STUDY OF THE STABILITY OF POLYUNSATURATED FATTY ACIDS IN PORK MEAT AFTER STORAGE AND COOKING

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***Abstract*— A lot of products containing large amounts of ω-3 fatty acids can be found on the market, but those essential polyunsaturated fatty acids are known to be very sensitive to oxydation. During food storage or processing, that oxydation could be induced by several factors such as light, oxygen or temperature At the consumer level, it would be interesting to known how much ω-3 fatty acids remain in products such as those from animal origin (meat or eggs), after storage and cooking. The stability of the polyunsaturated fatty acids in two types of pork meat differing in fatty acids composition were evaluated: the first type consisted of pork meat where ω-6 and ω-3 fatty acids were present in an optimal ratio of 1/1 (due to the addition of linseed in the the pork feed) and the other type consisted of standard pork meat. The stability was evaluated over the course of 10 weeks storage at +4°C and -20°C for raw ground meat and meat sausage. Ground meat was also cooked in two cooking modes: in the oven, without fat and pan fried with or without fat. The fatty acids were quantified using a gas chromatography-mass spectrometry (GC-MS) method. No variation of the fatty acid content was observed after storage, for both types of meat, as well as after oven cooking (which was performed without fat). Pan-frying seemed to not change the polyunsaturated fatty acid content in "ω-3 rich" pork meat. However, as expected, cooking without fat allows a better conservation of the fatty acids profile of the meat comparing to cooking with culinary fat.**

***Index Terms*— fatty acids, gas chromatography/mass spectrometry, pork meat, stability.**

I. INTRODUCTION

The ω-6 LA (linoleic acid) and ω-3 ALA (α-linolenic acid) fatty acids (FA) are said to be essential for humans because we are not able to synthesize them and we need to find them in the food. They are precursors of longest chain fatty acids, and compete, in this process of elongation, for the same enzymes. So a larger intake of ω-6 fatty acid from our food will lead to a default in ω-3 EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) which are said semi-essential fatty acids. EPA and DHA are known for their benefic effects, in particular to prevent different pathologies, mainly cardiovascular diseases (McMillin, Bick, Benedict, 1992; Huikuri, Castellanos, Myerburg, 2001). Nowadays, it is considered that people consume too much ω-6, and in western diets in general, the ratio bewteen ω-6 and ω-3 is around 20-40. This imbalance could promote the appearance of a "modern day" metabolic syndrome with an increase in diseases such as cardiovascular diseases, type 2 diabetes, obesity, allergies, inflammations, cancers, stress, etc. For several years, it was considered that for our organism, the ideal ratio between fatty acids ω-6 and ω-3 in food is 1:1. A recent study realized for the American Heart Association (Harris Mozzaffarian, Rimm, Kris-Etherton, Rudel, Appel, Engler, Engler, Sacks, 2009) showed that ω-6 fatty acids have no pro-inflammatory effects in humans. Furthermore, this study confirm the hypo-cholesterolemian potency of ω-6 fatty acids. This study suggest to abandon the idea that ω-3 and ω-6 fatty acids display opposit effects and to not use anymore the ratio w3/w6 to qualify the intake of these fatty acids. This study recommend to increase the intake in ω3 and to maintain the intake in ω6 fatty acids

A lot of products containing large amounts of ω-3 fatty acids can be found on the market (Wood, Richardson, Nute, Fisher, Campo, Kasapidou, Sheard, Enser., 2003; Raes, Haak, Balcaen, Claeys, Demeyer, De Smet, 2004), but it is known that those polyunsaturated fatty acids can be easily oxidized (by light, temperature, etc) in pork meat (Monahan, Buckley, Morrissey, Lynch, Gray, 1992; Nurnberg, Kuchenmeister, Nurnberg, Ender, Hackl, 1999) or other food items.

In general, it is not known how much ω-3 fatty acid remains in the product when it is eaten by the consumer, after storage and/or cooking.

Indeed, only few studies focusing on improving the fatty acid composition of pork consider the influence of cooking mode and the culinary fat addition (Haak, Sioen, Raes, Van Camp, De Smet, 2007). This study aimed to investigate how the cooking mode and the culinary fat can influence the fatty acid profile and the stability of the polyunsaturated fatty acids of pork meat. Influence of time and temperature storage of pork meat was also investigated.

II. MATERIALS AND METHODS

*Cooking experiment***.**

Two types of pork meat were used : " ω-3 rich" pork meat (coming from porks fed with linseeds containing feed) and standard pork meat. The meat used was ground meat coming from pork soulder. A total of 36 samples were used for both cooking modes. Two raw samples of each type were analysed in each cooking exeperiment to be used as reference samples. *Oven cooking procedure:* Four samples of ground meat of each type (approximately 70g each) were cooked at the oven (set to 180°C) without culinary fat until the core temperature reaches 80°C (between 20 and 22 minutes). During the cooking process, the core temperature was monitored continuously with thermic probes (TC type T, Testo). *Pan-frying procedure:* Ten samples of ground meat of each type were cooked in the pan without fat and four different culinary fats: butter, margarine, sesame and peanut oils. The amount of culinary fat used was around 5% of the weight of the raw meat. Each cooking experiment of the meat was realised in duplicate and took 20 min, during which the meat was cooked 15 min on one side and 5 min on the other side.

Storage experiment.

"ω-3 rich" pork sausage as well as "ω-3 rich" and standard pork shoulder ground meat were used. Three and four conditions of storage were investigated for meat sausage and raw ground meat samples respectively: vacuum-packed stored at 4°C and -20°C, plastic-bag-packed stored at 4°C and at -20°C. All samples were stored in the dark, and analyzed after 1 and 2 weeks storage (plastic-bag-packed, 4°C), after 3, 4 and 6 weeks of storage (vacuum packed, 4°C), or after 2, 4, 6, and 8 weeks of storage (vacuum packed, -20°C). Samples of ground meat were approximately 70g each while samples of meat sausage were approximately 30g each. Two samples of each type were analysed at day zero of storage to be used as reference samples, as well as 2 to 4 samples of each storage conditions. A total of 45 and 66 samples were used for meat sausage and ground meat storage study respectively.

Lipid extraction and fatty acid analysis.

Meat samples were minced and lyophilised for 48 hours (Benchtop, Virtis, USA). Then, extraction of the total lipids was done using hexane at 125°C for 20 min in an Accelered Solvent Extraction (ASE) system (ASE 200, Dionex, Sunnyvale, CA USA). The lipids were methylated using KOH/MeOH (0.5 N) (3x20 min at 70 °C) followed by HCl/MeOH (1/1; v/v) (20 min at 70°C). Tridecanoic acid (C13:0) was used as an internal standard to quantify the fatty acids present in pork meat and nonadecanoic acid methyl ester (C19:0-ME) was used as injection standard. 100 mg of fat were then used for the saponification/methylation of the fatty acids. The fatty acid methyl esters (FAME) were separated by gas chromatography (Focus GC, ThermoFinnigan, USA) using a CP-Sil88 column for FAME (100m×150×0.25 mm, 0.2µm) (Varian Inc., USA) and analysed with an ion trap PolarisQ mass spectrometer (ThermoFinnigan, USA). The GC conditions were: inlet: 250°C; splitless injection; helium as the carrier gas at 1.5ml/min; temperature program: 55°C for 1 min, followed by an increase of $5°C \cdot min^{-1}$ to 180°C, then $10°C \cdot min^{-1}$ to 200°C for 15 min, then an increase of $10°C \cdot min^{-1}$ to 225°C for 12 min.; total run time was 57.50 minutes. The peaks were identified by comparing their mass spectrum and retention times with those of the corresponding standards (Sigma-Aldrich, Belgium). The MS conditions were: transfer line: 250°C; ion source: 220°C; collision energy: 35 eV; full scan: 50-650 from 18 to 57.50 min. In each chromatographic run, different ions were monitored for each fatty acid analysed, which allowed to perform detection and quantitative analysis. A calibration curve was performed for each of the 23 fatty acids determined.

III. RESULTS AND DISCUSSION

Cooking experiment.

Oven cooking procedure: Oven cooking resulted in an unchanged fatty acids profile in both " ω-3 rich" and standard pork meat (data not shown), showing that the PUFA content remains intact after that cooking mode.

Pan-frying procedure: Figure 1 shows the fatty acids composition (major FA representing more than 90% of total FA) in raw and pan fried ground " ω-3 rich" pork. Pan frying without fat of the " ω-3 rich" meat does not change its fatty acid content. When the meat is cooked with fat, it appears clearly, as expected, that the composition of the culinary fats had a greater infuence on its fatty acids profile than the cooking process. Indeed, palmitic (C16:0) and stearic (C18:0) acids, which are less present in sesame and peanut oils than in raw pork meat, decrease of approximately 10% after pan-frying with peanut and sesame oils. Pan-frying with butter resulted in a decrease of the amount of linoleic acid (C18:2ω6) in meat, due to the fact that butter contains very few linoleic acid. In all cases of pan-frying experiments with culinary fat, the α-linolenic acid (C18:3ω3) content showed a decrease : of 15% (cooking with margarine), 23% (cooking with butter), and 27% (cooking with sesame and peanut oils).

The same kind of results were obtained for standard pork meat, for palmitic, stearic and linoleic acid after pan-frying with oils. A decrease of oleic acid (C18:1ω9) of approximately 20% was observed after the use of butter, margarine and sesame oil, while no α-linolenic acid was detected in standard pork meat (data not shown).

Figure 1 : Fatty acids composition of raw and pan fried ground " ω-3 rich" pork meat. Mean ± SD. n=4 for raw meat and n=2 for cooked meat.

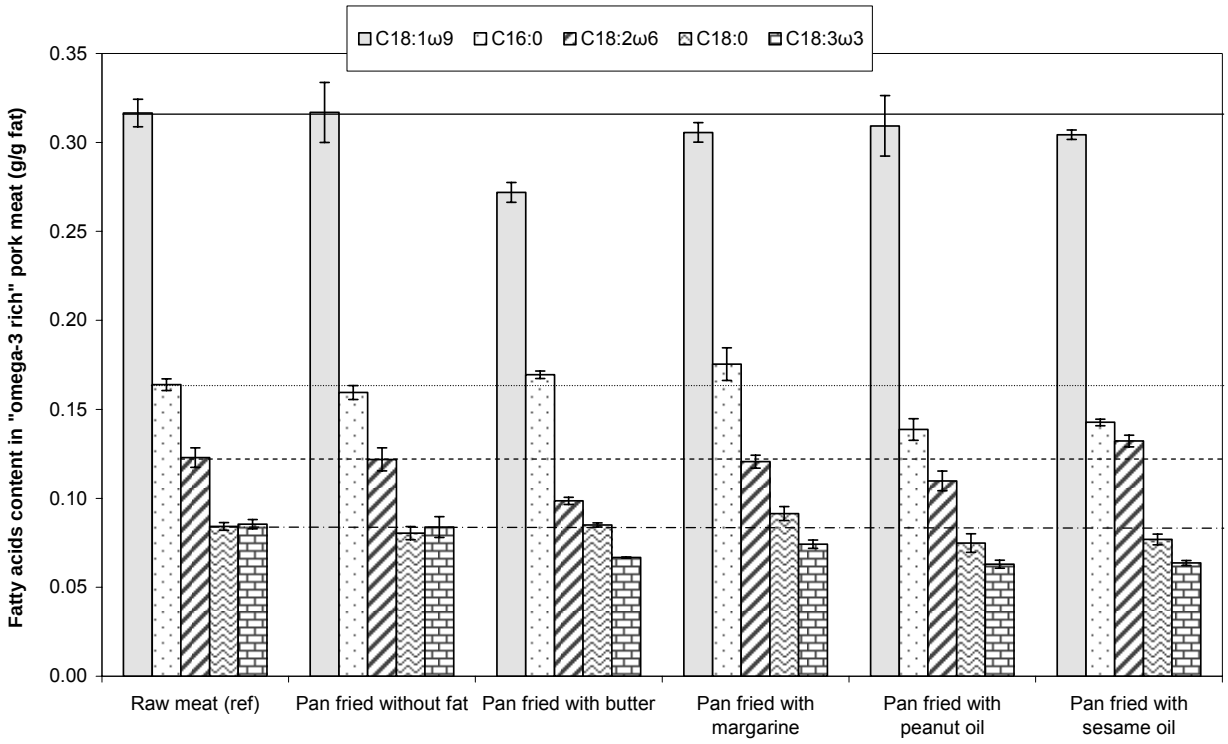

Figure 2 compares the saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and total fatty acid content in raw and cooked " ω-3 rich" and standard pork meat. No difference appears after oven cooking, but when we consider pan-frying, the figure shows a decrease of the total fatty acids content in standard pork meat after pan-frying both with or without culinary fat. This decrease seems to be due mainly to the decrease of MUFA (C18:1w9 and C16:1w7). The fact that no decrease of the fatty acid content is observed in " ω-3 rich" after pan-frying without fat could be explained by the presence of natural antioxidants in the feed of " ω-3 rich" pigs (and not in the feed of standard pork) which would have a protective effect on fatty acids towards oxidation.

Storage experiment.

No variation in fatty acids composition was observed after storage during 6 week at 4°C or 10 weeks at -20°C, for ground meat and meat sausage, made from" ω-3 rich" or standard pork, when compared to "day 0".

IV. CONCLUSION

Omega-3 fatty acids intake by the consumer through "ω-3 rich" pork meat "seems not to be affected by storage and cooking. However, as expected, cooking without fat allows a better conservation of the fatty acids profile of the meat comparing to cooking with fat. On the contrary, fatty acids contained in the standard pork meat appeared to be more sensitive to degradation. This difference could be explained by the presence of antioxydants in the feed of "omeaga-3 rich" pork feed and not in the feed of standard pork.

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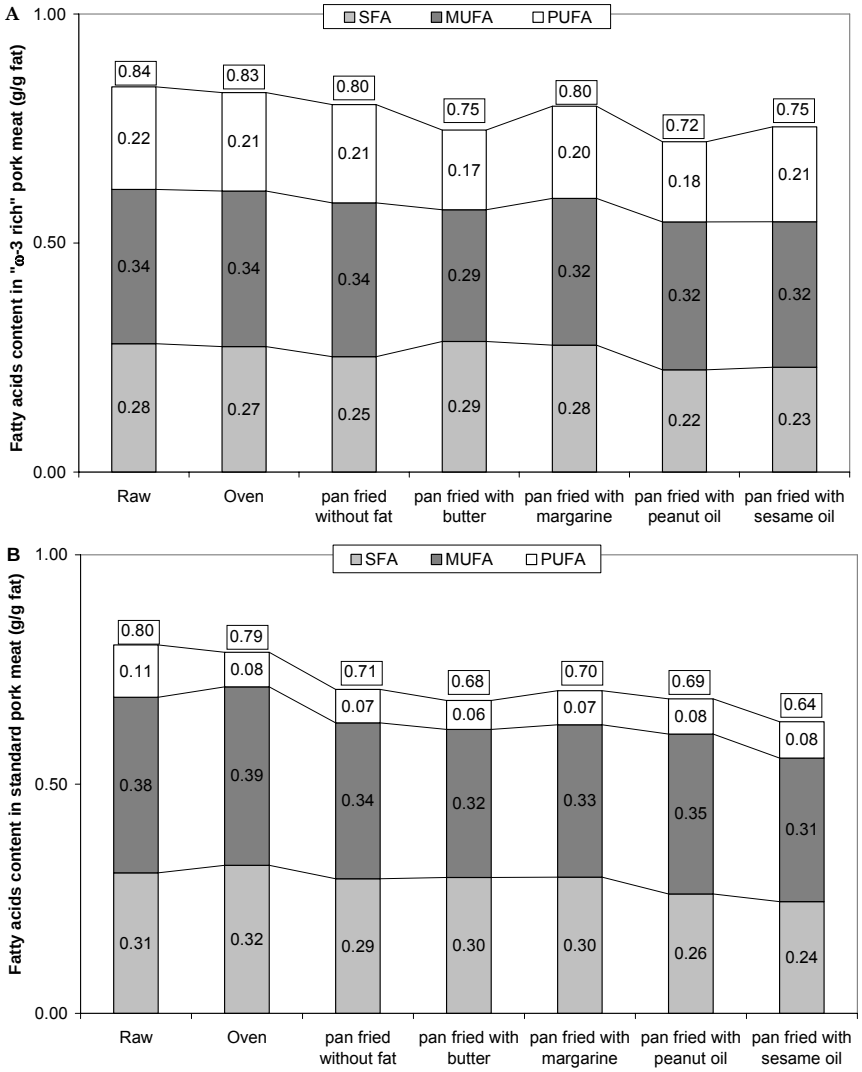
Figure 2 : Fatty acids composition of raw and pan fried ground " ω-3 rich" pork meat (A) and standard pork meat (B). Mean ± SD. n=4 for raw and oven cooked meat and n=2 for pan fried meat. Total fatty acid content are indicated in the boxes. SFA : Saturated Fatty Acids (Σ C10:0, C12:0, C14:0, C16:0, C17:0, C18:0, C20:0, C22:0, C24:0), MUFA : Monounsaturated Fatty Acids (Σ C16:1ω7, C17:1, C18:1ω9), PUFA : Polyunsaturated Fatty Acids (Σ C18:2ω6, C18:3ω6, C18:3ω3, C18:4, C20:2ω6, C20:3ω3, C20:4, C20:5, C22:5, C22:6).



REFERENCES

Haak, L., Sioen, L., Raes, K., Van Camp, J., De Smet, S. (2007). Effect of pan-frying in different culinary fats on the fatty acid profile of pork. *Food Chem.*, 102, 857-864.

Huikuri, H.V., Castellanos, A., Myerburg, R.J. (2001). Sudden death due to cardiac arrhythmias. *The New England Journal of Medicine,* 345, 1473-1482.

McMillin, J.B., Bick, R.J., Benedict, C.R. (1992). Influence of dietary fish oil on mitochondrial function and response to ischemia. *Am J Physiol Heart Circ Physiol,* 263, 1479-1485.

Monahan, F.J., Buckley, D.J., Morrissey, P.A., Lynch, P.B., Gray, J.I. (1992). Influence of dietary fat and alpha-tocopherol supplementation on lipid oxidation in pork. *Meat Science*, 31, 229–241.

Nurnberg, K., Kuchenmeister, U., Nurnberg, G., Ender, K., Hackl, W. (1999). Influence of exogenous application of n _ 3 fatty acids on meat quality, lipid composition, and oxidative stability in pigs. *Archives of Animal Nutrition*, 52, 53–65.

Raes, K., Haak, L., Balcaen, A., Claeys, E., Demeyer, D., De Smet, S. (2004). Effect of linseed feeding at similar linoleic acid levels on the fatty acid composition of double-muscled Belgian blue young bulls. *Meat Science*, 66, 307-315.

Harris, W.S, Mozzaffarian, D., Rimm, E., Kris-Etherton, P., Rudel, L.L., Appel, L.J, Engler M.M., Engler, M.B., Sacks, F (2009). Omega-6 fatty acids and risks for cardiovascular disease : a science advisory from the American Heart Association subcommittee of the Council on nutrition, physical activity, and metabolism; council on cardiovascular nursing; and council on epidemiology and prevention. *Circulation*, 119, 902-907.

Wood, J.D., Richardson, R.I., Nute, G.R., Fisher, A.V., Campo, M.M., Kasapidou, E., Sheard, P.R., Enser, M. (2003). Effects of fatty acids on meat quality: a review. *Meat Science*, 66, 21-32.