Comparison of Traditional and Alternative Curing Ingredients on Curing Reactions in a Model Meat System

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Summary with Implications

To meet consumer trends, alternative curing ingredients are used to replace sodium nitrite and cure accelerators. Due to the complexity of meat, it is challenging to compare traditional and alternative ingredients for curing reactions. Using a model system, sources of nitrite (traditional, sodium nitrite and alternative, cultured celery juice powder), salt, and cure accelerators (traditional, sodium erythorbate, or alternative, cherry juice powder) at ingoing sodium nitrite concentrations of 10, 50, 100, 150, or 200 ppm were evaluated for curing reactions. More complete curing reactions were indicated by a higher concentration of cured meat pigment, and lower sulfhydryl groups. Lower residual nitrite indicates reduction of nitrite into nitric oxide, and higher reducing capacity indicates a higher concentration of antioxidants. Traditional nitrite and celery juice powder treatments had similar concentrations of residual nitrite and cured meat pigment. Celery juice powder treatments with and without a cure accelerator had the most sulfhydryl groups and a high residual reducing capacity. This research demonstrates cultured celery juice powder and cherry powder develop similar concentrations of cured meat pigment as traditional sodium nitrite and sodium erythorbate, but antioxidants native to alternative ingredients may lessen the production of nitrosated cysteine.

Introduction

In meat curing, many reactions occur between the meat, nitrite, and other added ingredients. These reactions contribute to familiar cured meat characteristics such as color, flavor, aroma, and safety. Traditional curing processes utilize sodium nitrite. Nitrite reacts with myoglobin in meat, to produce the pink cured meat pigment nitrosylhemochromagen. Nitrite also reacts with sulfur-containing proteins in the meat, specifically cysteine, to generate nitrosated cysteine. The speed of these reactions is increased by adding a cure accelerator. Sodium erythorbate is typically used as a cure accelerator in processed meat manufacturing but natural sources of ascorbic acid, such as cherry juice powder, can provide a similar function.

Consumer demand for natural products is increasing, and traditional curing ingredients are being replaced with alternative ingredients to produce cured meat products. Synthetic sodium nitrite can be replaced with cultured celery juice powder, and sodium erythorbate can be replaced with ascorbic acid from acerola cherries. While similar product characteristics can be achieved with traditional or alternative sources of curing ingredients, tracking specific reactions can allow for a more detailed understanding of the equivalency of traditional and alternative ingredients. The objective of this study was to evaluate the effects of curing solutions containing either traditional sources of nitrite and cure accelerators, or alternative sources of nitrite and cure accelerators and the effect of ingoing nitrite concentration on curing reactions in model meat systems.

Procedure

The project used a factorial arrangement of treatments: 2 meat model solutions, 5 curing system solutions, and 5 ingoing nitrite concentrations. The meat model solutions were cysteine (615 ppm) and cysteine plus myoglobin (615 ppm and 48 ppm, respectively), in a 5.6 pH phosphate buffer. Using the two meat model solutions provided the ability to decipher differences in reactions with each component. Solutions were evaluated representing different curing systems. The three traditional curing system solutions were evaluated: sodium nitrite (SN), sodium nitrite with sodium chloride (NaCl) to equal the salt contained in celery juice powder treatments (SN/NA), sodium nitrite with NaCl and sodium erythorbate (equivalent to 547 ppm; SN/SE). Two alternative curing system solutions were developed for comparison against the traditional systems: celery juice powder (VegStable 504, Florida Food Products, Inc., Eustis, FL; CP), and celery juice powder and acerola cherry powder (VegStable 515 to provide 486 ppm ascorbic acid; CP/CH.). The curing system solutions were evaluated at ingoing nitrite concentrations of 10, 50, 100, 150, and 200 ppm of sodium nitrite or equivalent from celery juice powder.

A curing solution (5 ml) was added to each model meat solution (5 ml) in 13 ml test tubes, capped, heated in a water bath (30 min at 104°F, and 30 min at 176°F), and air cooled (15 min at 73°F) to simulate meat curing during the cooking. All model curing solutions were analyzed for residual nitrite, residual sulfhydryl groups, and residual reducing capacity (DPPH neutralized). In addition, the model meat curing solutions containing myoglobin were evaluated for cured meat pigment concentration (nitrosylhemochromogen).

The experiment was conducted as a completely randomized design with a factorial treatment arrangement and three independent replications. Data were analyzed using the GLIMMIX procedure of SAS. Interactions of effects and main effects of model meat solution (cysteine, or cysteine and myoglobin), curing system (SN, SN/NA, SN/SE, CP, CP/CH), and ingoing nitrite concentration (10, 50, 100, 150, or 200 ppm) were analyzed. When significant interactions or main effects were identified ($P \leq 0.05$), means separation was conducted using the post hoc adjustment of Tukey honestly significant difference test.

Results

Nitrite reactions: Cured Meat Pigment and Residual Sulfhydryl Groups

In this system, curing reactions occur with nitrite, myoglobin, and the amino acid cysteine. Cure accelerators increase the rate and extent of the reactions. Nitrite reactions

Table 1. Influence of curing system and ingoing nitrite concentration on cured meat pigment and residual reducing capacity (reflected as DPPH Neutralized) using a model meat curing system

Curing System[1]	Cured Meat Pigment (ppm)	Residual reducing capacity (DPPH Neutralized (μM))
SN	15.96[b]	2.98[d]
SN/NA	18.18[b]	3.14[cd]
SN/SE	19.23[ab]	4.98[b]
CP	16.76[b]	3.46[c]
CP/CH	22.57[a]	6.65[a]
Standard error	0.99	1.00
Ingoing nitrite concentration (ppm)	**Cured meat pigment (ppm)**	**Residual reducing capacity (DPPH neutralized (μM))**
10	13.4[y]	4.65[x]
50	17.85[x]	4.41[xy]
100	19.71[x]	4.18[yz]
150	20.52[x]	4.01[yz]
200	21.22[x]	3.93[z]
Standard error	0.97	1.00

[1]SN-sodium nitrite, SN/NA-sodium nitrite and sodium chloride SN/SE-Sodium nitrite, sodium chloride and sodium erythorbate, CP-Cultured celery juice powder, CP/CH-Cultured celery juice powder and acerola cherry juice powder

[a-d]For curing system main effect, means within a column without a common superscript are significantly different ($P < 0.001$)

[x-z]For ingoing nitrite concentration main effect, means within a column without a common superscript are significantly different ($P < 0.001$)

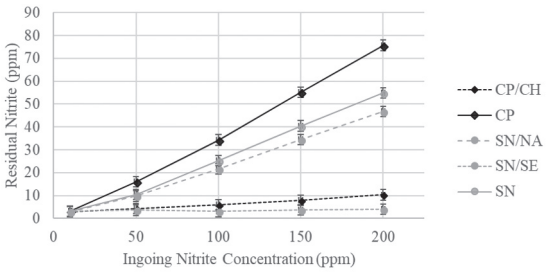

Figure 1. Interaction of curing system and ingoing nitrite concentration on residual nitrite in a model meat curing system. SN-sodium nitrite, SN/NA-sodium nitrite and sodium chloride SN/SE-Sodium nitrite, sodium chloride and sodium erythorbate, CP-Cultured celery juice powder, CP/CH-Cultured celery juice powder and acerola cherry juice powder. Error bars indicate ± standard error.

with myoglobin result in the production of cured meat pigment (nitrosylhemochromagen) and nitrite reactions with cysteine produce nitrosated cysteine result in fewer residual sulfhydryl groups. As nitrite is consumed by reactions in the system, lower residual nitrite levels occur.

In this experiment, the main effects of curing system and ingoing nitrite concentration were significant for cured meat pigment ($P < 0.001$; Table 1). Treatments containing cure accelerators (SN/SE and CP/CH) had greater concentrations of cured meat pigment indicating that a greater portion of the total myoglobin reacted with nitrite. The amount of cured meat pigment was greater when ingoing nitrite increased from 10 to 50 ppm but did not increase further when greater than 50 ppm of nitrite was added.

An interaction between curing system and ingoing nitrite concentration also was identified for the concentration of residual sulfhydryl groups ($P < 0.001$; Figure 1). At 10 ppm, all curing systems were similar. As ingoing nitrite concentration increased, curing systems containing celery juice powder had more residual sulfhydryl groups (CP, CP/CH) than any treatment with sodium nitrite (SN, SN/NA, SN/SE). The SN/SE treatment was intermediate and traditional curing systems without sodium erythorbate (SN, SN/NA) had the least residual sulfhydryl groups; suggesting cure accelerators (reducing compounds) or other antioxidant compounds in cultured celery juice powder could shift nitrosating reactions to produce less nitrosated cysteine.

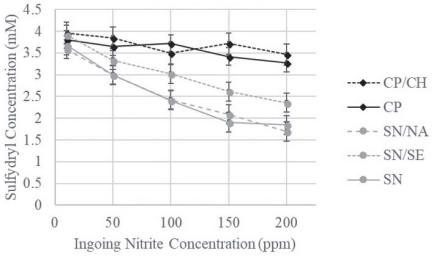

Figure 2. Interaction of curing system and ingoing nitrite concentration on residual sulfhydryl groups in a model meat curing system. SN-sodium nitrite, SN/NA-sodium nitrite and sodium chloride SN/SE-Sodium nitrite, sodium chloride and sodium erythorbate, CP-Cultured celery juice powder, CP/CH-Cultured celery juice powder and acerola cherry juice powder. Error bars indicate ± standard error.

Residual Nitrite

An interaction between curing system and ingoing nitrite concentration occurred for residual nitrite concentration ($P < 0.05$; Figure 2). At 10 ppm, no differences between curing systems could be identified but as the concentration of ingoing nitrite increased, differences between curing systems were identified. Curing systems without cure accelerators (SN, SN/NA, CP) displayed greater concentrations of residual nitrite than those with cure accelerators (SN/SE, CP/CH), and residual nitrite concentration increased with increasing ingoing nitrite concentration. This can be explained by cure accelerators increasing the reduction of nitrite to nitric oxide to react with components of the model meat system as would occur during meat curing.

Residual Reducing Capacity

For residual reducing capacity, measured by DPPH neutralized, the main effects of curing system and ingoing nitrite concentration were significant ($P < 0.001$; Table 1). The CP/CH curing solution had the most residual reducing capacity followed by the SN/SE; these had added cure accelerators which are reducing compounds. Celery juice treatments had more residual reducing capacity than the traditional alternatives, indicating native antioxidant compounds in the powders. As ingoing nitrite concentration increased the residual reducing capacity decreased since

more could be utilized to reduce nitrite to nitric oxide with greater ingoing nitrite concentrations.

Meat System Effect on Residual Nitrite and Sulfhydryl groups

The cysteine model meat solution had less residual nitrite and less remaining sulfhydryl groups than the cysteine and myoglobin model solution ($P < 0.001$), suggesting the reaction of nitrite with myoglobin occurs before the reaction with cysteine.

Conclusions

Results from this model system can be used to better explain the curing reactions that occur between nitrite, myoglobin, and sulfur-containing amino acids in meat. Traditional and alternative curing ingredients developed similar cured meat pigment, especially when cure accelerators were used. However, the use of cultured celery juice powder and acerola cherry juice powder resulted in less nitrosated cysteine, indicating that native antioxidants might influence the reactions between nitrite and sulfur-containing amino acids. This experiment helps provide a better understanding of the equivalency of traditional or alternative nitrite sources and can be used in combination with previous research to provide better recommendations to processors who are interested in producing alternatively cured beef products.

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