleic acid (*cis*-9, *cis*-12 octadecadienoic acid) with conjugated double bonds. The *cis*-9, *trans*-11 and *trans*-10, *cis*-12 CLA are the major CLA isomers in nature and both have been related to positive health effects (Bhattacharya, Banu, Rahman, Causey, & Fernandes, 2006). Supplementation of swine feeding with CLA has also gained increasing attention during the last decade, as an approach for improving productive, carcass and meat quality traits and, at the same time, for obtaining meat and meat products enriched in CLA (Martin, Muriel, Antequera, Perez-Palacios, & Ruiz, 2008a; Schmid, Collomb, Sieber, & Bee, 2006).

Evidences about the involvement of CLA isomers in oxidative processes has been found. Ha, Storkson, and Pariza (1990) showed that CLA was a more effective antioxidant than α-tocopherol and almost as effective as butylated hydroxytoluene in model systems. Ip, Chin, Scimeca, and Pariza (1991) found that dietary CLA decreased the concentrations of thiobarbituric acid reactive substances (TBARS) in rat liver and mammary gland tissues. Joo, Lee, Ha, and Park (2002) also reported lower values of TBARS in loins from CLA-fed pigs. However, the antioxidant effect of CLA is unclear and controversial, since other studies have even shown a pro-oxidant effect of CLA or no implication of these fatty acids in oxidative processes (Hur, Park, & Joo, 2006). In a previous work, we found no significant effect of dietary CLA on the susceptibility to oxidation of fresh loin of pig, but liver showed a higher oxidative stability with dietary CLA (Martin et al., 2008a). Therefore, the claimed antioxidant effect of CLA needs to be more carefully examined.

The modification in the fatty acid profile caused by dietary CLA has been suggested as one of the reasons that might explain the lower levels of oxidation found by several authors in meat and meat products from CLA-fed animals. Feeding with CLA causes an increase in the ratio of saturated fatty acids (SFA) to unsaturated fatty acids (Dugan, Aalhus, & Kramer, 2004; Martin, Antequera, Gonzalez, Lopez-Bote, & Ruiz, 2007). Thus, meat from CLA-fed animals might be less susceptible to lipid oxidation as well as to the production of colour changes and volatile compounds. However, such an increase in the ratio of SFA to unsaturated fatty acids could have negative health implications from the consumer standpoint (Department of Health, 1994). Thus, including high levels of MUFA in pig diets when using dietary CLA could be a strategy for counteracting the decrease in MUFA caused by CLA.

In the present work, the effects of dietary CLA and MUFA and their interaction on lipid oxidation, changes in instrumental colour and the volatile profile of fresh loin chops during refrigerated storage was studied.

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2. Material and methods

2.1. Animals and feeding

Three levels (0%, 1% and 2%) of a commercial CLA-enriched oil supplement (CLA-60, BASF, Dortmund, Germany), containing approximately 56% of CLA isomers (28% *cis*-9, *trans*-11 and 28% *trans*-10, *cis*-12) and two levels of MUFA (low; 19% and high; 39%) were combined for pig feeding (Table 1). All diets were formulated to provide similar protein and energy levels, fulfilling the advised nutritional needs for gilts at the ages studied (National Research Council, 1998).

The experiment was conducted using 288 finishing gilts (Large white ♂ × Landrace × Large white ♀). Pigs weighing 70 kg and at about 140 days of age were randomly allotted to the six different feeding treatments in four replicates of each treatment (12 pigs per replicate). Pigs were housed in an environmentally-controlled experimental grower/finisher shed. Pigs were group-housed (12 pigs per pen) and had *ad libitum* access to feed (single space dry feeders) and water (nipple drinkers) until a final average weight of 107 kg. After fattening (53 days), pigs were slaughtered at a local slaughterhouse by electrical stunning and exsanguination.

2.2. Sampling

Representative samples of mixed diets were taken before the beginning of the trial in order to determine their chemical and fatty acid composition.

Eight animals from each treatment were randomly selected for sampling. Loins from slaughtered animals were taken within 10 min after bleeding and kept at 4 °C for 24 h. Loin chops (1.5 cm thick) were over-wrapped in PVC film and stored at 4 °C for 7 days. The samples were analyzed at 0, 1, 2, 4 and 7 days of storage. At each time period, a small sample of the chop (5 cm^2) was cut and frozen at −80 °C until analysis, while the rest of the chop was kept under refrigeration until the next sampling time.

2.3. Analytical methods

The analysis of the composition of the feeds was performed according to the Association of Official Analytical Chemists (AOAC, 2000): crude protein (reference 954.01), crude fat (reference 920.39), crude fibre (reference 962.09) and ash (reference 942.05). Feed analysis is shown in Table 1.

The instrumental colour (CIE L^*, a^*, b^*, CIE, 1976) of the chops was measured at each time point of refrigerated storage. The measurements were performed in triplicate on the surface of the chops

Table 1
Ingredients and chemical composition of the experimental treatments

Ingredient (%)	Low MUFA feed			High MUFA feed		
	0% CLA	1% CLA	2% CLA	0% CLA	1% CLA	2% CLA
Barley	53.3	53.3	53.3	53.3	53.3	53.3
Wheat	15.0	15.0	15.0	15.0	15.0	15.0
Bran	8.0	8.0	8.0	8.0	8.0	8.0
Soybean meal, 44%	16.0	16.0	16.0	16.0	16.0	16.0
Palm oil	1.6	1.1	0.6	1.0	0.5	0.0
Soy olein	0.4	0.4	0.4	0.0	0.0	0.0
Olive olein	0.0	0.0	0.0	3.0	3.0	3.0
Hydrogenated stearin palm	3.0	2.5	2.0	1.0	0.5	0.0
CLA	0.0	1.0	2.0	0.0	1.0	2.0
Carbonate	1.2	1.2	1.2	1.2	1.2	1.2
Phosphate	0.4	0.4	0.4	0.4	0.4	0.4
Salt	0.4	0.4	0.4	0.4	0.4	0.4
L-Lysine 50	0.17	0.17	0.17	0.17	0.17	0.17
L-Threonine	0.03	0.03	0.03	0.03	0.03	0.03
Coline 75	0.04	0.04	0.04	0.04	0.04	0.04
Vitamin and mineral premix	0.5	0.5	0.5	0.5	0.5	0.5
Chemical composition (%)						
Dry matter	89.2	89.6	89.4	89.3	89.5	89.6
Ash	4.9	5.1	5.0	5.1	5.6	5.3
Crude fiber	4.2	4.3	4.1	4.7	4.3	4.6
Crude fat	7.7	6.9	7.3	7.2	7.1	6.8
Crude protein	16.4	16.0	15.8	16.7	16.5	15.8
Nitrogen free extractives	62.8	64.1	64.0	62.4	62.7	63.8
Fatty acid composition (%)						
C14:0	0.8	0.6	0.5	0.5	0.3	0.3
C16:0	35.3	30.4	25.6	25.4	19.7	15.0
C16:1	0.1	0.1	0.1	0.5	0.4	0.4
C18:0	22.8	20.1	16.6	11.4	7.6	4.6
C18:1 $n-9$	18.1	18.0	18.7	37.8	37.9	37.8
C18:2 $n-6$	19.9	20.2	19.8	20.6	22.2	22.5
C18:3 $n-3$	1.8	1.7	1.6	1.8	2.1	2.1
cis-9, *trans*-11 CLA	0.0	3.9	8.0	0.0	4.3	7.9
trans-10, *cis*-12 CLA	0.0	3.7	7.9	0.0	4.2	8.1
∑SFA	59.7	52.0	43.5	38.8	28.4	20.6
∑MUFA	18.8	18.6	19.2	38.9	38.8	38.7
∑PUFA[a]	21.5	21.9	21.5	22.4	24.4	24.7

CLA (conjugated linoleic acid), SFA (saturated fatty acids), MUFA (monounsaturated fatty acids), and PUFA (polyunsaturated fatty acids).
[a] Excluding CLA isomers.