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Antioxidant effect of seasonings derived from wine pomace on lipid oxidation in refrigerated and frozen beef patties

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ABSTRACT

This work evaluates the ability of three different seasonings (obtained from wine pomace) to inhibit lipid oxidation in raw and cooked beef patties. Seasonings were incorporated to beef patties recipe as other solid ingredient at the level of 2 g/100 g. The storage conditions assayed were: refrigeration (4 °C, 15 days) with high-oxygen atmosphere (70% O_2, 30% CO_2) and freezing (−18 °C, 6 months). Two independent experiments with 3 replicates were carried out. Furthermore, the inhibitory effect on lipid oxidation was compared with the effectiveness of sulfites, an antioxidant widely used in the meat industry. Both types of storage significantly induced increases of thiobarbituric acid reactive substances (TBARS) and volatile organic compounds (VOCs) (hexanal, 1-pentanol, 1-hexanol, 1-octen-3-ol, 2,3-octanedione, and 2-pentylfuran) measured with gas chromatography–mass spectrometry (p-value < 0.05). The three seasonings showed different effectiveness to inhibit lipid oxidation under the three conditions studied, being the seasoning made from seedless wine pomace the most effective. This seasoning significantly inhibited the formation of VOCs, revealing their potential capacity to delay the formation of rancid odors during storage of meat products. Samples with sulfites presented contrary results respect to TBARS levels, which were reduced in refrigerated samples but promoted in the frozen patties.

1. Introduction

Lipid oxidation is one of the major factors that limit the shelf-life of meat products. It involves the formation of hydroperoxides that are easily broken down to different volatile organic compounds (VOCs) such as alkanes, alkenes, aldehydes, ketones, alcohols, esters, and acids causing rancid and unpleasant flavors and reducing the sensorial quality of meat products (Frankel, 1983; Kanner, 1994). Meat products are extensively affected by lipid oxidation, as they usually contain high levels of fat and pro-oxidants such as salt. Furthermore, processes such as grinding or cooking also decrease the stability against lipid oxidation, due to structural degradation and the release of pro-oxidants (Alfawaz, Smith, & Jeon, 1994; Kanner, 1994). High-oxygen atmosphere, used in the meat industry to retain a bright red color, also accelerates the process of lipid oxidation and the appearance of off-flavors (Zhao, Wells, & McMillin, 1994).

The development of a global meat market and the increase of distance between producers and consumers have increased the use of freezing as a preservation technique (Leygonie, Britz, & Hoffman, 2012). Low temperatures and low levels of available water drastically reduce microbial and chemical reactions, thereby extending the shelf-life of these products. However, freezing also modifies the homeostasis of the meat system, due to the cryoconcentration of solutes in the unfrozen phase. These changes may damage cell membrane leading to leakage of intracellular pro-oxidants such as lipases and metals, affecting the chemical stability of the product (Leygonie et al., 2012). Moreover, the catering and retail sector is increasingly interested in ready-to-eat foods that can be stored over long periods. Some consumers also prefer cooked products due to their convenience and their shorter preparation times. However, storage of cooked products is usually linked to extensive lipid oxidation and the development of the unpleasant “warmed-over flavor” (Carpenter, O'Grady, O'Callaghan, O'Brien, & Kerry, 2007; Igene, Pearson, Merkel, & Coleman, 1979).

Several chemical additives can be used to inhibit lipid oxidation

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and consequently extend the shelf-life of meat products (Cornelius & Lilian, 2005). For instance, sulfites, which are mainly applied in meat products as antimicrobial agents, although they also exert an important function as antioxidant. However, sulfites consumption has been linked to allergic reactions and safety concerns over their long-term consumption have yet to be clarified (Cornelius & Lilian, 2005). Moreover, consumer rejection of chemical additives is growing and the food industry is constantly looking for natural additives. Natural products, such as spices and plant extracts, have been proposed as natural antioxidants to replace the use of chemical additives (Brewer, 2011; Lindberg Madsen & Bertelsen, 1995; Yanishlieva, Marinova, & Pokorný, 2006).

New seasonings with interesting nutritional and technological properties (rich in fiber, minerals and antioxidants) derived from wine pomace have been recently patented (García-Lomillo, González-SanJosé, Del Pino-García, Rivero-Pérez, & Muñiz-Rodríguez, 2014; González-SanJosé, García-Lomillo, Del Pino-García, Dolores-Rivero, & Muñiz-Rodríguez, 2015). According to the fact that spices and seasonings are usual ingredients of beef patties recipes, the main aim of this work was to study the potential of three red wine pomace seasonings (RWPSs) to retard or inhibit lipid oxidation in beef patties stored under different conditions (raw refrigerated under high-oxygen atmosphere, raw and cooked frozen vacuum-packaged patties), comparing their antioxidant effect with the antioxidant capacity of sulfites.

2. Materials and methods

2.1. Material

A mixture of different beef meat cuts, especially prepared for hamburger elaboration, was obtained from a local supplier (Gros Mercat, Burgos, Spain). Different batches were purchased for each experience. Common salt, food grade starch and a commercially available mixture of phosphates were provided by Doscadesa (Murcia, Spain) and sodium metabisulfite ($Na_2S_2O_5$) (Panreac, Barcelona, Spain) were used in the formulation of beef patties. The seasonings under study were prepared at the pilot plant of the Food Technology Department of the University of Burgos (Spain), following the patented process described by González San José et al. (2015). Briefly, WRWPS (whole red wine pomace seasoning) was made from dehydrated red wine pomace (drying in air oven), and to obtain SdRWPS, (seed red wine pomace seasoning) and SkRWPS (skin red wine pomace seasoning), seeds were separated from dehydrated wine pomace by sifting. The three different seasonings are the powdered products (particle sizes of less than 0.250 mm (SkRWPS and WRWPS) and 0.355 mm (SdRWPS)) obtained by successive milling-sieving process to the three cited raw materials: the whole and seedless red wine pomace and the separated seeds (García-Lomillo et al., 2014).

For lipid oxidation assessment, perchloric acid was purchased from VWR International (Barcelona, Spain), and 2-thiobarbituric acid, cyclopentanone, dichloromethane, hexanal, 1,1,3,3-tetraethoxypropane were purchased from Sigma (St. Louis, USA).

2.2. Patty preparation

Control beef patties were prepared by mixing 920 g of previously chopped and minced meat, 12 g of potato starch and 50 mL of water in which 3 g of a commercially available mix of food grade phosphates had previously been dissolved, and the corresponding quantity of salt to obtain a final concentration of 1.5 g of salt per kg of patty. Sulfite samples were similarly prepared by adding the corresponding quantity of sodium metabisulfite to obtain a final concentration of 300 mg of SO_2 per kg of patty (300 ppm). Beef patties with seasonings were formulated in the same way, using the corresponding amount of seasoning to obtain a final concentration of 2 g/100 g. This level was in agreement with previous studies in which the consumers' acceptance of patties made with different levels of the seasonings was assayed (González-SanJosé et al., 2014). Briefly, the addition of 2 g of seasoning by 100 g of patty was accepted since it did not induce significant modification of odor, taste, and mouthfeel sensations, although color was significantly modified.

Furthermore, the promising effect observed against protein oxidation was also considered (Garcia-Lomillo, González-SanJosé, Skibsted, & Jongberg, 2016).

Ingredients were mixed in a food processor for 5 min and patties of 100 g were manually formed and packaged, or cooked and then packaged. Cooked samples were processed according to the procedure described by Carpenter et al. (2007) in a fan-assisted oven (Berto's, Padova, Italy) previously heated at 180 °C, until an internal temperature of 72 °C was reached (8 min), and subsequently maintained for 8 min.

Raw patties were stored under two different conditions, high-oxygen atmosphere (70% O_2/30% CO_2) and refrigeration, and vacuum packing and freezing. In the high-oxygen atmosphere, samples were packaged in trays of polyethylene/ethylene vinyl alcohol/polystyrene (Sanviplast, Barcelona, Spain) with permeability to oxygen of 0.99 $cm^3/(m^2$ day atm). They were then sealed using a polyethylene terephthalate polyvinylidene chloride/polyethylene film with an oxygen permeability of 7 $cm^3/(m^2$ day atm) (Amcor, Burgos, Spain). The vacuum-packaged samples (raw and cooked), were sealed in polyamide/polyethylene bags (20/70 μm) (Vacioplast, Salamanca, Spain) with an oxygen permeability lower than 40 $cm^3/(m^2$ day atm). The samples were frozen using a conventional freezer working at −30 °C and stored over 6 months at −18 °C. Sampling of the refrigerated patties (conserved at 4 °C) was conducted at days 0, 4, 8, 12 and 15 days of storage, and at months 0, 2, 4, and 6 of the frozen samples. Frozen samples were thawed at 4 °C for 12 h before analysis. This study was performed in duplicate, that means that two experiments were carried in different days (experience A and B), and in each experiment three independent batches were prepared and analyzed.

The chemical composition of the beef patties was analyzed using a FoodScan™ near-infrared spectrophotometer (Foss Electric A/S, Hillerød, Denmark), and data processing done with ISIscan™ Software.

2.3. Thiobarbituric acid reactive substances (TBARS) analysis

TBARS method was conducted according to the method proposed by Tarladgis, Watts, Younathan, and Dugan (1960) with minor modifications. Briefly, samples were homogenized in 3.86% perchloric acid, filtered, and distilled. Three mL of the resulting distillate were mixed with 1 mL of 0.04 M of 2-thiobarbituric acid in perchloric acid (10%), and incubated at 100 °C for 45 min. After incubation, samples were cooled, and their absorbance was measured at 532 nm using a U-2000 Hitachi spectrophotometer (Tokyo, Japan) against a blank where sample was replaced with 3 mL of perchloric acid. Quantification was conducted by preparing a standard curve with tetraethoxypropane and the results were expressed in ppm of malondialdehyde (MDA). The quantification limit (0.08 ppm of MDA) of the method was calculated using the DETARCHI software (Sarabia & Ortiz, 1994).

2.4. Analysis of volatile organic compounds (VOCs)

Volatile organic compounds were evaluated by a headspace solid-phase dynamic extraction (HS-SPDE) coupled with gas