EFFECT OF RADIATION PROCESSING OF PORK PRODUCTS ON ITS LIPIDS

E. Zanardi*[1], A. Battaglia[1], S. Ghidini[1], M. Conter[1], A Badiani[2] and A. Ianieri[1]

[1]Dip. di Produzioni Animali, Biotecnologie Veterinarie, Qualità e Sicurezza degli Alimenti, Università degli Studi di Parma, via del Taglio 8 – 43100 Parma, Italy [2]DIMORFIPA, Alma Mater Studiorum - Università di Bologna, via Tolara di Sopra 50 - 40060 Ozzano Emilia (Bologna), Italy. E-mail: emanuela.zanardi@unipr.it

Keywords: irradiation, pork, lipid, oxidation, 2-alkylcyclobutanones

Introduction

Radiation processing is one of the emerging technologies to ensure the microbiological safety of meat. This is one of the most important issues of the meat industry, especially for producers exporting to USA and Japan where the absence of some pathogenic bacteria is required. Although the effectiveness against most pathogens is well known, radiation brings about biochemical changes that could affect the nutritional adequacy of food. Lipids are one class of nutrients affected by irradiation treatment. Irradiation-induced lipid oxidation products are dose-dependent and their formation is influenced by packaging, storage and other processing conditions before and after radiation processing. In addition, the irradiation of lipids results in the formation of 2-alchylcyclobutanones, unique radiolytic products from precursor fatty acids. These molecules, proposed as a marker of irradiation of fat-containing food, have been recently reported as genotoxic (Knoll *et al.*, 2006).

The present study attempted to establish whether radiation processing of three different Italian pork products resulted in changes to the lipid oxidation status and 2-alchylcyclobutanone content during storage under vacuum and refrigerated conditions.

Materials and Methods

Salame Milano, coppa and pancetta were the three traditional Italian processed pork products investigated. Salame Milano is a typical minced, dry cured and fermented pork product; coppa is made up by the entire neck muscle, deboned, cured and afterwards matured in natural casing; pancetta is made up of the muscular and adipose tissues of the ventral region of the pork, cured and seasoned. The meat products at the end of maturing were packed under vacuum, placed in cardboard boxes and electron irradiated under refrigerated condition at 2, 5 and 8 kGy absorbed dose by using a linear accelerator. The three doses are within the range of 10 kGy which has been set by the World Health Organisation as a level presenting non-toxicological hazard. The degree of lipid oxidation and the content of 2-alchylcyclobutanones were determined after 0 (T_0) and 60 days (T_1) of vacuum storage in refrigerated conditions. Lipid oxidation was determined by the thiobarbituric acid reactive substances (TBARS) method as proposed by Novelli *et al.*, (1998). 2-alchylcyclobutanones (2-ACB) were determined according to the European Standard EN 1785 (2003) based on GC/MS analysis. 2-dodecylcyclobutanone (2-DCB), 2-tetradecylcyclobutanone (2-TDCB) and 2-(5'-tetradecenyl)cyclobutanone (2-TdecCB) were the three molecules considered because they are derived from the major fatty acid precursors (respectively palmitic, stearic and oleic acid) found in the processed pork products investigated.

Results and Discussion

The TBARS values are presented in Table 1. The pork products irradiated up to 5 kGy radiation dose did not differ significantly from the non-irradiated ones. However, the radiation dose of 8 kGy was able to accelerate the lipid oxidation process. Among the three pork products, pancetta showed the highest TBARS values. This could be attributed to its higher fat content (33.9 ± 3.9 %) compared to that of salame Milano (31.2 ± 1.5 %) and coppa (20.0 ± 5.1 %). Vacuum packaging was very effective for inhibiting irradiation-induced lipid oxidation during storage, in agreement with Jo *et al.*, (2002). TBARS values measured just after the irradiation treatment (T_0) did not differ significantly from those measured after 60 days of storage (T_1), with the exception of radiation dose 5 kGy for all the three pork products and 2 kGy for pancetta.

Table 2 shows the 2-alchylcyclobutanone content. These molecules were absent in the non-irradiated pork products. Similar to TBARS values, pancetta showed the highest content of 2-ACB. The concentration of 2-ACB is dose dependent. At 2 kGy radiation dose they were found in a few samples at concentrations very near to the limit of quantification. At 5 and 8 kGy they were present in all the samples, except 2-TdecCB, the presence of which was only detected at 8 kGy radiation dose. Vacuum packaging was not sufficient to limit the formation of 2-ACB. In most cases the content of the 2-ACB measured after 60 days of vacuum storage (T_1) was significantly higher compared to the amounts detected just after the treatment (T_0). 2-DCB and 2-TDCB are the two molecules most frequently detected. Their concentration was always lower than 0.60 μg/g. When it was present, 2-TdecCB reached highest levels, which ranged between 0.99 and 3.81 μg/g. This result is in agreement with the findings of Kim *et al.*, (2004) who detected the 2-ACB in dried shrimps at a radiation dose of 0.5 kGy with 2-TdecCB found in the highest concentration.

Table 1: TBARS values (mg MDA/kg) in the irradiated processed pork products (a,b, in a column, and z,y, in a line, stand for significant differences, P≤0.05, Scheffè's test).

Pork product	Irradiation dose (kGy)	T_0	T_1
Salame Milano	0	$0.108\pm0.019^{b,z}$	$0.104\pm0.010^{a,z}$
	2	$0.135\pm0.021^{ab,z}$	$0.233\pm0.135^{a,z}$
	5	$0.124\pm0.007^{ab,y}$	$0.199\pm0.037^{a,z}$
	8	$0.148\pm0.024^{a,z}$	$0.202\pm0.154^{a,z}$
Coppa	0	$0.085\pm0.009^{b,z}$	$0.075\pm0.036^{b,z}$
	2	$0.088\pm0.014^{b,z}$	$0.091\pm0.025^{b,z}$
	5	$0.083\pm0.020^{b,y}$	$0.204\pm0.079^{a,z}$
	8	$0.163\pm0.045^{a,z}$	$0.146\pm0.056^{ab,z}$
Pancetta	0	$0.187\pm0.080^{ab,z}$	$0.179\pm0.066^{b,z}$
	2	$0.227\pm0.042^{ab,y}$	$0.394\pm0.098^{a,z}$
	5	$0.130\pm0.027^{b,y}$	$0.273\pm0.030^{b,z}$
	8	$0.260\pm0.024^{a,z}$	$0.245\pm0.049^{b,z}$

Table 2: 2-alchylcyclobutanone content (μg/g) in the processed pork products irradiated ([1] not detectable; [2] detected in less than 3 samples out of 5; a,b, in a column, and z,y, in a line, stand for significant differences, P≤0.05, Scheffè's test).

2-ACB	Irradiation dose (kGy)	Salame Milano		Coppa		Pancetta	
		T_0	T_1	T_0	T_1	T_0	T_1
2-DCB	0	n.d.[1]	n.d.	n.d.	n.d.	n.d.	n.d.
	2	traces [2]	traces	0.04±0.01	n.d.	0.05 ± 0.01^{c}	traces
	5	$0.03\pm0.01^{b,y}$	$0.07\pm0.02^{b,z}$	$0.05\pm0.02^{b,z}$	$0.07\pm0.01^{b,z}$	$0.12\pm0.03^{b,z}$	$0.11\pm0.03^{b,z}$
	8	$0.13\pm0.03^{a,y}$	$0.35\pm0.13^{a,z}$	$0.13\pm0.06^{a,y}$	$0.26\pm0.05^{a,z}$	$0.26\pm0.07^{a,y}$	$0.57\pm0.20^{a,z}$
2-TdecCB	0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	2	n.d.	n.d.	n.d.	n.d.	n.d.	traces
	5	traces	traces	n.d.	traces	$1.09\pm0.38^{b,z}$	$0.72\pm0.10^{b,z}$
	8	0.99 ± 0.10^{y}	2.34 ± 0.77^{z}	0.73 ± 0.38^{y}	1.73 ± 0.41^{z}	$2.52\pm0.80^{a,z}$	$3.81\pm1.28^{a,z}$
2-TDCB	0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	2	traces	traces	0.04 ± 0.01^{b}	n.d.	traces	traces
	5	$0.05\pm0.02^{b,y}$	$0.09\pm0.03^{b,z}$	$0.06\pm0.03^{ab,z}$	$0.08\pm0.03^{b,z}$	$0.10\pm0.02^{b,z}$	$0.09\pm0.03^{b,z}$
	8	$0.13\pm0.01^{a,y}$	$0.33\pm0.11^{a,z}$	$0.11\pm0.05^{a,y}$	$0.31\pm0.09^{a,z}$	$0.24\pm0.08^{a,z}$	$0.42\pm0.14^{a,z}$

Conclusions

The three Italian processed pork products investigated (salame Milamo, coppa and pancetta) submitted to radiation processing at 2 and 5 kGy did not present a significant increase in lipid oxidation products either just after the treatm or after 60 days of vacuum storage. However, a marked increase was observed at 8 kGy radiation dose. The content of 2-alchylcyclobutanones increased with radiation dose. Their presence has been recorded occasionally at 2 kGy and constantly at higher radiation doses (5 and 8 kGy). A significant increase of 2-alchylcyclobutanones was observed during vacuum storage of irradiated pork products.

References

EN 1785 (2003) "Detection of irradiated food containing fat–Gas-chromatographic/mass spectrometric analysis of 2-alkylcyclobutanones".

Jo C., Ahn D.U., Byun M.W. (2002) Irradiation-induced oxidative changes and production of volatile compounds in sausages prepared with vitamin E-enriched commercial soybean oil. *Food Chemistry*, 76, 299-305.

Kanatt S.R., Chander R., Sharma A. (2006) Effect of radiation processing of lamb meat on its lipids. *Food Chemistry*, 97, 80-86.

Kim Kyong-Su, Seo Hye-Young, Lee Jeong-Min, Park Eun-Ryong, Kim Jun-Hyoung, Hong Cheul-Hee, Byun Myung Woo (2004) Analysis of radiation-induced hydrocarbons and 2-alkylcyclobutanones from dried shrimps. Journal of Food Protection, 67, 142-147.

Knoll N., Weise A., Claussen U., Sendt W., Marian B., Glei M., Pool-Zobel B.L. (2006) 2-Dodecylcyclobutanone, radiolytic product of palmitic acid, is genotoxic in primary human colon cells and in cells from preneoplastic lesions. *Mutation Research*, 594, 10-19.

Novelli E., Zanardi E., Ghiretti G.P., Campanini G., Dazzi G., Madarena G., Chizzolini R. (1998) Lipid and cholesterol oxidation in frozen stored pork, salame Milano and mortadella. *Meat Science*, 48, 29-40.