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PHOSPHOLIPID OXIDATION IN TURKEY PRE-COOKED MEAT

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INTRODUCTION

Warmed-Over Flavour (WOF) is the term used to describe rapid development of oxidised flavour in cooked meat during storage. Polyunsaturated fatty acids from phospholipids appear to be the main precursors of oxidised products which contribute to WOF (Gray and Pearson, 1987). The development of WOF has been generally studied in relation to changes in total phospholipids but limited information is available on individual phospholipid alterations. Recent advances in phospholipid class fractionation and quantification, using the HPLC system fitted with a light scattering detector, allowed more precise and easy investigation of the changes of individual phospholipids during the development of the WOF.

The objective of the present study was to investigate the changes in lipid composition of turkey breast meat during cooking and subsequent refrigerated storage, with special emphasis on long chain polyunsaturated fatty acids of individual phospholipid classes.

MATERIALS AND METHODS

Materials

Samples of *Pectoralis* muscles of six turkeys were cooked for fifteen minutes according to an industrial process (steam cooking; RH:80%). The final internal temperature of the meat samples was approximately 75°C. After cooling, samples were stored under vacuum at 4°C for 21 days. Analysis were performed on raw and cooked meat and after 7, 14, and 21 days of cooked meat storage.

Methods

Lipids were extracted from 10g of meat as described by Folch *et al.* (1957) and separated into triglycerides and phospholipids on silica cartridges according to the method of Juaneda and Rocquelin (1985). The main phospholipid classes were separated into phosphatidylethanolamine (PE), phosphatidylcholine (PC), phosphatidylinositol (PI) cardiolipin (CL), and sphingomyelin (SPH) by HPLC and quantified with a light scattering detector using the procedure described by Leseigneur-Meynier and Gandemer (1991). Total lipid and triglyceride contents were determined by weighing and phospholipid content by phosphorus assay (Bartlett, 1959). All lipid fractions were transesterified with methanol/HCL/ dimethoxypropane (10:1:0.4: v/v/v) as described by Berry *et al.* (1965). The fatty methyl esters (FAME) were analyzed by gas liquid chromatography. Thiobarbituric acid reactive substances (TBA-RS) were quantified in total lipid extract as described by Buege and Aust (1978). Conjugated dienes and trienes were measured on total lipid extract by the procedure of Kawakatsu *et al.* (1984). Water content was determined by drying 5g of meat at 103°C. Heme iron was estimated by the method of Hornsey (1956).

Data were subjected to analysis of variance according to the GLM procedure of SAS software. The fixed effect model involved storage time (five levels: raw meat, cooked meat after 0, 7, 14 and 21 days of storage).

RESULTS AND DISCUSSION

Effect of cooking (Tables 1 and 2 and Figures 1 and 2)

Cooking yield was of 75%. Cooking losses were mainly composed of water and a small amount of dry matter. Heme iron decreased sharply from 2.38 to 0.48mg/100g of raw meat during cooking. Total lipids in raw turkey meat accounted for 1.7g/100g, triglycerides for 1.2g/100g and phospholipids for 0.42mg/100g. Total lipid and triglyceride contents decreased significantly during cooking, while phospholipid amount remained almost constant (Table 1). These results indicate that the decrease in total lipids is due to the loss of triglycerides in the drip. Phospholipids of turkey raw meat were composed of 62% PC and 28% PE. These results compare favourably with the data of Acosta *et al.* (1966). Cooking caused few changes on phospholipid classes except for PE which decreased significantly (-20%) (Table 1). This result is consistent with previous studies where PE was the most sensitive phospholipid to lipid oxidation during processing of meat and meat products (Gandemer, 1990). Fatty acid compositions of all lipid fractions of raw turkey meat are shown in Table 2. Cooking decreased significantly polyunsaturated fatty acids (PUFA) in the total phospholipid fraction (Figure 1). The most pronounced loss was found in PE. In this phospholipid class, 22% of n-6 fatty acid and 40% of n-3 fatty acids were lost during cooking and 20:4 n-6 and 22:6 n-3 were the main PUFA altered during cooking.

Cooking initiated lipid oxidation. Thus conjugated diene and triene values (Figure 2) increased significantly after cooking (approximately 50%) and TBA-RS numbers increased also (0.16 in raw meat to 1.15 in cooked meat). Increase in diene and triene values generally are regarded as an index of the peroxidation of fatty acids. Fatty acid peroxidation is known to induce double bond migration in fatty acid chains. Due to the cooking temperature, a fraction of the peroxides were decomposed to form TBA reactive substances.

Effect of 4 °C storage (Table 1; Figures 1 and 2)

As expected, water, heme iron and lipid contents of cooked meat showed no significant change during refrigerated storage. Moreover, no changes occurred in total phospholipid content nor in individual phospholipid class proportions. No significant decrease was observed in PUFA proportions in total phospholipids, PC and PE during storage (Figure 1 and Table 1). However, lipid oxidation occurred during refrigerated storage of cooked meat; if conjugated diene and triene values remained steady during the 4 °C storage, TBA values increased up to 14 days and then declined (Figure 2). The rate of lipid oxidation was obviously low because the most sensitive lipid classes to oxidation such as phospholipids, PE or long chain polyunsaturated fatty acids remained unchanged during storage.

CONCLUSION

The effect of cooking and 4°C storage on the lipids of turkey *Pectoralis* muscle was studied. Cooking significantly affected lipid oxidation in turkey meat as is evidenced by the PUFA decrease in total phospholipids and PE. This marked decrease in PUFA during the cooking process was associated with oxidation as evidenced by the marked increase in both diene-triene and TBA values. Only small changes were observed in lipid fractions during the subsequent refrigerated storage. However it appears that lipid oxidation occurs slowly. Further investigations will be required to relate these observations to the appearance of WOF in turkey meat. Therefore, analysis of volatile compounds and sensory analysis is planned in a complementary study.

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REFERENCES

ACOSTA, S.O., MARION, W.W., and FORSYTHE, R.H. 1966. Total lipids and phospholipids in turkey tissues. *Poutry Sci.* 45:169-172.

BARTLETT, G.R. 1959. Phosphorus assay in column chromatography. *J. Biol. Chem.* 234:446-468.

BERRY, J.F., CEVALLOS, W.H., and WADE, R.R. 1965. Lipids class and fatty acid composition of intact peripheral nerve and during Wallerian degeneration. *J. Am. Oil Chem. Soc.* 42:492-500.

BUEGE, J.A., and AUST, S.D. 1978. Biomembranes-biological oxidation systems. IN : PACKER, L. (ed). *Methods in enzymology*. Oxygens radicals in biological systems, 105. Academic Press, New York. p.119.

FOLCH, J., LEE, M., and STANLEY, S.G.H. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.* 226:497-509.

GANDEMER, G. 1990. Les phospholipides du muscles : composition et altération au cours des traitements technologiques. *Rev. Franç. Corps Gras.* 37:75-82.

GRAY, J.I., and PEARSON, A.M. 1987. Rancidity and warmed-over flavor. *Adv. Meat Res.* 3:221-229.

HORNSEY, H.C. 1956. The colour of cooked cured pork. I. Estimation of the nitric oxid-haem pigments. *J. Sci.Food Agric.* 7:534-540.

JUANEDA, P., and ROCQUELIN, G, 1985. Rapid and convenient separation of phospholipids and non-phophorus lipids from rat heart using silica cartridges. *Lipids.* 20(1):40-41.

KAWAKATSU, M., TERAO, J., and MATSUSHITA, S. 1984. Phospholipid oxidation catalysed by ferrous ion and ascorbic acid. *Agric. Biol. Chem.* 48:1275-1278.

LESEIGNEUR-MEYNIER, A., and GANDEMER, G. 1991. Lipid composition of pork muscle in relation to the metabolic type of the fibres. *Meat Sci.* 29:229-241.

Table 1. Effect of cooking and subsequent refrigerated storage on heme iron, and lipid contents of raw and cooked turkey meat. (Results for cooked meat are expressed on the basis of 100 g of raw meat.)

	Raw meat	Cooked meat Storage time (in days) 0	7	14	21
Heme iron (µm/100g raw meat)	2.38[a]	0.48[b]	0.48[b]	0.48[b]	0.48[b]
(g/100g raw meat)					
Total lipids	1.6[a]	1.2[b]	1.2[b]	1.2[b]	1.1[b]
Triglycerides	1.2[a]	0.8[b]	0.7[b]	0.8[b]	0.7[b]
Phosphatids	0.42	0.44	0.42	0.43	0.44
(mg/100g raw meat)					
Phosphatidyle-thanolamine	120[a]	87[b]	80[b]	80[b]	86[b]
Phosphatidicholine	260[b]	291[a]	273[b]	276[b]	276[b]
Phosphatidlinositol	28[b]	47[a]	51[a]	56[a]	56[a]
Cardiolipin	11[c]	10[c]	12[c]	14[b]	19[a]
Sphingomyclin	1[b]	5[a]	4[a]	4[a]	4[a]

Means with the same letter are not sigificantly different.

Table 2. Fatty acid composition of the main lipid classes in raw meat (as a % of the total area of methyl esters).

Fatty acids	Total lipids	Triglyc-erides	Phospho-lipids	Phospha-tidylcholine	Phosphat idylethanolamine
Satur-ated	32.5	28.7	36.7	40.7	27.7
Monouns-aturated	32.8	44.0	19.6	23.5	13.6
18:2	22.4	23.4	19.8	22.4	13.0
20:4	5.7	0.7	12.7	5.5	21.2
N-6	30.2	24.1	37.4	31.0	43.4
18:3	2.0	3.1	0.3	0.4	0.6
N-3	4.5	3.1	6.4	4.8	15.4
Polyuns-aturated	34.7	27.2	43.8	35.8	58.7

Each value is the mean of six samples.