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Oak wood extracts as natural antioxidants to increase shelf life of raw pork patties in modified atmosphere packaging

A. Soriano[a], M.E. Alañón[b,*], M. Alarcón[a], A. García-Ruíz[a], M.C. Díaz-Maroto[a,b], M.S. Pérez-Coello[a]

[a] *Area of Food Technology, Faculty of Chemical Sciences and Technologies, University of Castilla-La Mancha, Avda. Camilo José Cela, 10, 13071 Ciudad Real, Spain*
[b] *Regional Institute for Applied Scientific Research (IRICA), University of Castilla-La Mancha, Avda. Camilo José Cela, 10, 13071 Ciudad Real, Spain*

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ABSTRACT

The use of antioxidants and refrigeration storage in modified atmosphere packaging, MAP, are the main strategies to slow down the oxidative and microbial deterioration of fresh meat. Synthetic antioxidants are commonly used for this purpose, however due to their controversial health effects, natural alternatives for their replacement are being looked for. The main aim of this work is the evaluation of pressurised aqueous extracts from oak wood as natural preservative of pork patties. The effect of different amounts of oak wood extracts (0.05, 0.5 and 1.0%) on the self-life of pork patties packed in MAP in refrigeration during 12 days were studied in comparison with the use of sodium ascorbate as synthetic preservative. Samples treated with oak wood extracts showed lower lipid oxidation, higher antioxidant capacity and an inhibitory effect on the enterobacteria growth. Furthermore, the addition of oak wood extracts resulted in a dramatically decrease of the volatile compounds coming from the lipid oxidation reactions. On the other hand, it is noteworthy that the use of oak wood extracts modified sensorial characteristics. Intensity colour was higher and new sensorial features such as oak wood and sweet spices appeared which were well appreciated.

1. Introduction

One of the major causes of quality deterioration of meat are the microbial spoilage and the oxidative phenomena. Lipid oxidation is the main reaction produced, however oxidation deterioration also affect to proteins, pigments, vitamins and carbohydrates which entails nutrient and organoleptic quality losses reducing meat products self-life (Kanner, 1994).

The higher proportion of unsaturated fatty acids in the triglycerides of pork, the different processing stages of meat products (crushing, mixing, fat addition….) and the packing in atmospheres rich in oxygen, make oxidative processes more prone to be developed in pork patties packed in modified atmosphere packing (MAP) than in other meat products. Synthetic antioxidants such as butylated hidroxyanisole (BHA), butylated hidroxytoluene (BHT), tert-butylhydroquinone (TBHQ), ascorbate or sulphites are commonly added to fresh and further processed meats to prevent oxidation reactions. However, due to their potential adverse health effects, interest in looking for alternative antioxidants from natural sources has been increased dramatically during the last decade (Naveena, Sen, Vaithiyanathan, Babji, & Kondaiah, 2008; Nunez de Gonzalez et al., 2008).

Fruits, spices, herbs and other plant material are rich in phenolic compounds which are capable of inhibit oxidation reaction by scavenging free radicals, chelating prooxidative metals, quenching singlet oxygen and photosensitizers, and inactivating lipoxygenase (Choe & Min, 2009; Shah, Bosco, & Mir, 2014). The antioxidant properties of a huge number of natural extracts from vegetal matrices in meat products have been tested (Karrer, Lopez, & Gelly, 2013; Shah et al., 2014). Among them, rosemary extract, due to its antioxidant effects higher than those exhibited by synthetic ones, was approved as new additive for use in foodstuffs by the European Union (Directive 95/2/EC). On the other hand, commercial extracts from pinewood (Pycnogenol®) exhibited notable antioxidant and antimicrobial effects in cooked beef meat (Ahn, Grun, & Fernando, 2002; Ahn, Grun, & Mustapha, 2007).

In the last years, the revalorization of agricultural food processing waste has aroused great interest since in many cases these residues are natural sources of valuable compounds. The use of emerging green technologies has allowed the sustainable extraction of target compounds by means innocuous solvents, even water in the case of pressurised liquid extraction (PLE), which facilities the application of these extracts in food industry (Chemat, Abert Vian, & Cravotto, 2012; Heng,

* Corresponding author.
E-mail address: mariaelena.alanon@uclm.es (M.E. Alañón).

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Tan, Hong Yong, & Ong, 2013). Some by-products from chestnut, pomegranate and avocado have been evaluated as natural source of antioxidants and antimicrobial compounds to increase the self-life of refrigerated raw patties (Andrés, Petrón, Adámez, López, & Timón, 2017; Lorenzo, Sineiro, Amado, & Franco, 2014; Rodríguez-Carpena, Morcuende, & Estévez, 2011; Turgut, Isikci, & Soyer, 2017). But probably, oenological industry entails the main niche of by-products generation rich in natural phenolic compounds with antioxidant and antimicrobial functionalities (Bañón, Díaz, Rodríguez, Garrido, & Price, 2007; García-Lomillo, González-San José, Del Pino-García, Ortega-Heras, & Muñiz-Rodríguez, 2017; García-Lomillo, González-San José, Skibsted, & Jongberg, 2016; Garrido, Auqui, Marti, & Linares, 2011; Poveda, Loarce, Alarcón, Díaz-Maroto, & Alañón, 2018).

In the field of oenology, oak wood is used for the manufacturing of wooden barrels where wines undergo the chemical modifications during ageing stage. However, during the barrels manufacturing, a large amount of residues, around 80%, are generated (Tonnellerie Vicard, 2012). This great quality oak wood is characterized by high amounts of polyphenolic compounds such as ellagitannins which are regarded as important bioactive polyphenols (Quideau, 2009). The antioxidant and antimicrobial properties of oak wood have been reported recently (Alañón, Castro-Vázquez, Díaz-Maroto, Gordon, & Pérez-Coello, 2011; Alañón, Castro-Vázquez, Díaz-Maroto, Hermosín-Gutiérrez, Gordon, & Pérez-Coello, 2011; Alañón, García-Ruiz, Díaz-Maroto, Pérez-Coello, & Moreno-Arribas, 2015). However, to the best our knowledge, the replacement of synthetic preservatives by oak wood extracts to be used in meat products as source of natural antioxidant and antimicrobial compounds has not been evaluated yet. On the other hand, it is worthy to note that oak wood also contains large quantities of volatile compounds such as oak lactones, vanillin, or eugenol among others which are responsible of the pleasant sensorial features described as coconut, vanilla, nutty, toasty….(Alañón, Díaz-Maroto, & Pérez-Coello, 2012; Pérez-Coello & Díaz-Maroto, 2009). Therefore, the use of oak wood extracts not only could be interesting from the oxidative and microbial deterioration point of view but also from the enhancement of sensorial characteristics.

In this sense, the multitargeted role of pressurised aqueous extracts from oak wood in replacement of synthetic preservatives in meat products is postulated. With this aim, the antioxidant activity and antimicrobial capacity of oak wood extracts to increase the self-life of pork patties packed in MAP was evaluated. In order to estimate the potential activity of oak wood, three percentages were tested (0.05%, 0.5% and 1.0%) and compared to a control formulation (only pork patties) and control with synthetic preservative (sodium ascorbate) during a period of 12 days. The analysis of volatile compounds of pork patties and their monitorization during the storage time were also performed as well as the sensorial evaluation.

2. Materials and methods

2.1. Samples

2.1.1. Meat raw materials and ingredients

Pork meat (*Longissimus dorsi* muscle) and fresh pork backfat were obtained from a local market (Ciudad Real, Spain). These raw materials were achieved from 6 females slaughtered at the age of 10 months and with 80–85 kg of carcass weight after 24 h at 4 °C. A total of 2 loins, with weights between 4.0 and 4.3 kg, and 1.5 kg of pork backfat obtained from the same females, were used in each elaboration replicate. The others ingredients used in the formulation were mineral water, sodium chloride and sodium ascorbate (Panreac Química, S.A., Barcelona, Spain).

2.1.2. Aqueous oak wood extracts

Aqueous extracts were obtained by pressurised liquid extraction (ASE 200, Dionex Corp. Sunnyvale, CA) with subcritical water (Alañón, Alarcón, Marchante, Díaz-Maroto, & Pérez-Coello, 2017). American oak wood (*Quercus alba*) chips as cooperage by-product were used (Tonelería Magreñán, La Rioja, Spain). Two grams of wood sawdust were mixed with 500 mg of diatomaceous earth, used as dispersing agent to reduce the dead volume of a 11 mL stainless steel cell. Extraction conditions were as follow: temperature 120 °C, pressure 1500 psi, two extraction cycles of 10 min. To avoid possible contaminations, the extraction system was rinsed between samples. The extracts were freeze-dried under vacuum (1.1×10^{-2} mbar) for 24 h, at a condenser temperature of −53.2 °C. Once freeze-dried, the extracts were vacuum packed and stored in a desiccator until their use. Oak wood extract was characterized using the methodology proposed by Alañón et al., 2017, whose chemical composition is shown Table 1.

Table 1
Chemical composition of pressurised oak wood extracts used in the manufacturing of burger patties. Mean content and standard deviation of volatile compounds, total phenol index and radical scavenging activity (n = 2).

		Oak wood extract
Volatile compounds (μg/L)	Benzenic compounds	
	Guaiacol	6.19 ± 0.14
	Benzyl alcohol	5.07 ± 0.04
	Phenylethyl alcohol	49.56 ± 38.92
	Eugenol	72.592 ± 4.02
	Syringol	20.67 ± 0.42
	vanillin	348.67 ± 19.77
	Lactones	
	trans-β-methyl-γ-octalactone	74.86 ± 4.41
	cis-β-methyl-γ-octalactone	625.13 ± 35.93
	Furanic compounds	
	Furfural	61.17 ± 5.25
	5-Hydroxymethylfurfural	105.27 ± 13.12
Total phenol index ($mg_{gallic\ acid\ equivalents}$/L)	TPI	2180.8 ± 36.20
Radical scavenging activity ($mmoles_{Trolox\ equivalents}$/L)	DPPH	31.20 ± 5.66
	ABTS	32.00 ± 3.39

2.1.3. Manufacture of burger patties

Five different types of burger patties were prepared starting from a basic formulation: 71% pork meat, 15% pork backfat, 13% water and 1% sodium chloride. First, pork meat and backfat were minced separately in an Unger W-98 table-top mincer (Andher, Campo de Criptana, Spain) with an 8 mm plate. Then, sodium chloride dissolved in water was added and the mixture was mixed manually for 3 min. This mixture was divided into five batches: one was used as control (C) once 10% of water was added to complete its formulation; to the remaining four batches were added 400 ppm of sodium ascorbate (AC), and 0.05%, 0.5% and 1.0% of freeze-dried oak wood extract (W1, W2, W3), respectively. Both sodium ascorbate and freeze-dried extracts were dissolved in water (10% of the total) before their utilization. After kneading each mixture for 2 min, pork patties were formed using a conventional burger-maker (100 g/patty), to give dimensions of 8.5 × 11.5 × 1.5 cm. Each burger patty was individually packed in thermoformed polypropylene plastic containers (16.45 × 11.85 cm and 460 mL capacity), heat sealed by a transparent top film (polyamide 15 and polypropylene 50), and in modified atmosphere (80% O_2 and 20% CO_2, Aligal 27, Air Liquide, Madrid, Spain), using an Orved packing machine (Andher, Alcázar de San Juan, Ciudad Real, Spain). In order to simulate the conditions of sale in the market, burger patties were stored in a vertical display with transparent glass doors and provided with white light lamps (150 lm) (Pecomark, Barcelona, Spain) for 12 days at 4 °C, and with 12 h/day of exposure to light. A total of 12 burger patties were taken into account per each treatment. Three burger patties were sampled at 0, 4, 8 and 12 days of chilled storage, one of them to carry out microbial and physicochemical analysis, and the other two patties