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Effects of adding red wine on the physicochemical properties and sensory characteristics of uncured frankfurter-type sausage

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ABSTRACT

The aim of this work was to evaluate the quality and sensory characteristics of RTE frankfurter-type sausage cured with celery juice powder and including red wine. Four frankfurter treatments including a conventionally cured treatment without red wine (control) and three treatments cured with pre-converted vegetable juice powder and 0%, 5% or 10% (*v*/*w*) red wine were prepared. Results showed that adding 5% red wine increased the a*-value, and the textural resilience, cohesiveness and springiness of the frankfurters, as well as decreased lipid/protein oxidation of the final products. Added wine also introduced new volatiles (alcohol and ester compounds) to the frankfurters. The principal component (PC) analysis showed that the pre-converted vegetable juice powder achieved the same effects as the conventional curing agents for typical frankfurter properties. However, the addition of excess amounts of red wine (10%) to the meat batter decreased the pH of meat batter and accelerated lipid oxidation.

1. Introduction

Frankfurters are an emulsion-type sausage prepared with lean and fat meats, water and other ingredients (salts, curing agents and spices), stuffed into casings, and then subjected to thermal processing under controlled temperature and relative humidity (Coloretti et al., 2014; Feiner, 2006).

Sodium nitrite is a curing agent that is considered to be a chemical preservative, and thus is prohibited in items that are labeled 'Natural' or 'Preservative-free' products (FSIS, 2006). However, there has been a dramatic growth in natural, minimally processed, and preservative-free food products over the past several years (Sloan, 2015). Many of these products utilize natural sources of nitrate such as celery juice or "pre-converted" vegetable materials containing nitrite. Meat products cured using the natural sources of nitrate/nitrite are typically labeled as 'uncured' or 'natural' products (Myers et al., 2013).

In some Mediterranean areas, pork meat and fat are minced, then mixed with salt, macerated garlic, pepper and red wine to improve the aroma profile of the final product (Spaziani, Torre, & Stecchini, 2009). *Salama da sugo*, a typical Italian product, includes up to 15% (*v*/*w*) red wine in the meat batter to form of 'sugo'(=juice) which characterizes the product after cooking and crucial aromatic profile (Gardini et al., 2013). Rason, Laguet, Berge, Dufour, and Lebecque (2007) also studied fermented sausages produced in the Massif Central (France) that include up to 50 mL of wine per kg of meat batter to provide a flavor associated wine after swallowing. In Portugal, the tradition of wine making has been associated with the production of sausages, and red wine is often used as the main ingredient to provide a characteristic flavor to marinades, which are used both in the cooking of pork and the preparation of dry pork sausages (Linares, Garrido, Martins, & Patarata, 2013).

The amount of wine added not only affects the flavor profile, but also other chemical and sensory parameters. For example, wine has a low pH (3.0–3.6) due to the presence of organic acids such as tartaric, malic, succinic, lactic and acetic acids (Volschenk, van Vuuren, & Viljoen-Bloom, 2006). As a consequence, high wine concentration can be responsible for a significant pH reduction and can provide a pool of antioxidants (phenolic compounds) to the meat batter. Thus, addition of wine may inhibit microbial growth and delay lipid and protein oxidation (Coloretti et al., 2014). Products formulated with vegetable-sourced nitrate or nitrite, typically contain less nitrite than conventional cures, and red wine may supplement some of the effects of nitrite such as suppressing oxidation of lipids (Özvural & Vural, 2011). However, excessive addition wine may change the pH of meat batter to a point significantly closer to the isoelectric point of muscle proteins and cause poor emulsion formation as a result (Damodaran, 2008).

While the effect of added wine on the microbial growth and quality changes of fermented sausages has been reported, no similar research reports on uncured frankfurters are available. The objective of this study was to determine the effects of added red wine on the quality of RTE frankfurters-type sausage manufactured with vegetable juice

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powder as the curing agent. The hypothesis of this research is that the pre-converted vegetable juice powder will achieve the same effects for color and flavor as nitrite in conventionally cured frankfurters, and that adding red wine to the meat batter will decrease lipid/protein oxidation.

2. Materials and methods

2.1. Preparation of frankfurter-type sausage

Fresh lean beef trim (fat content approx. 10% *w*/*w*) and fat beef trim (fat content approx. 50% *w*/*w*) were purchased from a local processor. The fat content of the beef trim was first analyzed using an Anyl-Ray Fat Analyzer (Kartrig Pak, Model 316-48, Davenport, IA) in order to combine the lean beef trim and fat beef trim in proper proportion to give a final product with 29% fat. The lean trim was chopped first in a silent cutter with most of the ice (19.7% *w*/*w*), NaCl (1.3% *w*/*w*), dextrose (0.7% *w*/*w*), sodium phosphate (0.3% *w*/*w*), sodium erythorbate (0.04% *w*/*w*), and spices (mustard flour 0.7% *w*/*w*, coriander 0.2% *w*/*w*, ground black pepper 0.2% *w*/*w*, ground nutmeg 0.07% *w*/*w*, garlic powder 0.04% *w*/*w*, ground red pepper 0.04% *w*/*w*). Chopping was continued until the batter temperature reached to 40 °F (4–5 °C). After that, the fat beef trim was added to the chopper with the remaining salt and spices, and chopping continued until the batter temperature reached to 55 °F (13 °C). Shortly before chopping was completed, the meat batter was divided into four equal portions. Curing ingredients (0.18% *w*/*w*): conventional curing agent (modern cure, 6.25% nitrite) or pre-converted vegetable juice powder (celery powder) (Florida Food Products, Inc., Eustis, FL), and red wine was added to the meat batter following the experimental design and composition shown in Table 1. The pre-converted vegetable juice powder contained nitrite already converted from nitrate by the supplier. Red wine, produced from the Concord grape, was purchased from a local winery (Prairie Moon Winery and Vineyards, Ames, IA). The meat batter was blended thoroughly using a mixer (Higashimoto Kikai, Japan). After emulsification, the meat batter was stuffed into collagen casings (No. 17 peelable cellulose casings) using a vacuum stuffer (RS 4003-165, RISCO, Italy). The sausages were then cooked in a conventional thermal processing chamber to 71 °C internal temperature using to the following schedule: reddening for 10 min at 70% relative humidity (RH) and 43 °C; smoking for 30 min at 82% RH and 63 °C; steam cooking for 1 min at 100% RH, and followed by a 15 min cold shower. The finished frankfurters were chilled in a 4 °C-cold room overnight. After chilling, the frankfurters were peeled and vacuum-packaged in polyethylene bags (nylon/polyethylene, 9.3 mL O_2/m^2/24 h at 0 °C; Koch, Kansas City, MO).

2.2. Proximate composition analysis

Compositional analysis was performed using AOAC methods (2000). Moisture content was determined by weight loss after 12 h at 105 °C in a drying oven. Fat content was determined using the Soxhlet solvent extraction system (Lab-line® Multi-unit Extraction Heater, Lab-line Instruments, Inc., Melrose Park, IL). The pH values were measured using a homogenate prepared with 10 g of sample and distilled water (90 mL) and an Orion Star A211 pH meter.

2.3. Color measurements

Color was measured using a Hunterlab Labscan spectrocolorimeter (Hunter Associated Laboratories Inc., VA, USA). The spectrocolorimeter was calibrated against white and black reference tiles covered with the same film as that used for meat samples. Lightness (CIE L*-value), redness (CIE a*-value), and yellowness (CIE b*-value) were recorded using an illuminant D65, 10° (light source) with a 0.13 inch port size. Five measurements for each sample were taken at random locations on the surface of each of the meat samples (de Oliveira, Carvalho, & Prache, 2012).

2.4. Texture profile analysis

The texture profile of the frankfurters was analyzed using the method of Choi et al. (2013). Texture analysis was performed in triplicate on each sample at room temperature with a texture analyzer (TA-XT2i, Stable Micro Systems Ltd., Surrey, UK). One-inch lengths of frankfurter samples were cut from the central portion of each frankfurter. Prior to analysis, samples were allowed to equilibrate to room temperature. The conditions for texture analysis were as follows: probe test speed 5.0 mm/s; probe post-test speed 5.0 mm/s; strain 50%, pause time between compression cycles 3.0 s; and amount of force for the texture analysis to initiate data capture 5 g. A TA-25 with 2 inch diameter stainless probe was used. The calculation of TPA values was obtained using force and time plots. Values for hardness, resilience, cohesiveness, springiness and chewiness were determined as described by Bourne (1978).

2.5. Lipid oxidation

Lipid oxidation of the frankfurters was measured as 2-thiobarbituric acid reactive substances (TBARS) following the method of Zhu, Lee, Mendonca, and Ahn (2004) modified for cured meat. Five grams of minced meat was weighed into a 50-mL test tube and homogenized with 50 μL butylated hydroxyanisole and 15 mL of deionized distilled water (DDW) using a Polytron homogenizer (Type PT 10/35, Brinkman Instruments Inc., Westbury, NY, USA) for 15 s at high speed. One milliliter of the meat homogenate was transferred to a disposable test tube (13 × 100 mm), sulfanilamide (1 g/100 mL, 20 μL) was added, and mixed thoroughly. The samples were held at room temperature for 5 min and then thiobarbituric acid/trichloroacetic acid (20 mM TBA/15 g/100 g TCA, 2 mL) was added. The mixture was vortex-mixed and incubated in a boiling water bath for 15 min to develop color. Then samples were cooled in ice-water for 10 min, vortex-mixed again, and centrifuged for 15 min at 2000 ×*g* at 4 °C. The absorbance of the resulting supernatant solution was determined at 532 nm against a blank containing 1 mL of DDW and 2 mL of TBA/TCA solution. The amounts of TBARS were expressed as milligrams (mg) of malondialdehyde (MDA) per kilogram (kg^{-1}) of meat.

2.6. Protein oxidation

Protein carbonyl content was used as a measure of the degree of protein oxidation in meat. Carbonyl content was determined using the 2,4-dinitrophenylhydrazine (DNPH) derivatization method (Lund, Hviid, Claudi-Magnussen, & Skibsted, 2008): 1 g of muscle was transferred to

Table 1
Frankfurter sausage formulations with varying percentages of red wine and curing ingredients.

Treatment	Curing agent	Control group	Celery group	5% wine group	10% wine group
Curing agent	6.25% nitrite	0.18% (*w*/*w*)	–	–	–
	Pre-converted vegetable juice powder (celery powder)	–	0.18% (*w*/*w*)	0.18% (*w*/*w*)	0.18% (*w*/*w*)
Red wine		–	–	5% (*v*/*w*)	10% (*v*/*w*)