Safety of Alternatively Cured Meats

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Curing is a historical method of preserving meat and poultry products. In current terms, it is recognized as a process where nitrate or nitrite is added with other ingredients, including salt, to raw meat and poultry meat and under the right conditions preserves the product with characteristic color, flavor and safety expectations. The primary ingredient responsible for these curing characteristics is nitrate or nitrite. The mechanism of curing is the same regardless of nitrite source, *e.g.,* sodium nitrite, celery powder or other plant-derived source of nitrate/nitrite.

CURING CHEMISTRY

Nitrite rather than nitrate is the functional constituent for the curing in meat and poultry products. If a nitrate compound is utilized, it must be reduced to nitrite. Typically, this reduction is performed by microorganisms that convert nitrate to nitrite. Conversion is not needed if sodium nitrite (NaNO2) or pre-converted plant-based nitrite is added. The chemistry of the curing process is outlined in the figure below.

The conversion of myoglobin to nitrosohemochrome can be assessed using the classical wet chemistry analysis called the Hornsey method, where an extract of the product is made and analyzed spectroscopically. This measures the percentage of the total heme pigment that is in the nitrosohemochrome form, *i.e.*, what percentage of the pigment has been "cured."

ORGANOLEPTIC CONSIDERATIONS

One consideration when using an alternative curing system is whether it will result in a typical cured product from an organoleptic standpoint. Since the same curing reaction takes place when using either sodium nitrite or plant-based nitrite, it is logical to conclude that the organoleptic attributes will be the same, as long as a sufficient equivalent level of nitrite is used. The Processing Inspectors' Calculations Handbook (1995 Revision, Page 12) states that 40 ppm of nitrite is "sufficient for color-fixing purposes and to achieve the expected cured meat or poultry appearance". Sebranek and Bacus (2007) also conclude that 40-50 ppm of nitrite is adequate for development of a stable cured color and flavor.

FOOD SAFETY

Nitrite is very effective in inhibiting the growth of *Clostridium botulinum* even at levels of nitrite less than 120 ppm. Hustad et al. (1973) determined that 50 ppm of ingoing nitrite inhibited toxin production in wieners for at least 28 days at 27°C. The effect of nitrite on bacterial inhibition is expected to be independent of nitrite source, so nitrite is reasonably expected to provide the same level of food safety, at any particular level of nitrite, regardless of whether it is derived from sodium nitrite or a plant-based ingredient (*e.g.,* celery, beet). The second consideration is whether an alternative curing system will provide sufficient bacterial inhibition for bacteria that have food safety implications, such as *Listeria monocytogenes*. As noted above, it is logical to conclude that nitrite will be effective regardless of the source, whether from sodium nitrite or with plant-derived nitrite ingredients such as celery. There is an abundance of scientific literature, commercial practices, and FSIS policies that support the premise that safe cured meat and poultry products can be produced. As shown in Fig. 1, the functionality of nitrite anion is not changed based on the initial nitrate/nitrite ingredient source.

As with any meat or poultry product, including cured and uncured items, manufacturers will need to consider the impact of formula and other factors (*e.g.*, product type, manufacturing process) on all relevant food safety parameters. Adjustments to any factors that affect food safety will trigger a need to consider whether other changes are useful or necessary. For example, if sodium is adjusted in formula, a manufacturer may need to make additional formula, processing, or other changes to achieve the same level of food safety protection. Establishments are responsible for ensuring that products cured with ingredients derived from plants have met the safety and other characteristics (*i.e.*, flavor and color) expected if cured by sodium nitrite. This can be achieved through a variety of scientific experiments and measurements.

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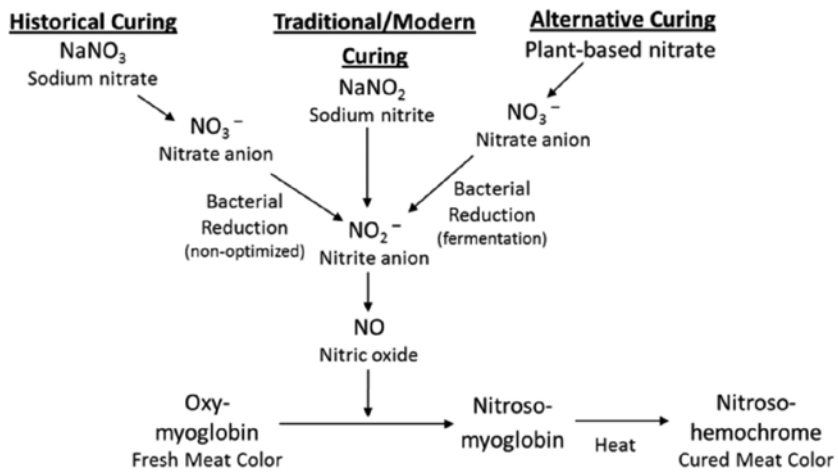

Figure 1. Curing chemistry

SCIENTIFIC STUDIES

There are a growing number of studies looking at the microbial growth of products cured with plant derived nitrite ingredients compared to those conventionally cured through the direct addition of sodium nitrite, however much of this research has not been published within peer-reviewed journals. Most of the academic research has occurred in the last five years and is in process of being published. Data also exists among establishments and ingredient companies, but that data is proprietary to each respective business sector.

Currently, the safety of plant-derived nitrite cured meat products has been evaluated in two different approaches. The first approach is a comparison of commercially available meat products that have been purchased at retail, inoculated, stored at specific environmental conditions and evaluated for microbial growth. Benefits to this approach include an evaluation of the safety characteristics of commercial products available to consumers and a general survey of current products available. Limitations to this approach include a lack of control over each product's shelf-life and unknown ingoing nitrite levels. Products in these studies also use a variety of ingredients and processes that can only be partially ascertained from the researchers' report of the product label. Because of this, this approach can show trends and identify areas for further study, but cannot provide guidance for formulating products.

The second approach is to produce products with known levels of ingredients and then inoculate and evaluate for growth. Benefits to this approach include standardization of processing parameters, ingredients, and microbial evaluation, as well as more reproducible data. This approach can also be used to provide guidance for formulating products to meet food safety requirements, if the study is designed with that in mind. Each of the two approaches can provide valuable data, but should be evaluated within the constraints of each method.

Commercial brands of conventionally cured meat products purchased at retail stores and inoculated typically inhibited the growth of *Clostridium perfringens* longer than brands of frankfurters and hams cured with plant-derived nitrite (Jackson et al., 2011a). This is likely due to lower levels of residual nitrite commonly observed in commercial brands of plant-derived nitrite cured products purchased at retail (Sindelar et al., 2007). This does not mean that the plant-cured products are inherently less safe; simply that they may require additional interventions or a more rapid chilling process. Certain brands of plant-derived nitrite cured frankfurters had similar growth protection as conventionally cured frankfurters, which demonstrate that formulas of plant-cured products can be adjusted to provide a similar level of inhibition to conventionally cured products.

Jackson and others (2011b) showed that meat treatments formulated with plant-derived nitrite did not inhibit C. perfringens as long as conventionally cured meats. However addition of certain natural antimicrobials resulted in similar inhibition for treatments formulated with plant-derived nitrite as compared to conventionally cured treatments. This again demonstrates that meats cured with plant-derived nitrite can provide similar inhibition to conventionally cured meats.

The work of Glass and Sindelar (2010) examined the antilisterial activity of a variety of natural flavorings, plant extracts and microbial fermentation byproducts for use in plant-cured meat and poultry products. Antimicrobials delayed listerial growth compared to control samples without antimicrobials. Glass and Sindelar (2010) data suggest that natural growth inhibitors can enhance food

safety like conventional growth inhibitors, but efficacy is enhanced in the presence of nitrite. Xi and others (2011) evaluated the effectiveness of curing frankfurters with plant-derived nitrite ingredients with or without an additional antimicrobial. No significant growth of L. monocytogenes was observed for 28 days from the initial 3 log10 CFU/g among all treatments. The frankfurters cured conventionally or containing cranberry powder with preconverted nitrite sourced from celery powder, did not have any significant growth of L. monocytogenes from the initial 3 log10 CFU/g over the 49 day test period.

Under specific conditions, plant-derived nitrite cured meat products can be effective in preventing the growth of *L. monocytogenes* and *C. perfringens*. The work of Glass and Sindelar (2010) and Jackson et al. (2011a; 2011b) demonstrate that products cured with plant derived nitrite can be made safely. Where there are reduced levels of nitrite in these products, in most cases an increased level of food safety ingredients, additional food safety ingredients, and/or other interventions (such as HPP or more rapid cooling) will be necessary. This is no different from the changes that must be considered when reducing salt to lower sodium.

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