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Irradiation effect on fatty acid composition and conjugated linoleic acid isomers in frozen lamb meat

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Abstract

The effect of gamma radiation processing on the lipid content, fatty acid composition and conjugated linoleic acid (CLA) profile in frozen lamb meat was investigated. Samples of *longissimus thoracis* muscle from lambs fed lucerne basal diets either unsupplemented or supplemented with polyunsaturated vegetable oils were irradiated (7 kGy) and analysed. CLA contents in lamb meat did not affect ($P > 0.05$) the levels of lipid oxidation induced by the irradiation. No significant differences ($P > 0.05$) were observed for fatty acid composition, related nutritional indexes ($n-6/n-3$ and PUFA/SFA), as well as for total lipid and CLA contents, between non-irradiated (control) and irradiated meat samples. In contrast, meat irradiation affected the relative proportions of total *trans, trans* and *cis*/*trans* CLA isomers ($P < 0.001$), in addition to the percentage of some minor individual CLA isomers ($t11,t13$ and $t9,t11$, with $P < 0.05$ and $P < 0.001$, respectively). The percentage of total *cis*/*trans* CLA isomers slightly decreased in irradiated samples, while the relative proportion of total *trans, trans* isomers slightly increased. This observation may be explained by the higher susceptibility to autoxidation of the *cis* double bond relative to the *trans* configuration.

Keywords: Fatty acid composition; CLA isomers; Irradiation; Lamb meat

1. Introduction

Meat irradiation is recognized as a safe and effective method among the existing technologies to attain meat preservation (Kanatt, Chander, & Sharma, 2006). The use of high energy gamma rays or accelerated electrons to irradiate fresh meat extends shelf life and protects proliferation of pathogenic bacteria. The Food and Drug Administration approved irradiation for poultry meat and red meats (USA FDA, 1997) to control foodborne pathogens and to extend product shelf life (Ross & Engeljohn, 2000). In the European Union, the opinions on the use of irradiation differ in member countries. The greatest suppliers of irradiated foodstuffs are Belgium (e.g. meat, fish, eggs and cheese), France (e.g. mechanically recovered poultry meat and frozen frog legs) and the Netherlands (e.g. frozen poultry meat, spices and dehydrated vegetables) (European Union, 2006; Grolichová, Dvořák, & Musilová, 2004). In the USA, this technology is more common and there are also attempts to enforce irradiation not only for food safety but also for technological purposes.

Even though irradiation is a prospective technology, its application causes physical–chemical and biochemical

Abbreviations: CLA, conjugated linoleic acid; DAD, diode array detector; FAME, fatty acid methyl esters; LT, *longissimus thoracis*; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SEM, standard error of mean; SFA, saturated fatty acids; TFA, *trans* fatty acids.

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changes, that may affect the nutritional value and sensory characteristics of irradiated food (Dogbevi, Vachon, & Lacroix, 1999; Grolichová et al., 2004). However, according to the same authors, irradiation at low doses (up to 10 kGy) may have either non-measurable or non-significant impacts on meat properties. One of the major concerns with meat irradiation is its effects on lipid oxidation, meat colour and off-odor production (Ahn, Jo, Du, Olson, & Nam, 2000). Fats are among the least stable food components being very susceptible to ionizing radiation (Hammer & Wills, 1979), which may induce autoxidation. Radiation processing generates free radicals and accelerates oxidation of unsaturated fatty acids that may induce some biochemical changes in meat and influence its quality, such as the nutritional value (Du, Ahn, Nam, & Sell, 2000). Polyunsaturated fatty acids (PUFA) of the phospholipid fraction, which represent 0.5–1% of the total lipids in meat, are the major contributors for the development of rancidity during meat storage (Giroux & Lacroix, 1998) and so, the most susceptible during irradiation.

Conjugated linoleic acid (CLA) is a minor group of fatty acids, composed of positional (from positions 6,8- to 12,14-) and geometric (*trans*, *trans*, *trans*, *cis*, *cis*, *trans* and *cis*, *cis*) isomers of linoleic acid (18:2$n-6$) containing conjugated double bonds with a multitude of potential health benefits (see e.g. Prates & Mateus, 2002; Wahle, Heys, & Rotondo, 2004). Twenty different CLA isomers have been reported as occurring naturally in food, especially in ruminant fat (Sehat et al., 1998). The major CLA isomer, rumenic acid (18:2*c*9,*t*11), is produced in the rumen during the microbial biohydrogenation of dietary 18:2$n-6$ and in the tissues through delta9 desaturation of 18:1*t*11 (Griinari & Bauman, 1999). It is now accepted that the major contribution to 18:2*c*9,*t*11 in ruminant milk (Corl et al., 2002) and meat (Palmquist, St-Pierre, & McClure, 2004) is the endogenous synthesis. Recent interest in some CLA isomers was sparked off by biological activities that include anticancerinogenic, antiobesity, antidiabetogenic, anti-atherogenic and immunomodulation and modulation of bone growth (Belury, 2002; Cook & Pariza, 1998; Parodi, 2002; Whigham, Cook, & Atkinson, 2000). The information about CLA isomeric distribution appears to be important as isomer specific biological effects have been reported (Evans, Brown, & McIntosh, 2002).

Although many publications have evaluated the quality of irradiated bovine, ovine, swine and poultry meat (see e.g. Ahn et al., 2000; Du et al., 2000), the information on changes in fatty acid composition is scarce (see e.g. Brito, Lúcia, Villavicencio, & Mancini-Filho, 2002; Kanatt et al., 2006). In addition, as far as is known, there is no report on the effect of radiation processing on CLA isomeric distribution in meat. Moreover, it is still unknown if CLA enriched meat is more susceptible to irradiation induced lipid oxidation. Therefore, the objective of this study was to analyse the influence of gamma radiation processing, at the maximum doses allowed commercially (7 kGy), on the fatty acid composition, including the CLA isomeric profile, of vacuum-packaged frozen lamb meat samples. The samples were collected from an experiment where lambs were fed lucerne basal diets, either unsupplemented or supplemented with polyunsaturated vegetable oils, in order to produce meat with different levels of CLA.

2. Materials and methods

2.1. Reagents

Analytical grade and liquid chromatographic grade chemicals were purchased from Merck Biosciences (Darmstadt, Germany). Sodium methoxide (0.5 M solution in anhydrous methanol) was obtained from Sigma–Aldrich Ltd. (St. Louis, MO, USA) and the fatty acid methyl ester (FAME) standard mixtures were acquired from Nu-Chek-Prep Inc. (Elysian, MN, USA) and Supelco Inc. (Bellefonte, PA, USA). Commercial standards of individual CLA isomers (18:2*c*9,*t*11, 18:2*t*10,*c*12, 18:2*c*9,*c*11 and 18:2*t*9,*t*11) as methyl esters were purchased from Matreya Inc. (Pleasant Gap, PA, USA). Additional standards of individual (18:2*t*8,*c*10,18:2*c*11,*t*13) and mixtures (*cis, trans*, *trans, cis* and *trans, trans* from positions 7.9 to 12.14) of CLA isomers were prepared as methyl esters according to the procedure described by Destaillats and Angers (2003).

2.2. Animals and preparation of meat samples

Samples used in the present study were originated from an experiment where 32 Merino Branco lambs were randomly allocated to 4 groups that were fed, *ad libitum*, with one of the four pelleted diets: Control – control diet consisting of 100% pelleted dehydrated lucerne (*Medicago sativa* L.); SF – pelleted dehydrated lucerne supplemented with sunflower oil; SFLS – pelleted dehydrated lucerne supplemented with a blend of sunflower oil and linseed oil (2:1 v/v); LS – pelleted dehydrated lucerne supplemented with linseed oil. The level of oil inclusion in SF, SFLS and LS diets was 7.4% in a dry matter basis. The animals stayed on trial for 6 weeks and the *longissimus thoracis* (LT) muscle was collected from the carcasses (kept under refrigeration at +1 °C) 72 h after slaughter, minced, vacuum-packaged in polyethylene bags and stored at −70 °C. Details on animal husbandry and on the effects of lipid supplementation on fatty acid composition of meat are published elsewhere (Bessa et al., 2007). Samples from five lambs of each treatment were submitted to irradiation according to the procedure described below.

2.3. Meat irradiation

Irradiation was conducted at the CHIP – Centro de Higienização por Ionização de Produtos, installed in ITN – Instituto Tecnológico e Nuclear (Sacavém, Portugal),