Addition of Red Wine on the Physicochemical Properties and Sensory Characteristics of Uncured Frankfurter-type Sausage

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Summary and Implications

The aim of this work was to evaluate the quality and sensory characteristics of ready-to-eat (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. 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 effects of red wine might be advantageous in natural and organic processed meats where nitrite concentrations are typically less than in conventionally cured products. However, the addition of excess amounts of red wine (10%) to the meat batter may have negative effects on the meat quality.

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. 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. However, there has been a dramatic growth in natural, minimally processed, and preservative-free food products over the past several years. 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. 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. *Salama da sugo*, a typical Italian product, includes up to 15% (v/w) red wine in the meat batter to provide a form of ‘sugo’(=juice) which characterizes the product after cooking with a crucial aromatic profile. Fermented sausages produced in the Massif Central area of France 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. 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. 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. 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. However, excessive addition of 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. 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 frankfurter-type sausage manufactured with vegetable juice 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.

Materials and methods

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 in order to make a final product with 29% fat. Curing ingredients and red wine were 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 was purchased from a local winery. After emulsification, the meat batter was stuffed into collagen casings using a vacuum stuffer. The sausages were then cooked in a conventional thermal processing chamber to 71 °C internal temperature. 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^2/24h at 0 °C). Compositional analysis was performed using AOAC methods. The texture profile of the frankfurters was analyzed using a texture analyzer (TA-XT2i). Lipid oxidation of the frankfurters was measured as 2-thiobarbituric acid reactive substances (TBARS) method. Protein carbonyl content was used as a measure of the degree of protein oxidation in meat. The volatiles profiles of the samples were analyzed using a Solatek 72 Multimatrix-Vial Autosampler/Sample Concentrator 3100 connected to a Gas chromatograph/Mass spectrometer. Twelve trained sensory panelists were used to evaluate the sensory characteristics of the frankfurters. The sensory characteristics were evaluated using a 9-point scale. Attributes included color (1 = brown; 9 = light pink), flavor (1 = not detectable; 9 = extremely intense), texture (1 = very mushy; 9 = very firm) and overall quality (1 = bad; 9 = very good).

Statistical Analysis

Three replications of samples were used for each analysis. Data were analyzed by the GLM procedure of SAS (SAS 9.1 version) for different treatments. The fixed effect of treatments and the random effect of replications were included in the model. The differences in the mean values were compared by Tukey's multiple comparison method, and mean values and standard error of the means (SEM) were reported ($P < 0.05$). Principal component (PC) analysis was performed on XLSTAT (2015). Two principal components, PC1 and PC2 were retained to determine treatment scores.

Results and Discussion

After adding 10 % red wine to the frankfurters, the moisture content increased significantly ($P < 0.05$) while fat content and pH declined ($P < 0.05$). The lower fat content with the addition of 10 % red wine might be related to the pH decline as well as the increased liquid content (Table 2). The lightness score increased when the pre-converted vegetable juice powder (celery powder) was used to replace sodium nitrite. However, when different proportions of red wine were added into the meat batter together with celery juice powder, the lightness values decreased. The replacement of sodium nitrite with celery juice powder decreased the redness in the frankfurters. However, after adding 5% red wine to the meat batter, the redness of the frankfurters increased, probably because of the red pigments and the antioxidant activity of red wine. The antioxidant phenolic compounds in red wine can prevent the oxidation of heme pigments, but this trend did not continue with further addition of red wine. The addition of red wine significantly affected the textural properties of the frankfurters (Table 2): the control and celery juice powder with no added wine had the highest hardness and chewiness ($P < 0.001$). However, the hardness significantly decreased as the addition of red wine increased from 5% to 10%. The significant decline in hardness of frankfurter with 10% wine treatment was probably due to the pH decrease to closer to the isoelectric point. However, frankfurters with 5% red wine showed the highest resilience, cohesiveness and springiness ($P < 0.001$) among the treatments.

The frankfurters with 10% wine had significantly greater lipid oxidation than other treatments ($P < 0.05$). With 10 % wine, there was visible fat separation on the surface of the frankfurters and the contact with oxygen in the air, probably resulted in accelerated lipid oxidation. No significant difference was found between control and celery groups for protein oxidation. However, after adding increasing amounts of red wine, protein oxidation decreased ($P < 0.05$), indicating that the antioxidant compounds in the red wine can minimize protein oxidation in meat products during the process (Table 3).

Forty volatiles including 10 terpenoids, 7 sulfur compounds, 4 aldehydes, 2 ketones, 7 alcohols and 10 esters were identified in the frankfurters (Table 4). Among the quantified volatiles, terpenoids were the largest group, but were not found in the wine alone. Four aldehydes were found in the final frankfurter products, but there were no significant differences for those volatiles (2-methyl-buranal, 3-methyl-butanal, etc.) among the treatments. After adding red wine to the meat batters, hexanal became undetectable, which was unexpected. The amount of hexanal is usually associated with lipid oxidation, but such relationship between hexanal content and lipid oxidation was not found here. Small amounts of ketones were detected in all of the frankfurters: 2-propanone was only detected in control group while 2, 3-butanedione was found in celery and 5% wine group. 2-propanone could be formed in frankfurters from the branched chain amino acids. 2,3-butanedione can contribute to specific sausage aromas. Some unique volatile compounds were also formed after adding red wine to the meat batters. Seven alcohols were observed only in the frankfurters with red wine as might be expected. Among the alcohols, ethanol was the major alcohol compound in the frankfurters with red wine. 1-Propanol, 2-methyl-1-propanol and 3-methyl-1-butanol were also detected in frankfurters with red wine, but the amounts of those volatiles were much lower than ethanol. 2-Propano, 1-butanol and iso-amyl-alcohol, which were not present in the wine, were detectable in the final meat products. These observations further indicated that some secondary reactions occurred at the processing steps. Ten esters were found in the frankfurters with red wine. Esters were derived from the esterification of free fatty acids and alcohols. Ethyl acetate was the major ester compound detected. Ethyl propionate is considered a key volatile in wines, and this volatile was also detected in the frankfurters with red wine. However, some esters, including ethyl formate, 1-methylethyl acetate, isobutyl acetate, isoamyl acetate, ethyl 2-methylpropanoate, ethyl hexanoate and

ethyl caprylate, that are usually present in red wine were not found in the frankfurters that included wine. While the dilution factor of adding wine to the frankfurters may be part of the reason for this, it is also possible that because those compounds have relatively low boiling points (< 120 °C), they are likely to evaporate during thermal processing. Sensory evaluation suggested that addition of 5% wine improved the flavor and overall quality ($P < 0.05$) of the frankfurters without decreasing the color and texture score ($P > 0.05$). However, all of the sensory scores except flavor declined when the concentration of red wine increased to 10%, suggesting that 5% wine might be a critical point relative to sensory qualities of frankfurters.

Conclusion

Pre-converted vegetable juice powder achieved the same effect on cured meat properties as does nitrite for conventionally cured frankfurters, and adding 5% red wine to the meat batter decreased lipid/protein oxidation. However, 10% red wine added to the meat batters resulted in poor protein-fat stability, reduced textural integrity and accelerated lipid oxidation following processing. Consequently, addition of red wine appears to provide some potential advantages for processed meats, particularly with respect to oxidative changes and sensory profiles. These effects of red wine might be advantageous in natural and organic processed meats where nitrite concentrations are typically less than in conventionally cured products.

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)

Table 2 Moisture and fat content (%),pH and texture profile of frankfurters with varying percentages of red wine and curing ingredients[1]

	Control	Celery	5 % wine	10 % wine
Proximate composition:				
Moisture (g/100g)	52.40^{c}	53.25^{b}	52.77^{bc}	54.32^{a}
Fat (g/100g)	26.85^{a}	26.40^{ab}	26.64^{a}	25.55^{b}
pH	5.99^{a}	5.99^{a}	5.75^{b}	5.61^{c}
Texture profiles:				
Hardness (g)	4273.22^{a}	4270.39^{a}	3782.39^{b}	3102.01^{c}
Resilience (%)	37.46^{b}	38.88^{a}	39.65^{a}	37.33^{b}
Cohesiveness	0.73^{b}	0.72^{b}	0.75^{a}	0.72^{b}
Springiness (%)	90.25^{ab}	89.16^{ab}	90.48^{a}	88.46^{b}
Chewiness (g)	2927.92^{a}	2919.98^{a}	2686.03^{b}	2003.65^{c}

[1]Means with different letters within a row differ significantly ($P<0.05$).

Table 3 Lipid and protein oxidation of frankfurters with varying percentages of red wine and curing ingredients[1]

	Control	Celery	5% Wine	10% Wine
Lipid oxidation[2]	0.24^{b}	0.22^{b}	0.26^{b}	0.38^{a}
Protein oxidation[3]	1.34^{a}	1.40^{a}	0.81^{c}	1.08^{b}

[1] Means with different letters within a row differ significantly (P<0.05).
[2] Thiobarbituric acid reactive substances (TBARS) (mg malonaldehyde/kg meat)
[3] Carbonyl content (nmoles/ mg protein).

Table 4. Volatile profiles of frankfurters with varying percentages of red wine and curing ingredients[1]

Volatiles	Wine alone	Control	Celery	5%wine	10%wine
			Total ion counts × 10^4		
Terpenoids	0	221416^{b}	230029^{ab}	253773^{a}	241079^{ab}
Sulfur compounds	0	85298^{b}	94339^{a}	67622^{c}	63775^{c}
Aldehydes	15188	18458^{a}	15369^{ab}	15066^{b}	13971^{b}
Ketones	19702	3444^{ab}	2668^{b}	4570^{a}	0^{c}
Alcohols	6433621	0^{c}	0^{c}	5327480^{b}	6292331^{a}
Ester	1526526	0^{c}	0^{c}	88477^{b}	185269^{a}

[1]Means with different letters within a row differ significantly (P<0.05). Multi-comparisons were conducted among the frankfurters with varying percentages of red wine and curing ingredients. The volatiles of red wine were excluded.

Table 5 Sensory characteristics (9-point scale) of frankfurters with varying percentages of red wine and curing ingredients.

	Control	Celery	5% Wine	10% Wine
Color	6.4^{a}	6.0^{a}	6.2^{a}	6.0^{a}
Flavor	5.1^{c}	5.1^{c}	6.0^{b}	6.8^{a}
Texture	5.4^{a}	5.2^{a}	4.7^{a}	3.4^{b}
Overall quality	5.9^{b}	5.6^{b}	6.9^{a}	4.9^{c}

[1]Sensory scale: color (1 = brown; 9 = light pink), flavor (1 = not detectable; 9 = extremely intense), texture (1 = very mushy; 9 = very firm) and overall quality (1 = bad; 9 = very good).