CONJUGATED LINOLEIC ACID AND THE RATIO OF ω6:ω3 FATTY ACIDS ON THE OXIDATIVE STABILITY OF CHICKEN MEAT

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Background

Studies to change the composition and the quality of lipids present in the carcass of meat producing animals have increased lately. Products high in lipids, as meats, have call the attention of the meat scientists due to the high probability to suffer auto-oxidative reactions. The intake of rancid products may cause a great deal of health problems to the population due to its toxic effect on the cells (Ferrari, 1999). Adding conjugated linoleic acid (CLA) to the animal feed it is a reasonable way to improve meat lipid quality, therefore, its nutritional value. Dietary supplementation with CLA may change the composition of lipids produced by the liver (Belury & Kempa-Steczko, 1997) as well as reduce the total lipid concentration in rats (West et al., 1998). These alterations on the lipid profile by CLA supplementation may also result in changing on the oxidative stability of tissues. Joo et al (2002) supplemented finishing swine diets with CLA and observed that thiobarbituric acid-reactive substances (TBARS) values in the meat were higher for animals fed the control diet. Similar results were reported by Corino et al. (2002) in the meat of rabbits fed diets with 0,5% CLA. Previously, Du et al. (2000) reported that the oxidative stability of broiler meat is improved by using CLA supplemented diets. No information were found in the literature about the oxidative stability of broiler meat fed diets supplemented with different oil sources and enriched with CLA. It is believed that this association may improve carcass lipid composition as well as carcass quality.

Objectives

The purpose of this study was to evaluate the dietary supplementation of broiler diets with CLA and oil sources to produce different ratios of ω6:ω3 fatty acids on the oxidative stability of broiler meat submitted to refrigeration or freezing storage temperatures.

Materials and methods

One study was conducted using 100 male Ross broiler chickens with 21 days of age at the start of the experiment. Birds were selected from a population of 300 animals so that males birds used in the study were within of 10% of the mean body weight of the population. The experimental design was a completely randomized in a factorial arrangement 2 x 5 (two oil sources, i.e. soybean or canola oil and five levels of CLA supplementation, i.e. 0.0, 0.25, 0.50, 0.75 and 1.00%). Oils used were supplied by Bünge Alimentos and CLA (Lucta CLA 60) by BASF. The control diets had 4% of soybean or canola oil. CLA supplementation levels were obtained by isometrically replacing soybean or canola oil in the control diets. From 1 to 21 days of age chicks were raised in a corn-soy diet with 21% protein and 2.950 Kcal of metabolizable energy per Kg of diet. From 22 to 45 days of age the experimental diets were corn-soy diets formulated to at least reach nutrient levels recommended by the NRC (1994). At 45 days of age birds were killed by a cut in the jugular vein. Samples of breast and thigh meat were collected and part kept under refrigeration at 5˚C and the other part kept under freezing conditions at -20˚C. Oxidative stability was measured on meats kept under refrigeration after the third day of storage and on the frozen meat on days 25, 50, 75 e 100 of storage. Oxidative stability was measured using the procedure described by Tarladgis et al (1960) for the TBARS values. The F test at 5% of significance was used to compare results between sources of oils when interactions were not detected. When there was an interaction ($P<0.05$), it was used the SNK test to compare results between sources of oils. Regression analysis was used to report the effects of CLA levels.

Results and discussion

Under storage conditions fats and the fat content foods may undergo oxidation. The rate of oxidation depends upon the type of food and the storage conditions. The malonaldehyde is formed primarily by the oxidation of insaturated fatty acids, being the reaction more intense as the level of insaturation of the fat increases (Janero, 1990). Under freezing conditions our results (table 1) show that oxidation of the both breast and thigh meat occurred slowly and followed a linear pattern as storage time increased. Gava (1984) reported that in frozen food the enzymatic reactions occur at a slow but continuing rate. Lipids oxidation in highly insaturated fats particularly in red meat is a matter of concern due to the high levels of iron and phospholipids. On the thigh meat, during the first 50 days of storage was observed a significant interaction (oil sources x levels of CLA) on TBARS values. These results were better explained by a quadratic function (table 1 and figure 1, 2 and 3, $P < 0.05$). However on days 75 and 100 of storage this effect was not observed ($P > 0.05$). A significant interaction (oil sources and CLA levels) was also observed on TBARS values of breast meat (table 1). At day 25 of storage, independently of the oil source, was observed a significant reduction on TBARS values on thigh meat that plateau between 0.50 and 0.75% of CLA supplementation (Figure 1 and 3). At 25 days of storage, supplementation with 0.50% in association with soybean oil resulted in lower TBARS values for both breast and thigh meat when compared to that of canola oil supplemented birds. On breast meat of birds fed the soybean oil there was a linear reduction ($P < 0.05$) of TBARS values with increasing CLA levels at 25 days of storage. However, as storage time increased the interactive effect of oil source and levels of CLA on TBARS values of breast meat was better explained by a quadratic function. On days 50 and 100 of storage, a reduction on oxidation of the breast meat was observed with soybean oil and supplementation of CLA, stabilizing at the level of 0.50% and increasing again with higher levels. At 50 days of storage, levels of 0.75% of CLA in association with canola oil resulted in lower oxidation on both breast and thigh meat when compared to soybean oil. At this storage time, even without CLA supplementation the oxidation of breast meat was lower in birds fed canola oil. At 75 days of storage, again 0.75% of CLA in association with canola oil resulted in lower breast meat oxidation. Also, there was a linear reduction on TBARS values with growing levels of CLA on breast meat of canola fed birds. These overall results showed a synergic effect between CLA and oil source improving oxidative stability on breast and thigh meat during storage. Shantha et al.(1995) reported that CLA is a stable fat and its deposition on carcass fat may reduce the oxidative potential. Previously Shantha et al. (1994) have suggested that the stability of the levels of CLA on the meat during storage were probably related to its higher stability when compared with fats higher in polyunsaturated fatty acids. On the other hand, Du et al. (2000) suggested that the effect of CLA on meat stability quality is related to its effect on the increase in saturated fat content. Fresh food can be stored under refrigeration for a limited period of time, which reduce the rate of microbiological and enzymatic deterioration. The results of oxidative stability of breast and thigh meat stored under refrigeration are shown in table 2. Significant interaction (oil sources and levels of CLA) on refrigerated meat was observed (Figure 4 and 5). On the breast meat a linear reduction on TBARS values was observed with increased levels of CLA in association with canola oil (figure 4). Variations on TBARS values of breast meat of birds fed soybean oil was best explained by a quadratic function with reductions up to 0.50 % levels. However, the 0.25% level of CLA in association with soybean oil produced the lowest TBARS value on breast meat when compared with canola oil. On the thigh meat of broilers fed canola oil, variations on TBARS values followed a cubic function (figure 5). Therefore, under refrigeration supplementation of 1% of CLA in association with canola oil produced the lowest oxidation levels on the thigh meat when compared to that of birds fed soybean oil.

Conclusions

Considering the conditions under which this experiment was carried out, it can be concluded that:

1. The improve in the oxidation stability by CLA and dietary fat allows the use of diets with highly unsaturated fatty acids with no impairment of chicken meat quality

2. Oxidation stability of broiler breast and thigh meat was improved by CLA and oil supplementation.

3. On the frozen thigh meat CLA supplementation in association with canola or soybean oils resulted in higher oxidative stability during the first 50 days of storage. For breast meat the maintenance of meat quality was even longer up to 100 days.

4. Under refrigeration, breast and thigh meat quality was improved by the synergic effect of CLA and dietary oil. CLA in association with canola oil resulted in lower TBARS values for both breast and thigh meat, when compared with soybean oil.

5. The effect of levels of CLA on TBARS values depend upon the oil source used in the diet, the storage condition as well as the duration of storage.

References

Belury, MA., Kempa-Steczko, A. 1997 Conjugated linoleic acid modulates hepatic lipid composition in mice. **Lipids**, v. 32: 199-204.

Corino, C., Mourot, J., Magni, S., Pastorelli, G., Rossi, F. 2002. Influence of dietary conjugated linoleic acido on growth, meat qualit, lipogenesis, plasma leptin and physiological variables of lipid metabolism in rabbits. **J. Anim. Sci**., 80: 1020-1028.

Du, M., Ahn, DU.,Nam, KC., Sell, J.L. 2000. Influence of dietary conjugated linoleic acid on volatile profiles, color and lipid oxidation of irradiated raw chicken meat. **Meat Sci**., v. 56: 387-395.

Ferrari, CKB. 1999. Oxidação lipídica em alimentos e sistemas biológicos: mecanismos gerais e implicações nutricionais e patológicas. **Revista Nutrição**, v. 11: 3-14.

Gava, A.J. 1984. **Princípios de tecnologia de alimentos**. São Paulo: Nobel. 284p.

Janero,DR. 1990. Malonaldehyde and thiobarbituric acid-reactivity as diagnostic indices of lipid peroxidation and peroxidative tissue injury. **Free Rad. Biol. Med**. v.9:515-540.

Joo, ST., Lee, JI., Ha, YL., Park, GB. 2002. Effects of dietary conjugated linoleic acid on fatty acid composition, lipid oxidation, color, water-holding capacity pork loin. **J. Anim. Sci**., v. 80: 108-112.

National Research Council – NRC. 1994. **Nutrient requirements of poultry**. 9. ed. Washington, DC: National Academy Press, 156p.

Shantha, NC., Crum, AD., Decker, EA. 1994. Evaluation of conjugated linoleic acid concentrations in cooked beef. **J. Agric & Food Chem**., v. 42: 1757-1760.

Shantha, NC., Ram, LN., O´leary, J., Hicks, CL., Decker, EA. 1995. Conjugated linoleic acid concentrations in dairy products as affected by processing and storage. **J. Food Sci**., v. 60: 695-697.

Tarladgis, BG, Watts, BM, Younathan, MT, Dugan, LR. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. **J. Am. Oil Chem. Soc**., v. 37:44-48.

West, DB. Delany, JP., Camet, PM., Blohm, F., Truett, AA, Scimeca, J. 1998. Effects of conjugated linoleic acid on body fat and energy metabolism in the mouse. **Am. J. Physiol**., v. 44: R667-672.

Table 1 - TBARS values (mg of MDA/kg meat) of frozen breast and thigh meat of broilers fed diets with canola or soybean oil and CLA under different storage time.

	TBARS VALUES			
	25 DAYS OF STORAGE TIME			
	THIGH MEAT		**BREAST MEAT**	
CLA (%)	**SOYBEAN OIL[2]**	**CANOLA OIL[2]**	**SOYBEAN OIL[1]**	**CANOLA OIL**
0.0	0.167a	0.179a	0.095a	0.082a
0.25	0.106a	0.094a	0.056a	0.043a
0.5	0.058b	0.129a	0.051b	0.098a
0.75	0.070a	0.082a	0.05a	0.048a
1	0.084b	0.121a	0.039b	0.078a
	50 DAYS OF STORAGE TIME			
	THIGH MEAT		**BREAST MEAT**	
CLA (%)	**SOYBEAN OIL[2]**	**CANOLA OIL[2]**	**SOYBEAN OIL[2]**	**CANOLA OIL**
0.0	0.187a	0.187a	0.165a	0.111b
0.25	0.125a	0.112a	0.112a	0.109a
0.5	0.156a	0.148a	0.104a	0.129a
0.75	0.207a	0.142b	0.180a	0.106b
1	0.216a	0.140b	0.165a	0.115b
	75 DAYS OF STORAGE TIME			
	THIGH MEAT		**BREAST MEAT**	
CLA (%)	**SOYBEAN OIL**	**CANOLA OIL**	**SOYBEAN OIL**	**CANOLA OIL[1]**
0.0	0.267	0.238	0.196a	0.193a
0.25	0.231	0.227	0.161a	0.185a
0.5	0.224	0.252	0.173a	0.143a
0.75	0.218	0.203	0.176a	0.115b
1	0.230	0.235	0.160a	0.106b
	100 DAYS OF STORAGE TIME			
	THIGH MEAT		**BREAST MEAT**	
CLA (%)	**SOYBEAN OIL**	**CANOLA OIL**	**SOYBEAN OIL[2]**	**CANOLA OIL**
0.0	0.325	0.268	0.206	0.232
0.25	0.305	0.269	0.176	0.219
0.5	0.296	0.349	0.170	0.221
0.75	0.368	0.355	0.215	0.215
1	0.358	0.327	0.235	0.198

[a,b] Averages values within the same line with no common superscript differ significantly by the SNK test (P<0.05)
[1]Linear effect (P<0.05)
[2]Quadratic effect (P<0.05)

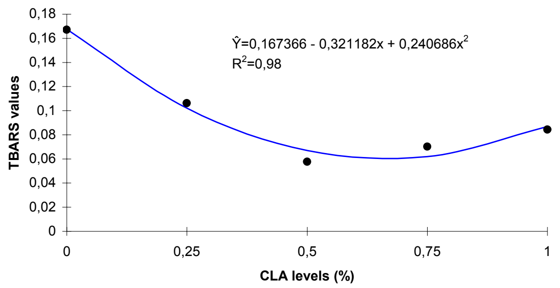

Figure 1. TBARS values (mg of MDA/kg meat) of frozen thigh meat of broilers fed diets with soybean oil and CLA, stored for 25 days.

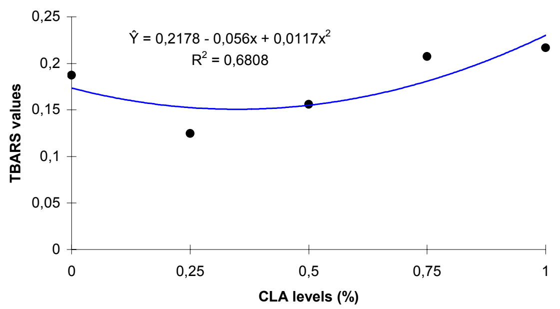

Figure 2. TBARS values (mg of MDA/kg meat) of frozen thigh meat of broilers fed diets with soybean oil and CLA, stored for 50 days.

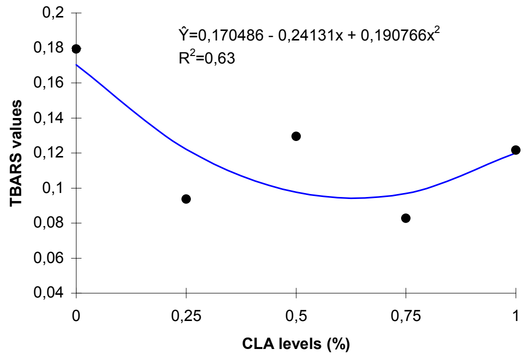

Figure 3. TBARS values (mg of MDA/kg meat) of frozen thigh meat of broilers fed diets with canola oil and CLA, stored for 25 days.

Table 2 – TBARS values (mg of MDA/kg meat) of refrigerated breast and thigh meat of broilers fed diets with canola or soybean oil and CLA.

	TBARS VALUES			
	THIGH MEAT		**BREAST MEAT**	
CLA (%)	**SOYBEAN OIL**	**CANOLA OIL[3]**	**SOYBEAN OIL[2]**	**CANOLA OIL[1]**
0.0	0.158b	0.214a	0.149a	0.140a
0.25	0.152a	0.159a	0.066b	0.150a
0.5	0.119a	0.122a	0.121a	0.108a
0.75	0.176a	0.152a	0.091a	0.112a
1	0.156a	0.124b	0.106a	0.095a

[a,b] Averages values within the same line with no common superscript differ significantly by the SNK test (P<0.05)
[1] Linear effect (P<0.05)
[2] Quadratic effect (P<0.05)
[3]Cubic effect (P<0.05)

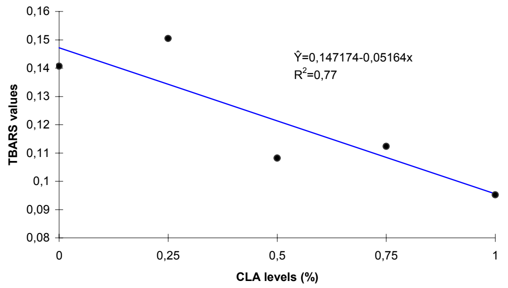

Figure 4. TBARS values (mg of MDA/kg meat) of refrigerated breast meat of broilers fed diets with canola oil and CLA.

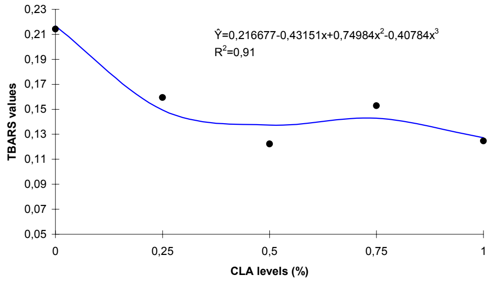

Figure 5. TBARS values (mg of MDA/kg meat) of refrigerated thigh meat of broilers fed diets with canola oil and CLA.