UPDATE SESSION

Pinking in Poultry Symposium

Karen E. Friesen and John A. Marcy

In fully cooked poultry items, the presence of a pink or undercooked appearance is a major concern. This problem, while not a food safety issue, does present a quality issue as well as an economic concern to the processor. It is agreed that this problem occurs in a wide variety of poultry products ranging from restructured turkey rolls, to chopped and formed nuggets, to whole muscle breast fillets. Several types of pinking have been identified. Some pinking is found only on the product surface, while other pinking may be uniformly dispersed throughout the product or only in an emulsified portion of a restructured product. As the occurrence is sporadic and the pattern is varied, the pink color may have several causes.

We recognize that pinking may be the result of certain ingredients that contain endogenous or processing induced nitrite, such as green peppers or direct dried soy protein. Water used for processing may also be a source of nitrate/nitrite. Birds may come in contact with the water anywhere from the chiller to the marinator. Seasonality has also been linked to pinking, with higher occurrences noted in spring and fall. Also, identified as probable causes of pinking include cold stress, inhalation of exhaust fumes prior to slaughter, improper stunning.

Pigment Chemistry

Three pigments are present in muscle, myoglobin, hemoglobin, and cytochrome c. Myoglobin, MW 17,000, facilitates transfer of oxygen from blood to muscle and has a denaturation temperature of 78.5C. Myoglobin is a globular protein with a heme iron center. Hemoglobin is a larger molecule than myoglobin and serves to transport oxygen throughout the blood system. Hemoglobin also has a higher denaturation temperature than myoglobin. Cytochrome c, a smaller molecule than MB, requires a denaturation temperature of 105C. Higher denaturation temperatures also presents the possibility that cytochrome c can survive some cook treatments. In general, concentrations of pigments are higher in thigh meat than breast, and concentrations increase with bird age. Also, turkeys have higher pigment concentrations than broilers. Denaturation rate of these pigments during heating is related to pH, time and temperature. It is important to note that high pH produces a protective effect on the pigments, making them more difficult to denature yielding more myoglobin in the cooked product and a redder color.

In cooked products, several pigments have been identified as possible sources of pinking in cooked poultry products. First is undenatured myoglobin, resulting from insufficient heat treatment or other conditions such as pH that prevented the denaturation of myoglobin. Cytochrome c is a mitochondrial transport heme protein that is more heat stable that the other pigments and has been associated with pinking. Levels of cytochrome c have been associated with preslaughter stress. Some work has associated cytochrome c as the heme source for globin hemochromes.

Situations also exist in processing that lead to formation of cured meat pigment – mono nitrosyl hemochrome. Nitrite or nitrate may be inadvertently added to a product through water, ice, ingredients (especially direct dried soy and milk proteins) and combustion gases. Myoglobin is oxidized to metmyoglobin and nitrite is reduced to nitric oxide which complexes with metmyoglobin. During heating, globin denatures and nitrosyl hemochrome complex is formed which has a pink color. Unlike undenatured myoglobin, nitrosyl hemochrome pigment cannot be extracted in phosphate buffers but is extractable in 80% acetone. Levels of sodium nitrite necessary for detectable pink color were 14 ppm for beef, 4 ppm for pork, 2 ppm for turkey, and 1 ppm for chicken (Heaton et al., 2000). It was also noted that nitrates must have a reduction mechanism, such as bacterial reduction or the reduction capability of the raw meat, to be reduced to nitrite and enter into the reaction.

Denatured globin hemochromes are pigments typically associated with fully cooked meats, including canned, autoclaved or refrigerated. During cooking, as myoglobin is denatured, a pink-forming ligand complexes with globin. One common form is nicotinamide hemochrome, formed by heme iron binding to the B vitamin nicotinamide. These pink compounds are not extractable due to the denatured globin portion of the protein. They are spectrally recognizable.

Karen E. Friesen
Tyson Foods, Inc.
2210 Oaklawn Drive
Springdale, AR 72762
Friesenka@tyson.com

Controlling Pink Color Defect

Raw Material pH

High pH triggers pinking by making denaturation of heme proteins more difficult. If possible, high pH raw materials should be segregated and utilized in cured products or formulations less likely to develop pink color.

Chelators

Research was conducted to find a compound that would competively bind in the 5th and 6th position of the unfolded globin, inhibiting pink color formation. Using a model system containing sodium nitrite, various chelators were added to determine if they would competively inhibit binding of nitrite to heme. Pink color, as determined by instrumental measurement, was lower for all chelators. EDTA, DTPA, and CVPA while effective in reducing pink color are not USDA approved for use in meat and poultry products. Nonfat dry milk, which does have USDA approval, was effective in reducing pink color development upon initial cooking and during storage (Schwarz et al., 1999).

Further work evaluated various dairy proteins (nonfat dry milk, sodium caseinate, and whey) and their effectiveness in reducing pink color formation. Initial screenings showed differences in effectiveness of a protein type from different suppliers. For example, a whey protein from supplier A decreased pink color, while whey protein from supplier B actually increased pinking (Slesinski et al., 2000a). Using sources from prior screening, whey protein and nonfat dry milk were effective in reducing pink color, while sodium caseinates were less effective. Combinations of whey protein and nonfat dry milk may be the most economic means step to controlling pinking through dairy proteins (Slesinski et al., 2000b).

Citric Acid

Citric acid added at 0.3% resulted in a 57% reduction in a* value (redness indicator) in cooked ground turkey formulated with nicotinamide. A 63% reduction in redness (a* value) was observed in ground turkey containing nitrite and the red color equal to control (Kieffer et al., 1999). Further work needs to be done to determine how to incorporate citric acid without sacrificing product texture or yield.

Thermal Processing and Chilling

A system containing turkey and nicotinamide, a pink color generating ligand, was cooked to internal temperature from 77 to 80C. Increasing internal temperature increased the pink color. It was hypothesized that higher temperatures allow globin to unfold creating a binding site for nicotinamide reactions. Slower chill rates, dry-chilling versus ice slush, promoted formation of pink color. However, lower endpoint temperatures and quick chilling may increase the potential for undenatured myoglobin (Claus et al., 1994).

Combustion Gases

Products cooked in a direct fire oven (air is in direct contact with the burner) may develop a pink color on the outer surface to approximately 10 mm in depth, known as a pink ring. This color, while desirable in products such as a smoked beef brisket, is undesirable in poultry items. Carbon monoxide (CO), nitrogen oxide (NO), and nitrogen dioxide (NO_2) are pinking agents found in combustion gases, with CO and NO most commonly identified as the color-reactive gases. Gas levels typically associated with gas ovens, CO at 149 ppm and NO at 5 ppm, were insufficient to cause surface pinking (Cornforth et al., 1998). Carbon monoxide has a low affinity for cooked meat pigments, and levels of nitrogen oxide required for pink color development are much higher than those found in gas ovens. However, nitrogen dioxide (NO_2) was identified as a very reactive gas on moist surfaces. Surface pinking occurred in turkey at 0.4 ppm and roast beef at 2.5 ppm. Nitrogen dioxide reacts with moisture to form nitrous acid, which enters into the cured meat reaction. Greater surface moisture will lead to greater penetration of the pink ring (Cornforth et al., 1998).

Where indirect cooking is not a viable option, controlling NO_2 levels may minimize formation of pink rings. NO_2 is a by-product of incomplete combustion, therefore, gas-air mixing and keeping your burners clean and running efficiently becomes critical. Pink ring also occurred in mixed oven loads of cured and noncured products and in a situation of direct-fire heated makeup air. One other step to controlling pink ring formation is to dry the product surface during early cooking to minimize NO_2 absorption.

STEPS TO CONTROLLING PINK COLOR DEFECT

1. Identify all potential sources of nitrite and nitrates – water, poultry, ingredients.
2. Monitor endpoint temperature.
3. Monitor raw material pH.
4. Avoid cross contamination of cured and noncured items.
5. Avoid long delays before processing.
6. Routinely monitor combustion gases.
7. Consider addition on selected nonmeat ingredients to formulation – nonfat dry milk, blended phosphates, indirect dried ingredients, acidifiers.
8. Document pink occurrences .

FUTURE RESEARCH NEEDS

- Documentation of effect of holding time on pink color formation.
- Role of bacterial load in the conversion of nitrate to nitrite.
- Pink color in turkey is primarily associated with the emulsion phase, while in broilers, the pink color is more in whole muscle pieces.
- Development of systems using the "pink controlling" ingredients.
- Information database for documentation and tracking of occurrences of pinking.
- Pinking as related to bone-in products and marrow staining.
- Anti-mortem or physiological conditions promoting pinking, ie. Preslaughter stress, gaseous environment around live birds.

- Role of the porphryin ring in pinking, since the acid porphyrin ring is pink, and porphyrin rings have the ability to chelate.
- Irradiation, sterilizing and pasteurizing doses, and effect on pinking.
- Development of pink color during freezing process.

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