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Injection order effects on efficacy of calcium chloride and sodium tripolyphosphate in controlling the pink color defect in uncured, intact turkey breast

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ABSTRACT

An experiment was conducted to test sequential injection of sodium tripolyphosphate (STP; 0.5% meat weight basis, mwb) followed by injection with or without addition of calcium chloride ($CaCl_2$, 500 ppm mwb), and to test the effect of post-injection delay prior to cooking. A second experiment evaluated the impact of injection order and delay time between independent addition of $CaCl_2$ (500 ppm mwb) and STP (0.5% mwb). Turkey was formulated without an added pink generating ligand (NONE), with nicotinamide (NIC; 0.1% mwb), or with sodium nitrite (NIT; 10 ppm mwb). A white colloid was observed in the extracellular space of treatments containing both STP and $CaCl_2$. Addition of $CaCl_2$ decreased nitrosylhemochrome but did not reduce levels of nicotinamide hemochrome or CIE a* values. Injection order or delay between injections did not contribute to controlling the pink defect in cooked, intact turkey breast.

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1. Introduction

The pink color defect is a condition that causes consumer concern or rejection of uncured, fully cooked light meat poultry products due to a not fully cooked appearance. Causes of the defect are well documented and include high meat pH, high reducing ability, the presence of extraneous nitrite, and high pigment levels (Holownia, Chinnan, & Reynolds, 2003; Maga, 1994). Potential consumer rejection of poultry products with the pink color defect decreases the value and potential uses of raw materials with these causative factors. For this reason, the use of ingredients to reduce the pink color defect holds considerable value.

Ingredients effective in reducing the pink color defect in ground poultry products include nonfat dried milk, calcium chloride, tricalcium phosphate, metal chelators (*trans* 1,2-diaminocyclohexane-*N,N,N′*,citric acid, sodium citrate, *N′* tetraacetic acid monohydrate, ethylenedinitro-tetraacetic acid disodium salt, diethylenetriamine pentaactetic acid), and whey protein concentrates (Dobson & Cornforth, 1992; Kieffer, Claus, & Wang, 2000; Sammel & Claus, 2003a; Sammel & Claus, 2003b; Sammel & Claus, 2007; Schwartz, Claus, Wang, Marriott, Graham, & Fernandes, 1997; Slesinski, Claus, Anderson-Cook, Eigel, Graham, & Lenz, 2000). With the exception of citric acid and sodium citrate, the listed metal chelators cannot be legally added to meat products. Additionally, metal chelators appear to be more effective in ground poultry products than whole muscle poultry products (Sammel & Claus, 2003a; Schwartz, Claus, Wang, Marriott, Graham, & Fernandes, 1999). Whey protein concentrates may increase occurrence of the pink color defect (Dobson & Cornforth, 1992; Sammel & Claus, 2003b; Slesinski et al., 2000). Sammel and Claus (2007) showed that calcium chloride and tricalcium phosphate were effective against pink color defect in ground turkey breast, but not in intact turkey breast. In addition, tricalcium phosphate decreased meat pH and cooking yield, which is unfavorable to commercial processors.

A solution of calcium chloride ($CaCl_2$) and sodium tripolyphosphate (STP) in water will yield a white colloid. Sammel and Claus (2007) incorporated calcium chloride and sodium tripolyphosphate into intact turkey breast simultaneously and observed the colloid form in the breast. They hypothesized that this colloid was due to the development of calcium–phosphate complexes in solution before injection. In turn, the complex may not have been able to enter the myofibers of intact muscle because the cell membranes were still intact and impermeable to such a large compound. It may be possible to inject each ingredient separately to promote complex formation within the intact muscle instead of in the injection solution. The hypothesis of this study was that $CaCl_2$ and STP must individually and uniformly enter into the intact muscle before forming a complex to provide adequate control of the pink color defect. To test the hypothesis, the objectives of this research were to determine if staging the incorporation of $CaCl_2$ and STP is needed to provide significant control of the pink color defect in uncured, cooked, and intact turkey breast meat. More specifically, this research investigated the effects of STP with and

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without $CaCl_2$, the order of incorporation of $CaCl_2$ and STP, and the delay between incorporation of each ingredient on control of the pink color defect.

2. Materials and methods

2.1. Turkey breast preparation

Eighty-one boneless, skinless turkey breasts (*pectoralis major*) were procured in two batches (36 and 45 breasts, respectively) from a local processor two days postmortem. Upon arrival at the University of Wisconsin Meat Science Laboratory, they were vacuum packaged, (barrier bag #7500-1981, Bunzl Processor Division, Kansas City, MO; Supervac GK 184/B, Smith Equipment Company, Clifton, NJ) five per bag, and frozen at −21 °C for 10–60 days. Prior to sample preparation, the breasts were thawed for 48–72 h at 2 °C. Following thawing, the frontal portion of the breast was cut to obtain roughly a cube-shaped (7–9 cm each side) section that weighed 497 g (±9 g). Each breast section was assigned to one of six experiments. A 10 g sample was retained from each breast before and after cooking to determine meat pH. The pH was measured with a pH meter (Accumet AR 50, Fischer Scientific, Pittsburgh, PA) equipped with a glass-encased pH probe (Orion 910600, Thermo Electron Corp., Beverly, MA) using the 10 g sample homogenized in 90 mL of distilled, deionized water.

The first experiment was conducted to test the addition of sodium tripolyphosphate (STP, Astaris, St. Louis, MO; 0.5% on a meat weight basis, mwb) with and without the addition of calcium chloride ($CaCl_2$, Sigma–Aldrich Co., St. Louis, MO, 500 ppm mwb), and to test the effect of post-injection delay prior to cooking. This experiment was done by including one of three pink generating ligands (PGL) in the injection solution. Breasts were injected without a PGL (NONE), with nicotinamide (NIC, Sigma–Aldrich Co., St. Louis, MO, 0.1% mwb) or with sodium nitrite (NIT, Sigma–Aldrich CO., St. Louis, MO, 10 ppm mwb). Individual breasts were randomly assigned to 1 of 4 injection treatments relative to STP and $CaCl_2$. Each treatment involved the injection of a solution containing STP followed immediately by the injection of a second solution. All treatments were formulated to contain sodium chloride (2% mwb) that was divided evenly between the first and second solutions. All ingredients were dissolved in distilled, deionized water and each solution was injected at 15% on a meat weight basis to achieve a 30% injection. For the formulations with a pink generating ligand, the PGL was included in the first solution to approximate the presence of the pink color defect prior to treatment. For the treatments with $CaCl_2$, the $CaCl_2$ was included in the second solution. The first two treatments served as references (trt 1: STP only, cooked immediately after injection and tumbling 90 min; trt 2: STP only, cooked 24 h after injection and tumbling 90 min). In treatment 3, each breast was injected with STP and then $CaCl_2$, tumbled for 90 min, and cooked immediately. Treatment 4 was the same as treatment 3 except each breast was cooked after 24 h storage post-injection and tumbling (4 °C).

Experiment two was conducted to test the impact of injection order and delay time between the independent addition of calcium chloride ($CaCl_2$, 500 ppm mwb) and sodium tripolyphosphate (STP, 0.5% mwb). Experiment two tested the effects on turkey breast formulated without an added pink generating ligand (NONE), with nicotinamide (NIC; 0.1% mwb), and with sodium nitrite (NIT; 10 ppm mwb), respectively. Individual breasts were randomly assigned to 1 of 5 injection treatments. Each treatment involved the injection of two solutions of ingredients dissolved in distilled, deionized water, each at 15% on a meat weight basis. All treatments included sodium chloride (2% mwb) divided evenly between the solutions. For the treatments formulated with a pink generating ligand (PGL), the PGL was included in the first solution. All treatments were cooked 48 h after the initial injection. In treatment 1, each breast was injected with a solution of STP, a solution of $CaCl_2$ immediately thereafter, tumbled (90 min), and stored (4 °C) until cooking. In treatment 2, each breast was injected with STP, tumbled (45 min), stored (6 h post initial injection), injected with $CaCl_2$, tumbled (45 min), and stored before being cooked. For treatment 3, each breast was injected with STP, tumbled (45 min), stored (24 h post initial injection), injected with $CaCl_2$, tumbled (45 min), and stored before being cooked. Treatments 4 and 5 were the same as 2 and 3, respectively, except $CaCl_2$ was incorporated in the first solution and STP was in the second solution.

For both experiments, each solution was injected into the turkey breasts using a 16 gauge needle attached to a 50 mL pistol-grip livestock dosing syringe (Model 1005, Neogen Corp., Lexington, KY). The syringe was set to deliver approximately 2 mL per injection. Injections were performed approximately 1 cm apart on both sides of the breast. The needle was completely inserted for each injection and solution was expelled while the needle was withdrawn. All injections were performed within an individual vacuum canister assigned to each breast and solution that was not taken up on the first injection was reinjected once.

Following injection, each breast was sealed in a 22.2 cm × 17.1 cm × 17.1 cm (length, height, width, respectively) rectangular vacuum canister (Model T16-0059, Jarden Consumer Products, San Francisco, CA) at −15 mm Hg using a household vacuum sealer (Model 01263, Jarden Consumer Products, San Francisco, CA). Each canister was wrapped in bubble wrap to prevent damage and movement during tumbling. Canisters were stacked in a 30.5 cm diameter cardboard tube (perpendicular to the long axis) with each canister lid facing in an opposite direction to allow the canisters to interlock in the tube. The ends of the tube were sealed and the tube was placed on a small vacuum tumbler chassis (Meat Packers & Butchers Supply Co., Los Angeles, CA). Each canister was tumbled (2 °C) at a rate of 11.7 rpm for the time specified for each treatment.

Percentage uptake was determined by removing each breast from its canister following tumbling and placing the breast in a barrier bag (#030168; Bunzl Processor Division, Kansas City, MO). A tare weight was subtracted for the barrier bag and the weight of each breast was recorded. The barrier bags were then vacuum-sealed and water cooked (90 °C water temperature, Model KET-12T; Cleveland Steam Cooking Specialists, Toronto, Canada) to an internal temperature of 80 °C. One extra breast sample was trimmed to 500 g, vacuum packaged in a barrier bag, fitted with two thermocouples in the geometric center, and used to determine when the target endpoint temperature was reached. Thermocouples were attached to a 12-channel thermocouple scanner (Model #92000-00, Cole Parmer Instrument Company, Barrington, IL). Immediately following cooking, all cooked samples were placed in ice and stored at 2 °C overnight before post-cooked weights determined.

2.2. Dependent variables measurements

A colorimeter (CR-300; 1 cm aperture, illuminant C; Minolta Co., Osaka, Japan) was used to measure CIE $L^*a^*b^*$ values and an ultraviolet/visible scanning spectrophotometer (Model 2101PC; Shimadzu Inc., Kyoto, Japan) was used to measure reflectance from 400–700 nm with 1 nm increments on freshly-cut surfaces of each sample. Both instruments were calibrated with a white plate (L^* 97.06, a^* −0.14, b^* 1.93; Minolta Corp., Osaka, Japan). Three 1.25 cm slices were cut perpendicular to the longitudinal axis of each intact breast sample from which 6 colorimeter readings and 3 reflectance scans were taken immediately following cutting.