Depletion of Nitrite from Meat Curing Brines during Refrigerated Storage

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Summary and Implications

A meat curing brine typical of those used commercially for injecting pork bellies during processing of sliced bacon was prepared with all curing ingredients including salt, sugar, sodium phosphate, sodium erythorbate and sodium nitrite, as a control. Brines without erythorbate, without phosphates and without erythorbate and phosphates were also prepared at the same time to evaluate the effects of those ingredients on nitrite reactions in the brine. Residual nitrite and brine pH were measured after 0, 1, 2, 4, 6 and 9 days of storage at 0 °C – 2 °C. The control brine lost over 200 parts per million (ppm) (19.6%) of the nitrite within 24 hours, and over 300 ppm (31.6%) after 48 hours. The brine with erythorbate but without phosphates lost almost 300 ppm (27.7%) following formulation but did not change during storage. The brines without erythorbate and without erythorbate and phosphate each maintained nitrite concentrations without significant change for up to 9 days of storage.

Consequently, the high concentration of curing ingredients necessary for injection brines of cured meats is likely to result in significant losses of nitrite relatively quickly even at refrigerated temperatures, depending on brine conditions and other ingredients. In general, injection brines for cured meats should be used as soon as possible following formulation to avoid potential nitrite losses prior to injection. Nitrite losses from the brine could result in reduced cured color stability in the finished product as well as loss of other cured meat quality characteristics expected from normal nitrite-based curing reactions.

Introduction

Meat curing brines for injected cured meat products such as hams and bacon must necessarily contain relatively high concentrations of the curing ingredients because the brines are injected over a range of about 10% to 30% of product weight (depending on the specific product and process), and the brines are expected to result in specific ingredient concentrations in the finished product. This means that the brines must contain about 3-10 fold (again depending on the product and process) greater concentrations of ingredients than intended for the finished product. Nitrite and reductants such as erythorbate react very readily with each other when in close contact, generating nitric oxide which is desirable in meat tissue but which is lost from brine if this reaction occurs prior to injection. It has long been recognized by the meat industry that injection brines should be used soon after formulation to avoid excessive nitrite losses but it has not been clear how rapidly nitrite is likely to be depleted under controlled conditions.

This experiment was initiated to determine the rate of nitrite depletion from a refrigerated curing brine with and without erythorbate and with and without phosphates.

Materials and Methods

An injection brine similar to those used commercially for producing sliced bacon from pork bellies was utilized for this study. Brines used for pork bellies are injected at relatively low levels of brine addition, meaning that the brine ingredients are present at greater concentrations in a bacon brine than for many other injection brines in order to deliver the desired amount of each ingredient to the injected product. The bacon brine used in this study was composed of 80.21% water, 13.03% salt, 3.22% sugar, 2.97% phosphates, 0.47% sodium erythorbate and 0.01% sodium nitrite, to be injected at 12% of green belly weight. The sodium nitrite at 0.01% in the brine is 1,000 parts per million (ppm), and will result in 120 ppm ingoing for the product when injected at 12% of product weight as required by the USDA-FSIS for injected bacon. The brines were formulated following industry practice of dissolving the phosphates in the water first, followed by the erythorbate due to the limited solubility of these two ingredients. Once the phosphates and erythorbate were completely dissolved, the salt and sugar were added with the nitrite added last to minimize reaction with erythorbate prior to sampling. Experimental brines without phosphates, without erythorbate, and without erythorbate and phosphates were formulated in the same fashion but with additional water included to replace the weight of each of those ingredients.

The brines were sampled immediately, then stored at 0 °C – 2 °C. Samples were collected again after 1, 2, 4, 6, and 9 days following the brine formulation. Sample analyses included residual nitrite and brine pH. Nitrite analyses followed AOAC (1990) procedures for colorimetric determination with Griess reagents, and the pH of the brines was measured using a calibrated electrode and pH meter.

The experiment was replicated 3 times and statistical analysis done using SAS software (SAS Institute, Inc., Cary, NC). A two-way ANOVA analysis was used to assess changes in nitrite concentrations. Main effects and two-way and three-way interactions of the three variables (erythorbate, pH and storage time) for effects on residual nitrite were determined.

Results and Discussion

Table 1 displays the values for residual nitrite with storage time. The control brine, with all ingredients, was over 200 ppm (19.6%) lower in nitrite concentration after 24 hours, and over 300 ppm (31.6%) lower after 48 hours. The brine with erythorbate but without phophates lost almost 300 ppm (27.7%) following formulation while the brines without erythorbate and without phosphates and erythorbate each remained unchanged even after 9 days of storage. The pH of the control brine ranged from 5.75 to 5.89 while the brine without phosphates ranged from 6.20 to 6.82. The brine without erythorbate ranged from 5.73 to 5.75 and the brine without phosphates and erythorbate ranged from 6.69 to 6.92. The phosphate blend used for this experiment was recommended by the supplier for injected bacon, and is designed to accelerate curing reactions to reduce residual nitrite in the finished product, an important consideration for bacon. Clearly, the phosphate blend resulted in a mildly acidic effect on the pH of the control brine. This is counter to what is expected of most phosphates used in processed meats which are alkaline and will result in an elevated pH. The acidic pH in conjunction with erythorbate is intended for bacon to create more rapid nitrite reactions for curing in order to reduce the amount of residual nitrite in the finished product, and this is evident in the bacon brine as well. However, it was somewhat surprising that the brine with erythorbate (without phosphates) at a pH of over 6 resulted in rapid loss of nitrite following formulation of the brine with little subsequent change during storage. The reason for this observation is not clear. Comparison of the main effects and interactions showed that all two-way and three-way interactions of erythorbate, pH and storage time were highly significant ($P<0.001$).

The results of this experiment confirmed that nitrite can be readily depleted from injection brines with the rate highly dependent on nitrite reaction with reductants such as erythorbate. Depletion of nitrite in this study was significant following formulation of the brine with nitrite and erythorbate (without phosphates) at pH 6.20 to 6.82, and within 24 hours for the brine with all ingredients including phosphates and at a pH of 5.75 to 5.89. Thus such brines should be used as soon as possible following brine formulation.

Table 1. Nitrite concentrations (ppm) of brines during storage at 0 °C (mean ± SE)

	Storage time (days)					
	0	1	2	4	6	9
Control (Initial pH = 5.76)	1044.36 $\pm 3.21^{aA}$	839.03 $\pm 12.80^{bB}$	714.71 $\pm 8.12^{cC}$	510.12 $\pm 7.77^{dC}$	357.18 $\pm 7.72^{eC}$	235.38 $\pm 4.79^{fC}$
w/o phosphates (Initial pH = 6.82)	755.40 $\pm 28.83^{B}$	850.62 $\pm 14.07^{B}$	840.99 $\pm 48.57^{B}$	742.54 $\pm 16.10^{B}$	737.92 $\pm 25.87^{B}$	805.65 $\pm 36.38^{B}$
w/o erythorbate (Initial pH = 5.75)	1088.03 $\pm 5.85^{A}$	1074.77 $\pm 10.15^{A}$	1080.79 $\pm 8.11^{A}$	1081.67 $\pm 26.13^{A}$	1078.15 $\pm 10.40^{A}$	1080.18 $\pm 0.89^{A}$
w/o phosphates and erythorbate (Initial pH = 6.71)	1074.13 $\pm 8.44^{A}$	1092.51 $\pm 24.51^{A}$	1091.53 $\pm 10.09^{A}$	1072.63 $\pm 2.97^{A}$	1077.94 $\pm 3.75^{A}$	1098.22 $\pm 7.00^{A}$

$^{a-f}$: Means with different superscripts within a row are significantly different ($P < 0.05$)
$^{A-D}$: Means with different superscripts within a column are significantly different ($P < 0.05$)

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