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Changes in fatty acids and polar material of restructured low-fat or walnut-added steaks pan-fried in olive oil

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Abstract

The study aims to determine the influence of pan-frying on the fatty acid composition and fat content and alteration of functional restructured beef steaks. Low-fat (*L*, 2% fat), 20% walnut-added (*W*, 13% fat) and medium fat (*M*, 13% fat) steaks were prepared and fried in extra virgin olive oil. Pan-frying increased fat in *L* and *W* steaks and decreased it in *M* ones. Raw *L* and *M* steaks showed similar fatty acid profiles while *W* ones contained a lower percentage of saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) but a higher percentage of polyunsaturated fatty acids (PUFA). The fatty acid profile of fried steaks was between that of the raw steaks and olive oil. Several fatty acids (g fatty acid/100 g edible steaks) were affected ($p < 0.001$) by the frying × meat-formulation interaction. Linoleic and linolenic acid contents did not decrease in fried *W* steaks, but decreased ($p < 0.05$) when data were expressed on a dry matter basis.

Frying increased SFA, MUFA and ω-6 PUFA contents in *L* samples while it decreased SFA and increased ω-6 PUFA in *M* steaks. Before and after frying, *W* steaks had atherogenic and thrombogenic indexes at least three times lower than their counterparts. Both indexes decreased in fried *L* samples while only the AI in *M* ones. Polar material content (PM) increased only in *L* samples. No relevant differences were found between PM of the fried steaks and that of their corresponding used oils. Results suggest that pan-frying improves the fatty acid composition of *L* and *M* steaks with minor changes in PM. The high retention of lipids observed in the *W* samples permits consumption of ω-3 PUFA- and ω-6 PUFA-enriched meat with a very low content of alteration compounds.

Keywords: Meat; Functional foods; Walnut; Fatty acids; Olive oil; Pan-frying; Polar material

1. Introduction

There exists epidemiological evidence relating meat consumption with degenerative disease (BNF, 1990; Higgs, 2000; Key, Allen, Spencer, & Travis, 2002). This has led to efforts to obtain low-fat meat and meat derivatives. Moreover, meat appears to be an adequate vector for functional ingredients to obtain meat derivates with potential functional effect (Fernández Ginés, Fernández-López, Sayas-Barberá, & Pérez-Alvarez, 2005; Jiménez-Colmenero, Carballo, & Cofrades, 2001; Jiménez-Colmenero, Reig, & Toldrá, 2006).

Given the unique combination of nutrients and phytochemicals in walnuts (Kris-Etherton, 1999; Nus, Ruperto, & Sánchez-Muniz, 2004), restructured beef steaks formulated with walnut display acceptable physicochemical and sensory properties (Jiménez-Colmenero et al., 2003) and frozen storage stability (Serrano, Cofrades, & Jiménez-Colmenero, 2006). Furthermore, our research group (Canales et al., 2007) has found that consumption of walnut-enriched meat improved the antioxidant profile of volunteers at increased CHD risk.

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Abbreviations

AI	atherogenic index	MUFA	monounsaturated fatty acids
L	low-fat restructured meat	FR	fat retention
M	medium fat restructured meat	SFA	saturated fatty acids
PM	polar material	TI	thrombogenic index
PUFA	polyunsaturated fatty acids	*W*	walnut enriched restructured meat

As is the case with other meat products, restructured beef steaks should undergo cooking prior to consumption. Deep-fat frying and pan-frying are two cooking methods used throughout the world as they are quick and produce food with appealing characteristics (Sánchez-Muniz, 2006). It has been extensively showed that during frying a two-way fat exchange between the frying medium and the meat is known to take place (Dobarganes, Marquez-Ruiz, & Velasco, 2000; Sánchez-Muniz, 2006). Thus, undesirable changes, including thermal oxidation (Dobarganes et al., 2000; Romero, Bastida, & Sánchez-Muniz, 2007; Sánchez-Muniz, 2006) may occur in the frying oil and food fat when using this cooking method. Furthermore, due to the uptake of oil by food during frying, thermal oxidation compounds in the frying medium and the fried food are normally quite similar (Dobarganes et al., 2000; Romero et al., 2007; Sebedio, Bonpunt, Grandgirard, & Prevost, 1990).

Although several studies have been designed to investigate the changes in the proximate and fatty acid compositions of some meat products caused by frying (Candela, Astiasaran, & Bello, 1996; Capita et al., 2003; Clausen & Ovesen, 2005), very few studies have been performed to investigate fatty acid and thermal oxidation changes in pan-fried low/medium-fat functional meat or walnut-added meat.

Our research group has studied the changes produced in the proximate composition and physicochemical properties of restructured beef steaks containing walnut that were cooked using different procedures (e.g. pan-frying) (Serrano, Librelotto, Cofrades, Sánchez-Muniz, & Jiménez-Colmenero, 2007). This study aims to determine the effect of pan-frying under domestic conditions on: (i) the fatty acid profile and absolute fatty acid content, (ii) the retention of specific fatty acid groups after frying and (iii) the thermal oxidation of potentially functional restructured low-fat (*L*) and 20% walnut-added (*W*) beef steaks, in comparison to that of medium-fat restructured steaks (*M*). Moreover, the thermal oxidation that occurred during frying in the restructured meats and in the frying oil was evaluated and compared.

2. Materials and methods

2.1. Preparation of products

Select beef top rounds were trimmed of visible fat and connective tissue and cut into strips (approx. $5 \times 4 \times 20$ cm). Lots of clean beef top rounds weighing approximately 1.2 kg each were vacuum-packed, frozen and store at −20 °C until use. Beef fat was passed once through a grinder (Mainca, Granollers, Spain) with a 0.6 cm plate and portions weighing approximately 0.5 kg were vacuum-packed, frozen at −20 °C and stored at that temperature until use.

Data on restructured steak preparation and the additives used were similar to those employed previously (Serrano, Cofrades, & Jiménez-Colmenero, 2004; Serrano et al., 2007). In short, meat and fat packages were thawed (approximately 18 h at 3 ± 2 °C, reaching between −3 and −5 °C and passed once through a grinder (Mainca, Granollers, Spain) with a 2 cm plate. Three different types of restructured beef steaks, low-fat (*L*), medium-fat (*M*) and 20% walnut-added (*W*) were formulated. Once prepared, restructured steaks (140 ± 3 g; 1.0 ± 0.05 cm thick) were packed individually in vacuum bags (Cryovac® BB4 L, oxygen permeability 30 $cm^3\ m^{-2}\ 24\ h^{-1}$ at 23 °C, 0% RH and 1 bar) and stored at -18 ± 2 °C until used (within the first three weeks after production).

2.2. Frying performance

Three thawed restructured beef steaks per formulation were used. Steaks were pan-fried in 25 ml of olive oil (extra virgin olive oil, Carbonell, Sos, Cuetara S.A., Madrid, Spain) for 5 min at a starting temperature of 170 °C (2 min 30 s per side) in a domestic 24 cm-diameter frying pan. Frying was finished when the steak core reached a temperature of 70 °C, determined beforehand by a datalogger (EBI-2T-211, Ebro Electronic GmbH & Co. Ingoldstadt, Germany).

Following pan-frying, all restructured steaks were cooled to room temperature (20–22 °C) for 30 min and immediately analyzed.

2.3. Moisture and fat content and fatty acid profile

Moisture was determined in three steaks according to the AOAC method (2000). Meat fat was extracted by the by Bligh and Dyer method (1959). Samples of the oils and extracted fats were saponified for 30 min at 60 °C with 40 ml/g 0.5 M NaOH in methanol and then methylated with boron trifluoride–methanol complex to achieve complete conversion to methyl esters (IUPAC, 1992). The methyl esters were extracted into hexane, freed of moisture over anhydrous sodium sulphate and dried under nitrogen.