EFFECT OF DIFFERENT COOKING METHODS ON OXIDATIVE STABILITY IN PORK MEAT

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Background:
Prior to consumption, meats should be cooked in some way and, usually, the left-over is chilled and reheated more that once. The cooking and reheating procedures can lead to rapid onset of lipid oxidation and consequent meat quality deterioration through storage time (Jensen et al., 1998). Heating is believed to accelerate the lipid oxidation by increasing free iron levels (Graf and Panter, 1991) and by denaturing cellular membranes, which facilitates the interaction of the highly unsaturated phospholipids with oxygen and with another prooxidants (Buckley et al., 1995). Decomposition of lipid peroxides yields a complex mixture of volatile compounds, many of which impart rancid, oxidized and other off-flavors characteristics to meat (Chan and Peterson, 1977). The terms "warmed-over flavor" (WOF) (Tims and Watts, 1958) and "meat flavor deterioration" (MFD) (Spanier et al., 1990) have been suggested to describe the overall increase in off-flavor notes and loss in desirable meat flavor quality. Hexanal, a major lipid autoxidation product, is most frequently quantified as a measure of lipid autoxidation in cooked meats (Melton, 1983). Flavor deterioration is particularly pronounced in cooked meats that are reheated (Lyon and Ang, 1990)
In addition to flavour problems, lipid oxidation may lead to formation of injurious compounds such as malonaldehyde (MDA) and cholesterol oxides (COPS), that have been linked to the development of several types of cancer and heart diseases (Draper et al., 1986; Addis and Hassel, 1992; Paniangvait et al., 1996). MDA and COPS accumulation is clearly a problem in precooked meat, specially during refrigerated storage and reheating (Pie et al., 1991).

Key words: Lipid oxidation, cholesterol oxidation products, hexanal, cooking methods, microwave reheating.

Objectives:
The objective of our study was to investigate the influence of different methods of cooking in the development of lipid and cholesterol oxidation in pork meat during refrigerated storage and subsequent reheating.

Methods:
Source of meat: *Longissimus dorsi* (n=14) were obtained from pigs fed a standard diet and slaughtered with an average life body weight of 90-95 kg. Carcasses were selected according to pH and EC measures for rejecting quality deviations, PSE or DFD meats (Bañón et al., 1996). *Longissimus dorsi* muscle was excised from the carcasses and all visible fat was removed. Meat was sliced into chops of 1 cm of thickness and divides in four batches according to its use (R: raw meat; B: boiled meat; O: roasted meat; F: pan-fried meat). Raw meat batch was held under refrigerated temperatures (4° C) until its analysis.
Methods of cooking: Both wet and dry methods of cooking normally employed under domestic conditions were used. Cooked samples reached an internal temperature of 72±2° C, regardless of the cooking method.
Roasting: Chops pork were wrapped in aluminium foil, placed in a preheated oven (180°C) and cooked for 15 min.
Pan-frying: The pan was preheated each time for 5 min to a moderate temperature (≈200° C). Chops were continuously tumbled for 5 minutes.
Boiling: Individual samples were placed in plastic bags and cooked by immersion in a water bath at 80° C for 20 minutes.
Packaging and storage conditions: After cooking, chops were immediately removed to their wraps and cooled at room temperature. They were either immediately used or placed on polystyrene trays over-wrapped with an oxygen-permeable PVC wrap. Cooked pork chops were stored at 4° C for 10 days and reheated by a microwave oven, to an internal temperature of 65±2° C, previously to analyses.
Chemical analysis: Pork chops samples were analysed in duplicate.
Lipid oxidation: Oxidative stability in raw and cooked meat was evaluated by measuring thiobarbituric acid reacting substances (TBARS) using the method described by Botsoglou et al. (1994). Results were expressed as mg malonaldehyde (MDA)/kg muscle. Lipid oxidation was evaluated at day 0, 3, 5,7 and 9 of refrigerated storage (4° C).
Cholesterol oxidation products (COPS): Total lipids were extracted according to the Folch et al. (1957) procedure. The lipid extract was located into a silica solid phase extraction (SPE) cartridge and eluted serially with hexane-ethyl acetate of 9:1 (v/v) and 8:2 (v/v) respectively. 19-OH cholesterol was added as internal standard. Finally, the COPS fraction were extracted by eluting with acetone and derivatizated by reaction with BSTFA and piridyne. Oxysterols were detected and quantified by using a GC, with capillary column (HP-5), equipped with a FID detector. The COPS levels were measured at days 0, 3 and 7 of refrigerated storage.
Hexanal: Sample homogenates (16.6% w/w) were prepared by homogenising 5 g cooked meat in 25 g distilled water. Ethyl butirate was included as an internal standard during homogenisation at a concentration of 1µg/g muscle. Aliquots (3 ml) of the homogenates were dispensed into 5 ml vials fitted with PTFE lined silicone septa and placed in a water bath set at 40° C. Hexanal was extracted by introducing a Polydimethylsiloxane/Divinylbenzene (PDMS-DVB) coated SPME fiber into the vial headspace. Quantification of hexanal was performed on a GC, with capillary collumn (CP-Wax), equipped with a FID detector. Analysis were carried out immediately after cooking and after 1, 2, 4 and 7 days of storage at 4° C.

Results and discussion:
There were significant ($P<0.001$) day and cooking method effects, but not significant ($P>0.1$) interactions between day and cooking, on lipid and cholesterol oxidation index evaluated (Table 1).
Lipid oxidation: TBARS values in raw meat (0.062±0.034) significantly increased ($P<0.01$) after cooking. The TBARS numbers of freshly boiled, roasted and fried samples were 11, 9.2 and 4.7 fold higher than those of raw meat, respectively. Pan-frying method determined lower ($P<0.05$) TBARS increases than boiling or roasting. The TBARS data (Figure 1) also showed that oxidative stability during storage was related with cooking procedure. TBARS numbers for B and O samples increased from 0.68 and 0.57 mg MDA/kg meat (day 0) to 3.94 and 3.92 mg MDA/kg meat, respectively, after 9 days of storage, while F samples showed an increase from 0.29 to 3.70 mg MDA/kg meat over the same period of time. Similar trends were established by several authors (Monahan y col., 1990; Jensen y col., 1997; Kingston y col., 1998; Hernández y col., 1999).
Cholesterol oxidation: Five oxysterols were identified both in raw and cooked meat (7β-OH, α-epoxi, triol, 25-OH and 7-ketocholesterol). 7β-OH and 7-keto concentration supposed almost 83% of the overall COPS levels. This data are consistent with those obtained by Zubillaga

and Maerker (1991). Total COPS number in raw meat (0.22±0.05) significantly (P<0.05) increased after boiling (0.81±0.25) and roasting (0.96±0.37), but only small increases were detected after pan-frying (0.52±0.34). Differences between cooking methods were maintained and increased during storage time (Fig. 2.). After 7 days of refrigerated storage, COPS levels in B, O and F samples were 7.5, 5.2 and 4.5 times higher than in freshly cooked meat. This results are in agree with those reported by Monahan et al. (1992) and Kowale et al. (1996).

Hexanal production: Hexanal levels measured in freshly fried samples (2.02±0.65) were significantly lower (P<0.05) than those quantified in boiled (3.95±0.75) and roasted (3.36±0.36) pork meat. Those differences were maintained through the length of storage time (Figure 3). Significant increases (P<0.05) in hexanal levels were detected after 4 and 7 days of refrigerated storage, regardless of cooking method. Our results were comparable to those of Brunton et al. (2000) but were lower than those obtained by Shahidi and Pegg (1994).

Correlations: Significant (P<0.01) Pearson correlation coefficients were found between TBARS and COPS values (r=0.600), TBARS and hexanal levels (r=0.583) and hexanal and COPS numbers (r=0.480).

Table 1. Analyses of variance

		TBARS		COPS		Hexanal	
Source	df	MS	F-value	MS	F-value	MS	F-value
Day	2	60.15	317.51*	72.67	30.39*	10.94	24.97*
Cooking	2	2.06	10.86*	27.52	11.51*	82.48	51.28*
Day x Cooking	3	0.17	0.88	6.60	2.76	0.65	1.48
Error	76	0.19	---	2.39	---	0.44	---

MS: Mean squares; * P<0.001

Fig 1. TBARS values (Mean±SEM) in cooked and reheated pork during refrigerated storage (4° C).

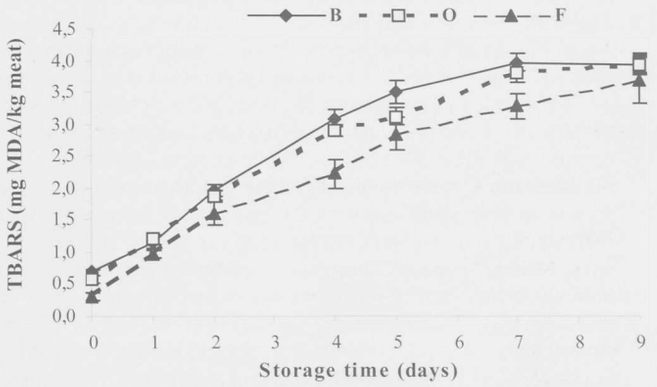


Fig 2. COPS levels (Mean±SEM) in cooked and reheated pork during refrigerated storage (4° C).

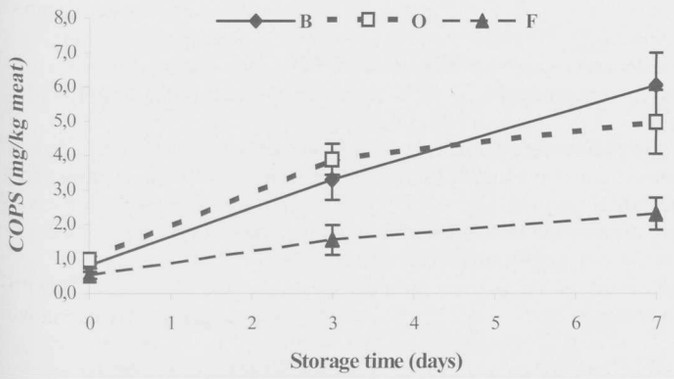
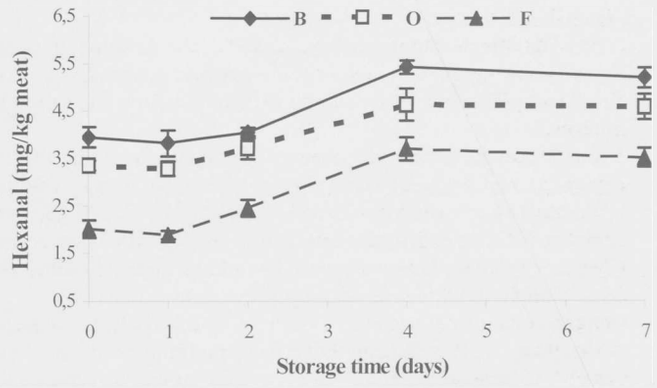


Fig 3. Hexanal values (Mean±SEM) in cooked and reheated pork during refrigerated storage (4° C).



PERTINENT LITERATURE: Addis, P.B.; Hassel, C.A. (1992). *Amer.Chem. Soc. Symposium Series*, **484**, p. 346; Bañón, S.J.; Garrido, M.D.; Pedauyé, J.; Seguí, J. (1996). *Eurocarne*, **45**: 29-35; Botsoglou, N.A.; Fletouris, D.J.; Papageorgiou, G.E.; Vassilopoulos, V.N.; Mantis, A.J.; Trakatellis, A.G. (1994). *J. Agric. Food Chem.*, **42**: 1931-1937; Brunton, N.P.; Cronin, D.A.; Monahan, F.J.; Durcan, R. (2000). *Food Chem.*, **68**: 339-345; Buckley, D.J.; Morrissey, P.A.; Gray, J.I. (1995). *J. Anim. Sci.*, **73**: 3122-3150; Chang, S.S.; Peterson, R.J. (1977). *J. Food Sci.*, **42**: 298-305; Draper, H.H.; McGirr, L.G.; Hadley, M. (1986). *Lipids*, **21**(4): 305-307; Folch, J.; Lees, M.; Sloan-Stanley, G.H. (1957). *J. Biol. Chem.*, **226**: 497-509; Graf, E.; Panter, S.S. (1991). *J. Food Sci.*, **56**: 1055-1058; Hernández, P.; Navarro, J.L.; Toldrá, F. (1999). *Food Sci. & Technol. Int.*, **5**(6): 501-508; Jensen, C.; Guidera, J.; Skovgaard, I.M.; Staun, H.; Skibsted, L.H. (1997). *Meat Sci.*, **45**(4): 491-500; Jensen, C.; Skibsted, L.H.; Bertelsen, G. (1998). In: *Proc. 44th ICOMST.* pp. 618-619. Barcelona, Spain; Kingston, E.R.; Monahan, F.J.; Buckley, D.J.; Lynch, P.B. (1998). *J. Food Sci.*, **63**(3): 386-389; Kowale, B.N.; Rao, V.K.; Babu, N.P.; Sharma, N.; Bisht, G.S. (1996). *Meat Sci.*, **43**(2): 195-202; Lyon, B.G.; Ang, C.Y.W. (1990). *Poult. Sci.*, **69**: 320-328; Melton, S.T. (1983). *Food Technol.*, **37**(7): 105-116; Monahan, F.J.; Buckley, D.J.; Gray, J.I.; Morrissey, P.A.; Asghar, A.; Hanrahan, T.J.; Lynch, PB. (1990). *Meat Sci.*, **27**: 99-108; Monahan, F.J.; Gray, J.I.; Booren, A.M.; Miller, E.R.; Buckley, D.J.; Morrissey, P.A.; Gomaa, E.A. (1992). *J. Agric.Food Chem.*, **40**: 1310-1315; Paniangvait, P.; King, A.J.; Jones, A.D.; German, B.G. (1996). *J. Food Sci.* **60**(6): 1159-1174; Pie, J.E.; Spahis, K.; Seillan, C. (1991). *J. Agric. Food Chem.*, **39**: 250-254; Shahidi, F.; Pegg, R.B. (1994). *Amer. Chem. Soc. Symposium Series*, **558**: 256-279; Spanier, A.M.; McMillin, K.W.; Miller, J.A. (1990). *J. Food Sci.*, **55**: 318-322; Tims, M.J.; Watts, B.M. (1958). *Food Technol.*, **12**: 240-243; Zubillaga, M.P.; Maerker, G. (1991). *J. Food Sci.*, **56**(5): 1194-1202.