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Antioxidant effect of spent, ground, and lyophilized brew from roasted coffee in frozen cooked pork patties

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ABSTRACT

The ability of light and dark roasted coffee (1 g/kg) in varying application forms (spent ground [SCG], whole ground [WGC], or lyophilized brew [LBC]) to inhibit lipid and protein oxidation in cooked pork patties stored at −18 °C was monitored over 3 months. Malondialdehyde (MDA) for the negative control (NC) increased from 0.31 to 1.11 mg MDA/kg pork over 3 months, while pork with coffee or rosemary oleoresin had lower values at month 3 (0.054–0.40 mg MDA/kg pork). The NC had the highest values for hexanal, octanal, and nonanal (2.59, 0.10, and 0.13 mg/kg pork, respectively), while light and dark LBC in pork inhibited hexanal (0.37 and 0.39 mg/kg pork), octanal (0.017 and 0.021 mg/kg pork), and nonanal (0.036 and 0.048 mg/kg pork) to the same extent as rosemary oleoresin at month 3 (0.30, 0.015, 0.036 mg aldehyde/kg pork, respectively). Thiol content for all treatments remained relatively stable from month 0 −3 (0.56–0.96 to 0.67–1.02), while metmyoglobin slightly increased (49–55% to 55–56%) over 3 months. The results suggest that adding coffee neither inhibited nor promoted protein oxidation in cooked pork patties but inhibited lipid oxidation resulting in comparable values to pork with added rosemary oleoresin.

1. Introduction

The efficiency and convenience offered by precooking products makes precooked pork appealing in today's fast-paced lifestyle (Nolan, Bowers, & Kropf, 1989). While the convenience appeals to consumers, precooking before packaging and storing can accelerate oxidation, deteriorating product quality (Dai, Lu, Wu, Lu, Han, Liu, et al., 2014; Kingston, Monahan, Buckley, & Lynch, 1998; Salminen, Estevez, Kivikari, & Heinonen, 2006; Sasse, Colindres, & Brewer, 2009). Cooking destroys the integrity of cell membranes releasing phospholipids, and inactivates several protective antioxidants e.g. catalase (Rhee, Anderson, & Sams, 1996). In addition, hemoproteins such as myoglobin are denatured allowing the release of the prooxidant iron, which can result in the warmed-over flavor (WOF). The WOF becomes predominant with precooking and is characterized by undesirable organoleptic qualities (Rojas & Brewer, 2007). These adverse qualities are due to the secondary products of lipid oxidation (LOX) such as hexanal, octanal, and nonanal. Destruction of cell membranes, decreased catalase activity, and the increase in nonheme iron can elevate the rate of LOX in cooked pork, therefore, it is important to apply strategies to prolong the shelf-life of cooked pork products (Fernandez-Lopez et al., 2003; Rhee et al., 1996).

Multiple preservation methods are applied to maintain meat quality, including storage temperature and antioxidants. Frozen storage is an effective method since low temperatures slow down oxidative reactions. However, freezing does not completely inhibit physical and chemical reactions causing discoloration and oxidative rancidity over time. Antioxidants (AOXs) can be added to combat LOX and protein oxidation (POX). Rosemary has become the industry natural AOX based on overall effectiveness in pork and other meat matrices (Georgantelis, Ambrosiadis, Katikou, Blekas, & Georgakis, 2007; Kim, Cadwallader, Kido, & Watanabe, 2013). The key bioactive antioxidant rosemary compounds are carnosol, carnosic and rosmarinic acid which readily donate their hydrogens acting as free radical scavengers. Recently, roasted coffee was shown to inhibit LOX as effectively as rosemary oleoresin in refrigerated beef with added salt, a known prooxidant of LOX (Lin, Toto, & Were, 2015). The bioactivity of roasted coffee is attributed to a combination of hydroxycinnamic chlorogenic acids (CGAs), and Maillard reaction products (MRPs), which scavenge free radicals

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and chelate metal catalysts of LOX and POX (Del Pino-Garcia, Gonzalez-SanJose, Rivero-Perez, & Muniz, 2012; Delgado-Andrade, Rufian-Henares, & Morales, 2005; Farah, 2012). Concentrations of AOX compounds differ in whole ground coffee (WGC), lyophilized brew coffee (LBC), or spent coffee ground (SCG) and by roast degrees. Spent coffee, from home or restaurant preparations, are of particular interest since substantial bioactive compounds may remain due to short brewing time and coffeemaker filter (Ludwig et al., 2012). Furthermore, SCG are considered waste products hence repurposing into a sustainable preservation method can result in economic gain for the meat and coffee industry, while still producing a safe, quality pork product.

To our knowledge, no studies have investigated the effectiveness of SCG as an antioxidant in food and limited studies have reported the effects of roasted coffee in food matrices: Nissen, Byrne, Bertelsen, and Skibsted (2004) in cooked frozen pork, Budryn and Nebesny (2013) in cookies and chocolate, and Lin et al. (2015) in raw refrigerated beef. The experimental objective was to determine the optimal combination of roast degree (light or dark) with application form (SCG, WGC, LBC) for the greatest AOX effect to preserve shelf life and quality in frozen precooked pork.

2. Material and methods

2.1. Chemicals

Aldehyde and 4-heptanone standards, bovine albumin serum, biuret reagent, HPLC grade methanol, water, formic acid, acetonitrile, ferrous sulfate heptahydrate and sodium phosphate dibasic anhydrous were purchased from Fisher Scientific (Tustin, CA, USA). Sodium phosphate monobasic was from Spectrum Chemical (Gardena, CA, USA). Ellman's reagent 5, 5'-dithiobis(2-nitrobenzoic acid), EDTA, ferrozine, trichloroacetic acid (TCA), 2-Thiobarbituric acid (TBA), and 1, 1, 3, 3,-tetramethoxypropane (TMP) were purchased from Sigma–Aldrich (St. Louis, MO, USA).

2.2. Preparation of coffee and pork treatments

Green Colombia Primeval coffee beans obtained from Rose Park Roasters (Long Beach, CA, USA) were roasted to produce a light (10 min 32 s to 210 °C) and dark (12 min 8 s to 235 °C) roast. Whole coffee beans were ground (Cuisinart "Grind Central" Coffee Grinder, East Windsor, NJ, USA) and passed through a 1.0 mm sieve (18-mesh size) resulting in WGC. Lyophilized brewed coffee was prepared following the methods indicated by Budryn and Nebesny (2013) with modifications. Coffee brew was prepared by heating water to 90 °C, then adding ground coffee to water at a 1 to 6 ratio. The solution was held at 90 °C for five min with constant stirring, filtered with a paper coffee filter to yield liquid brew, which was then lyophilized (Dura-Dry mP manifold lyophilizer, FTS Systems, model #FD2085C0000, Stone Ridge, NY, USA) to yield LBC. The remaining solid grounds from coffee brew extraction was lyophilized and used as SCG. Coffee was stored at <0 °C before use. Before incorporation into minced pork, all coffee forms were passed through a 1.0 mm sieve (18-mesh size).

Meat was prepared in accordance to AOAC Official method 983.18 (AOAC., 2010) with modifications. Minced sirloin pork chops from Butcher hogs, averaging 6 months in age, 95.34 kg live weight at the time of slaughter, was supplied and prepared at Farmer John® facilities (Vernon, CA, USA). Pork meat was minced in an industrial-sized chopper, and refrigerated (<4 °C) overnight prior to addition of coffee or rosemary oleoresin the following day. All treatments, negative control (NC), rosemary oleoresin [RO; Herbalox® HT-25 from Kalsec Inc. (Kalamazoo, MI, USA); (2 g/kg)], SCG, WGC, and LBC of light (1 g/kg) and dark (1 g/kg) roasts were mixed using a Hobart Legacy HL200 20 Qt mixer (Troy, OH, USA) for two min resulting in eight different treatment samples with uniform processing. This process was repeated per treatment in order to achieve true duplicates. The pork was transferred to polyethylene plastic bags, placed into cardboard boxes, and transported 56 km from Vernon to Orange, CA, USA.

2.3. Cooked pork preparation

Pork meat was stored at 4 °C until ready to be formed into pork patties (~3 h). Pork was prepared and cooked following the Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Fresh Meat (AMSA., 1995) with modifications. Pork patties (100 ± 1 g) were molded (11.5 cm diameter, 1.25 cm thickness) then cooked on two electric griddles (ToastMaster®, Model #TG21W & # TM161GR, St. Louis, MO, USA) set to 205 °C for 3.5 min on each side or until internal temperature reached a minimum of 72 °C in the center of the patty. Patties were cooled at 22–25 °C before being individually placed into oxygen permeable zipper bags (polyethylene, 16.5 cm × 14.9 cm). Patties were stored at −18 °C until ready to be analyzed. Patties from each treatment were transferred from −18 °C to 4 °C to thaw for 12 h, and were hand mixed for 30 s prior to analysis.

2.4. Chlorogenic, Maillard reaction products, and iron chelating ability quantification

Spent, ground, and lyophilized brew of light, medium, and dark roasted coffee were added to deionized water at 1 g/100 mL to test MRPs and 0.1 g/100 mL to test iron chelating ability and CGA, then incubated for 2 h at 22 °C. Quantification of CGA in the various forms of coffee were measured via HPLC following protocols by Lin et al. (2015). A C18 column (Kinetex, 2.6u C18 100A, 100 × 4.60 mm, Phenomenx, Torrance, CA, USA) was used at 30 °C using a flow rate of 1.5 mL/min with mobile phase (A) 1 mg/mL formic acid in HPLC water and (B) HPLC grade acetonitrile. Sample was injected (5 μL) with starting conditions of A/B, 95/5 held for 10 min. Solvent A was linearly decreased to 85% within 1 min and held for 0.5 min before returning back to starting conditions within 2.5 min. A standard curve of chlorogenic acid (0–0.6 mM) was used to quantify chlorogenic acid detected at 330 nm. Quantification of MRPs and ferrous iron chelating ability were measured following protocols by Teets and Were (2008).

2.5. Thiobarbituric acid reactive substances (TBARS) measurement

The TBARS assay was prepared as described by Lin et al. (2015) with modifications. The supernatant (5 mL) was reacted with 5 mL of 0.02 M TBA solution in glass test tubes. Recovery values were determined by spiking additional meat samples (randomly chosen each testing day) with 0.5 mL of 0.15 or 0.45 mM TMP solution to achieve final TMP concentration of 0.006 and 0.018 mM after 12.0 mL of TCA had been added. These mixtures were vortexed and centrifuged alongside the other samples. A TMP standard curve (0–7.5 nmol MDA/mL) was used to quantify MDA after 16 h incubation at 22–25 °C in the dark. Absorbance was measured at 532 nm and 600 nm, with the latter accounting for any potential turbidity, using a FLUOstar Omega multimode microplate reader (Cary, NC, USA).

2.6. Purge and trap gas chromatography measurement of volatile aldehydes

Volatile compounds from pork samples were extracted via distillation and measured by gas chromatography (GC) using