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# Effect of cooking on the chemical composition of low-salt, low-fat Wakame/olive oil added beef patties with special reference to fatty acid content

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ABSTRACT

Changes in chemical composition, with special reference to fatty acids, as affected by cooking, were studied in low-salt (0.5%)/low-fat patties (10%) with added Wakame (3%) and partial or total replacement of pork backfat with olive oil-in-water emulsion. The addition of Wakame and olive oil-in-water emulsion improved ($P<0.05$) the binding properties and the cooking retention values of moisture, fat, fatty acids and ash, which were close to 100%. Partial and total replacement of animal fat with olive oil-in-water emulsion reduced ($P<0.05$) saturated fatty acids (SFAs), while total replacement also reduced ($P<0.05$) polyunsaturated fatty acid (PUFAs) contents. The fatty acid concentration in cooked patties was affected by product formulation. Unlike the case of all animal fat patties, when olive oil was added the cooking process increased ($P<0.05$) SFAs, monounsaturated fatty acids (MUFAs) and PUFA n−3 (linolenic acid) and n−6 (linoleic acid) contents. Cooked formulated patties with seaweed and partial or total replacement of pork backfat by oil-in-water emulsion and with seaweed added were less calorie-dense and had lower SFAs levels, while samples with olive oil had higher MUFAs levels.



## 1. Introduction

Meat and meat products are important sources of many essential nutrients and contribute considerable proportions of the dietary intakes of various nutrients that are essential for optimal growth and development. However, consumption of some meat constituents (e.g. fat, saturated fatty acids—SFAs, cholesterol, and sodium) has been associated with a higher risk of major chronic diseases (e.g. ischemic heart disease, cancer, hypertension and obesity) (Hulshof et al., 1999; McAfee et al., 2010; Williamson, Foster, Stanner, & Buttriss, 2005). Changes in consumer demand and growing market competition have prompted a need to improve the quality and image of meat and meat products through the development of products with beneficial-health properties. This approach is of particular interest in the case of products like burgers or patties, since they are common meat products, widely accepted in certain population groups, and it is possible to easily induce changes of composition to improve their nutritional value and their beneficial-health properties (López-López, Cofrades, Yakan, Solas, & Jiménez-Colmenero, 2010).

Because seaweeds are potential sources of some nutrients and bioactive phytochemicals, recent reports suggest that their use as food ingredients opens up new possibilities for the development of functional foods (Bocanegra, Bastida, Benedi, Rodenas, & Sanchez-Muniz, 2009; Fleurence, 1999), including meat-based functional foods (Cofrades, López-López, Solas, Bravo, & Jiménez-Colmenero, 2008). Different seaweeds have been used in the formulation of various types of meat products (Chun, Park, Park, Suh, & Ahn, 1999; López-López, Cofrades, & Jiménez-Colmenero, 2009; López-López, Cofrades, Ruiz-Capillas, & Jiménez-Colmenero, 2009). Wakame (*Undaria pinnatifida*) seaweed is particularly promising as a meat ingredient due to its composition (dietary fiber, minerals, etc.) and technological properties (Cofrades et al., 2008; López-López, Cofrades, & Jiménez-Colmenero, 2009).

Lipids are among the bioactive components (functional ingredients) that have received most attention, particularly in connection with the development of healthier meat products (Jiménez-Colmenero, 2007). Although Wakame has a healthier lipid profile, in view of its low lipid content, addition of this whole seaweed to meat products does not cause any appreciable improvement in their lipid profiles (López-López, Bastida, et al., 2009). Therefore other strategies are necessary to produce healthier lipid formulations in meat products. Healthier lipid meat products have been developed by substituting animal fat with vegetable oils to produce a food more in line with health recommendations. This entails reducing SFAs and cholesterol and increasing monounsaturated fatty (MUFAs) and polyunsaturated fatty acids (PUFAs). Of vegetable oils, olive is the one that has received most attention, chiefly as a source of MUFAs (mainly oleic acid). Partial substitution (in various percentages) of pork backfat by olive oil (as a liquid or as an oil-in-water emulsion) has been tried in various cooked and cured meat products (Bloukas & Paneras, 1993; Koutsopoulos, Koutsimanis, & Bloukas, 2008; Lurueña-Martínez,

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Vivar-Quintana, & Revilla, 2004; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001; Paneras & Bloukas, 1994).

In this context, healthier low-salt (0.5%), low-fat (10%) beef patties with added Wakame seaweed (3%) and partial or total replacement of pork backfat with an olive oil-in-water emulsion were formulated (López-López et al., 2010). The results showed that Wakame can be used as a potential functional ingredient in low-salt beef patties to overcome the technological and sensory problems associated with low-salt products. Also, Wakame supplies fortified patties with considerable amounts of dietary fiber (~6% of the recommended daily dietary fiber intake in 100 g of product) and minerals such as Ca, Mg and K (>15% recommended daily amount in 100 g) while maintaining a normal Na content and a low Na/K ratio. Replacement of pork backfat by olive oil emulsion improved the appearance and juiciness of the patties, while on the nutritional side the resulting product was healthier in terms of the quality of the fat. The benefits of replacing SFAs with MUFAs derive from the fact that some SFAs (<18-carbon atoms chain length) raise total blood cholesterol and low-density lipoprotein (LDL) levels, which are associated with a high risk of cardiovascular disease, while MUFAs reduce the level of plasma LDL cholesterol without depressing the strong anti-atherogenic activity of HDL-cholesterol lipoproteins (Mattson & Grundy, 1985). Also, these products presented good technological, sensory and nutritional properties.

Beef patties, like other foods, will normally be cooked prior to consumption, and that in itself may affect composition. Varying amounts of different meat components (water, fat, and minerals) are lost during cooking of meat products, and these losses can significantly affect fat (fatty acid content) consumption and energy intakes (Badiani et al., 2002; Librelotto et al., 2008; Serrano, Librelotto, Cofrades, Sánchez-Muniz, & Jiménez-Colmenero, 2007; Sheard, Nute, & Chappell, 1998). Although olive oil has been added to pork patties in liquid form (Hur, Jin, & Kim, 2008) and to beef patties stabilized in an oil-in-water emulsion (López-López et al., 2010), no reports dealing with the effect of cooking on the chemical composition of these kinds of reformulated products could be found. Cooking-induced modifications need to be considered to achieve a more realistic assessment of the potential nutritional/functional benefits of foods, and particularly of healthier meat products.

The objective of this study was to determine how cooking affects the chemical composition, with particular reference to the fatty acid profile, of low-salt (0.5%), low-fat (10%) beef patties with added Wakame seaweed (3%) and partial or total replacement of pork backfat with olive oil-in-water emulsion.

## 2. Materials and methods

### 2.1. Raw materials and beef patty preparation

Lean beef (moisture 74%, protein 21%, fat 3.5% and ash 1.3%), pork backfat (moisture 7.32%, protein 3.97%, and fat 88.70%), Wakame seaweed (*U. pinnatifida*), olive oil (13% SFAs, 79% MUFAs and 8% PUFAs) and the other additives used in the formulations were described by López-López et al. (2010). The Wakame composition (protein 11%, fat 1.0% and ash 37% on dry matter; 39% SFAs, 15% MUFAs and 46% PUFAs) was reported by Cofrades et al., 2008.

The formulated beef patties were those described by López-López et al. (2010). Six different products (Table 1) were prepared to obtain 16.5% meat protein (from both lean beef and pork backfat) in all treatments. Pork backfat was added to the control sample (C) to give 10% fat content (all animal fat from meat and pork backfat). In order to achieve a healthier lipid formulation, pork backfat was partially or totally replaced with olive oil-in-water emulsion. Partial replacement samples (PE) were formulated with 5% animal fat and 5% olive oil-in-water emulsion; total replacement samples (TE) were formulated with 10% olive oil-in-water emulsion (no pork backfat added). Three additional samples were manufactured with the same lipid formulation, and 3% (dry matter) added Wakame seaweed (W, WPE and WTE). All products were made with 0.5% NaCl.

The formulated patties (85 g) were placed in plastic bags (Wipak7-gryspeert, PAE 110KFP), frozen at −25 °C in a Sabroe "Benjamin" model horizontal plate freezer (Hanst-Moller, Germany), vacuum packed and stored at −20 ± 2 °C until analysis (within 2 weeks of preparation).

### 2.2. Cooking method and thawing and cooking losses

Eight patties from each formulation were thawed (15 h, 2 °C ± 2) and manually wiped with a paper towel to remove visible exudates. The thawing loss (TL) was calculated as the weight difference between initial and thawed samples, expressed as a percentage of the initial weight. Four patties were wrapped in aluminum foil and cooked for 10 min in a forced air oven (Rational CM6, Groβküchentechnik GmbH, Landsberg a. Lech) at 170 °C to bring the temperature at the center of the product to 70 °C (López-López et al., 2010). These cooking conditions were previously standardized for temperature by inserting thermocouples connected to a temperature recorder (Yokohama Hokushin Electric YEW, Mod. 3087, Tokyo, Japan). The cooked patties were weighed again to measure the cooking loss (CL, %) by difference.

### 2.3. Proximate composition and energy content

Proximate analyses were carried out on raw and cooked formulated patties in triplicate. Moisture and ash (AOAC, 2000) and protein contents (LECO FP-2000 Nitrogen Determinator, Leco Corporation, St Joseph, MI, USA) were evaluated. Fat content was determined by a modified procedure of Bligh and Dyer (1959) (Hanson & Olley, 1963). Energy content (kcal) was calculated based on 9 kcal/g for fat, 4 kcal/g for protein, and 2 kcal/g for dietary fiber (RD 930/1992; RD 1669/2009).

### 2.4. Fatty acid profile

The lipid extracts of the raw and cooked formulated patties were analyzed by gas chromatography to determine fatty acid contents. The method of Morrison and Smith (1964) was used to obtain the fatty acid methyl esters (FAMEs), using 14% boric trifluoride in methanol. Chromatographic analysis of FAMEs was performed using a Perkin-Elmer gas chromatograph (Perkin-Elmer, USA) equipped with a split–splitless injector and a flame ionization detector (FID), using a fused silica capillary column (0.32 mm internal diameter and 30 m long). The mobile phase consisted of helium C-50 at a flow of 9 psig. Fatty acids were identified using Sigma reference standards. Quantification was done as reported (López-López, Cofrades, Ruiz-Capillas, et al., 2009).

In order to evaluate the risk of atherosclerosis and/or thrombogenesis, the atherogenic (AI) and thrombogenic indexes (TI) were calculated, on

**Table 1**
Formulated beef patties containing different combinations of pork backfat, olive oil emulsion, Wakame, NaCl and water (g).

| Sample | Meat | Backfat | Olive oil-in-water emulsion | Wakame[a] | NaCl | Water |
|---|---|---|---|---|---|---|
| C | 4943.4 | 446.4 | 0 | 0.0 | 30 | 580.2 |
| PE | 4972.8 | 242.4 | 300 | 0.0 | 30 | 454.8 |
| TE | 4999.8 | 0.0 | 600 | 0.0 | 30 | 370.2 |
| W | 4943.4 | 446.4 | 0 | 199.3 | 30 | 380.9 |
| WPE | 4972.8 | 242.4 | 300 | 199.3 | 30 | 255.5 |
| WTE | 4999.8 | 0.0 | 600 | 199.3 | 30 | 170.9 |

C, control patty; PE, patties formulated with partial substitution of pork backfat by olive oil-in-water emulsion; TE, patties formulated with total substitution of pork backfat by olive oil-in-water emulsion; W, patties formulated with added Wakame; WPE, patties formulated with partial substitution of pork backfat by olive oil-in-water emulsion and added Wakame; WTE, patties formulated with total substitution of pork backfat by olive oil-in-water emulsion and added Wakame.

[a] The Wakame was added at 3% dry matter.