Ability of Various Dairy Proteins to Reduce Pink Color Development in Cooked Ground Turkey Breast


ABSTRACT: Dairy proteins were evaluated for their ability to reduce pink color in ground turkey samples. Sodium nitrite and nicotinamide were added to induce pink color formation. Nonfat dry milk (NFDM) and 1 of the whey protein concentrates (WPC) reduced CIE a* values in samples containing 10 ppm sodium nitrite. All of the dairy proteins tested reduced CIE a* values in nicotinamide-treated samples. In samples prepared without nicotinamide or nitrite, only WPC reduced CIE a* values, while the other proteins tested had no effect or increased redness. NFDM or specific WPC proteins could be used to reduce the pink color defect and increase yield.

Key Words: poultry, pinking, whey, casein, caseinate

Introduction

The spontaneous and unexplainable occurrence of a pink color in cooked, uncured turkey is a problem the poultry industry has faced for many years. Many causes have been blamed for this defect, including nitrite or nitrate contamination (Ahn and Maurer 1987; Froning and others 1969; Mugler and others 1970; Nash and others 1983), oven gasses (Pool 1956), heat stability of cytochrome c (Girard and others 1990), and the formation of denatured globin and nicotinamide hemochromes (Cornforth and others 1986). Even with the large amount of research devoted to the pink color defect, this problem is still prevalent in the industry.

Dobson and Cornforth (1992) examined the ability of nonfat dry milk (NFDM) and whey protein concentrate (WPC) to reduce pink color development of stored turkey samples. The authors based their research on reports that NFDM was able to lighten the color of bologna (Rongey and Bratzler 1966) and that calcium caseinate had a whitening effect on chicken meat (van den Hoven 1987). NFDM was found to reduce red color development in the samples. However, WPC increased the redness (Hunter a) to a level that was “visibly pink” upon cutting. Dobson and Cornforth (1992) speculated that NFDM’s ability to reduce the pink color in turkey could be related to an increase of the oxidation-reduction potential leading to a reduction in the formation of denatured hemochromes.

Schwarz and others (1997) found that NFDM reduced red color when sodium nitrite (150 ppm), nicotinamide (1.0%), or no ligand was added. The ligands were added to the meat system in order to induce a pink color in the cooked turkey. The level of nitrite added by Schwarz and others (1997) would not be indicative of a contamination event but rather of a purposeful addition to produce a cured product.

The objective of this research was to determine the effectiveness of 7 commercially available dairy proteins on the reduction of pink color development in ground turkey breast samples treated to display a pink color. The pink color was induced in the products by the addition of 10 ppm nitrite or 1.0% nicotinamide.

Results and Discussion

Yield and pH

All of the dairy protein treatments increased yield (P < 0.05) compared to the reference samples (no added dairy protein) within each of the ligand treatments (Table 1). The increase in yield can be attributed to the ability of the dairy proteins to bind water, increase gelation, and stabilize the meat system during cooking (Huffman 1996; van den Hoven 1987). On average, yield increased approximately 3.7%, 2.5%, and 3.6% for the no ligand, nicotinamide, and nitrite-treated samples, respectively, compared to the reference samples within each ligand group. Although not the intent of the research, it was unknown why the nicotinamide-treated samples had a higher overall yield than the other ligand treatments.

Although there were some differences (P < 0.05) in the pH values of the treatments, these were considered marginal in terms of practical significance (data not shown). The mean pH values ranged from only 6.17 to 6.25 for all of the ligand treatments.

Color measurements

CIE a* values (redness). When no pink-color-generating ligand was added, NFDM had no effect on CIE a* values (P > 0.05) as compared to the reference sample produced with no-ligand samples (NL-REF; Fig. 1); this disagrees with the work of Dobson and Cornforth (1992) and Schwarz and others (1999), who found NFDM to reduce redness in samples where no pinking agents were added. The natural variation in raw materials may have obscured NFDM’s ability to reduce redness. In addition, the percentage of brine solution added for both of the studies mentioned was only 10% to 20% as compared to the 30% added in this work.

Compared to the NL-REF, WPC-A did not affect CIE a* values (P > 0.05), whereas WPC-B, 2 sodium caseinates (SC-A and SC-B), and MPC increased CIE a* (P < 0.05) and WPC-C decreased CIE a* (P < 0.05). These observations are very important because they demonstrate that the addition of certain dairy proteins may increase the redness in commercial products, while others may reduce redness. Additionally, the increase in redness is not consistent within the specific classes of dairy proteins, as was demonstrated among the WPC proteins. Dobson and Cornforth (1992) found that the WPC they tested increased the redness of the products to a “visibly pink” color with a corresponding increase in Hunter a (redness) values. In our work, WPC-B in-
creased the redness ($P < 0.05$) as was reported by Dobson and Cornforth (1992). Since, WPC-A had no effect on CIE $a^*$ values and WPC-C reduced CIE $a^*$ values ($P < 0.05$), these proteins could be added to increase yield and possibly improve texture without an increase in redness.

Nicotinamide, which has been reported to increase CIE $a^*$ values (Claus and others 1994; Cornforth and others 1986), also visually increased the nicotinamide-treated (NIC-REF) samples as compared to the NL-REF samples. All of the dairy proteins tested reduced the nicotinamide-induced pink ($P < 0.05$; Fig. 1) as compared to the NL-REF NFDM, all WPCs and MPC reduced values well below the no protein control ($P < 0.05$) virtually eliminating the pink color induced by the nicotinamide (Fig. 1). While the mechanism for the pink color reduction has not been revealed, it could be speculated that an interaction between the nicotinamide and dairy protein or the dairy protein and the heme during the cooking process might be involved.

Addition of 10 ppm sodium nitrite also visually increased the red color of the turkey samples compared to the NL-REF. Overall, the dairy proteins were not as effective at reducing nitrite-induced pinking compared to the NIC samples as was reported by Schwarz and others (1999). NFDM and WPC-C were the only 2...
proteins able to reduce (P < 0.05) the pink color among the nitrite-treated samples compared to the nitrite-treated (NIT-REF) samples (Fig. 1). SC-A, SC-B, WPC-B, and MPC increased the redness (P < 0.05) when nitrite was added (Fig. 1).

When evaluating the ability of the dairy proteins to reduce pink color in turkey under all 3 ligand treatments, NFDM, WPC-A, and WPC-C were the only proteins tested that consistently reduced or had no effect on the redness.

CIE b* (yellowness). When no pink-generating ligand was added, NFDM, SC-A, and WPC-A did not affect the yellowness (CIE b*) compared to the NL-NP control (P > 0.05; Fig. 2). However, SC-B, WPC-B, and MPC reduced CIE b* (P < 0.05), while WPC-C was the only protein to increase the yellowness (P < 0.05).

Within the nicotinamide-treated samples, NFDM, all of the WPC proteins, and the MPC increased the yellowness (P < 0.05) compared to the NIC-REF samples. Neither SC protein tested had an effect on the yellowness (P > 0.05) compared to the NIC-REF.

Overall, the nitrite samples appeared to be less yellow than the other ligand treatments. Within the NIT samples, only WPC-C increased the yellowness (P < 0.05) as compared to the NL-NIT control. SC-B, WPC-B and MPC reduced CIE b* (P < 0.05) while NFDM, SC-A, WPC-A had no effect (P > 0.05).

CIE L* (lightness). Increases in the lightness of turkey breast products may improve the overall appearance of the product. NFDM and all WPCs increased the lightness of the turkey samples regardless of ligand treatment (P < 0.05; Table 1), in contrast to Dobson and Cornforth (1992), where no increase was found. Both of the SC proteins tested reduced the lightness of the samples (P < 0.05) in all 3 ligand treatments with only 1 exception where the reduction in L* by SC-B was not significant (P > 0.05). MPC increased lightness in nicotinamide treated samples (P < 0.05) but did not have an effect in no ligand and nitrite-treated samples (P > 0.05).

Chroma and hue angle. Chroma, a measure of color saturation, does not relate to specific hue differences among samples. Within the ligand and dairy protein treatments, differences in chroma measurements were minimal (Table 1). Because the chroma values were similar, the hue offers a comparison of red color among turkey samples with lower values tending to be redder in color. Among the experimental samples, the hue angle measurements varied from a high of 91.9, which was yellow in color to a low value of 47.0, which was visibly pink in color (Table 1). Similar to CIE a* and CIE b* values, the dairy proteins did not consistently change the hue angle values over the different ligand treatments.

Generally, the hue angle measurements (Table 1) followed the same trends as the CIE a* value measurements (Fig. 1). The hue angle of the no ligand added and nitrite-treated samples followed the same trends as the CIE a* values when compared to the appropriate reference samples, with only a few exceptions. In both cases, NFDM and WPC-A did not have any effect (P > 0.05) on hue angle (Table 1). SC-B, WPC-B, and MPC decreased the hue angle (P < 0.05), and thus reduced yellowness and increased redness. SC-A caused a reduction in hue angle when no ligand was added (P < 0.05), but had no effect in the nitrite-treated samples. Only WPC-C was able to increase the hue angle as compared to the reference controls (NL-REF and NIT-REF). Within the nicotinamide-treated samples, all the dairy proteins reduced the hue angle (P < 0.05).

Pigment measurement

In the nicotinamide-treated samples, the amount of NICHEME was reduced (P < 0.05) by all of the dairy proteins with the exception of the 2 SC proteins (Table 1). With the exception of the 2 SC proteins, reductions in pigment followed similar patterns to the reduction of red color (CIE a*). Because the SC proteins reduced redness but did not reduce NICHEME, it is possible that SC-A and SC-B may have a different mode of action in reducing the nicotinamide-induced redness.

NFDM, WPC-A and WPC-C reduced NITHHEME, whereas SC-B, WPC-B and MPC increased NITHHEME. These changes in NICHEME also followed the same trend as reductions and increases in CIE a* values. This agrees with work done by Ahn and Maurer (1989), who found increased redness as NITHHEME increased.

Conclusions

NFDM, WPC-A, and WPC-C could be added to processed turkey products to potentially increase product yield, increase lightness, and reduce pink color generation caused by variations in nicotinamide content or nitrite contamination. Processors need to be aware that addition of some dairy proteins at a 3% level can increase pink color in turkey products. Further research should focus on the mechanism(s) responsible for the reduction in pink color by specific dairy proteins. An opportunity exists for a dairy protein or some component of dairy proteins to reduce or eliminate the pink color defect. Currently, WPC-C and NFDM show the best potential for this effect.

Materials and Methods

Sample preparation

Boneless turkey breast muscles (pectoralis major) were obtained from a Virginia processor for each of 3 replications on separate production days. The turkey breasts were transported on ice to the meat laboratory of Virginia Tech (Blacksburg, Va., U.S.A.), where they were coarsely ground through a 1.27-cm plate (model 4532, Hobart Mfg. Co, Troy, Ohio, U.S.A.). The composite turkey meat was mixed for 4 min, vacuum-packaged, and frozen in barrier bags (item 030056; Koch Supplies and Equipment Co., Kansas City, Mo., U.S.A.). Frozen turkey was stored for 1 to 6 wk at approximately −10 °C. After adequate thawing at 2 to 4 °C (approximately 36 to 48 h), the turkey was ground twice through a 4.76-mm plate.

The finely ground turkey samples were formulated to contain 2.0% sodium chloride, 0.5% sodium tripolyphosphate, and a pink-color-generating ligand (no ligand, 1.0% nicotinamide, 10 ppm sodium nitrite). The above ingredients were incorporated on a meat weight basis (MWB) in a 30% solution with distilled, deionized water making up the balance of the brine solution. Also formulated on a MWB, 7 commercial dairy proteins were added in the dry state at 3.0%. The dairy proteins tested included nonfat dry milk (NFDM; A.C. Legg Inc., Birmingham, Ala., U.S.A.), 2 sodium caseinates (SC-A, Alenate 180; and SC-B, K413; Kerry Ingredients, International, Beloit, Wis., U.S.A.), 3 whey protein concentrates (WPC-A, Alacen 841; WPC-B, Alacen 878; and WPC-C, Alacen 882). All products with the exception of NFDM and SC-B were obtained from New Zealand Milk Products Inc. (North America, Santa Rosa, Calif., U.S.A.). As a basis of comparison, reference samples containing no dairy proteins were also produced within the no-ligand (NL-REF), nicotinamide- (NIC-REF) and nitrite- (NIT-REF) treated samples.

The ligands sodium nitrite (0.10 g/L), nicotinamide (100 g/L), and no ligand (distilled deionized water only) solutions (220 mL each), were added to the ground turkey (2.2 kg) and mixed for 1 min (model K45SS; Kitchen Aid, St. Joseph, Mich., U.S.A.).
Pink Color Reduction by Dairy Proteins

U.S.A.). Large ligand batches (2.42 kg) were split into smaller portions (275 g) for individual dairy protein treatments. Upon addition of a salt/phosphate (50 mL; 100 g/L salt and 25 g/L phosphate) solution and the dry dairy proteins (3.0%, MWB), the samples were mixed for 1 min, using a hand mixer (model KHM3WH-1; Kitchen Aid, St. Joseph, Mich., U.S.A.). Approximately 45 g of the turkey mixture was stuffed into 50-mL plastic test tubes and centrifuged (model PR-2; International Equipment Company, Boston, Mass., U.S.A.) at 2000 × g for 10 min and stored overnight at 2 to 4 °C to allow for ingredient interactions. Samples were cooked in an 85 °C circulating water bath (custom-built; Virginia Tech, Blacksburg, Va., U.S.A.) to an internal temperature of 80 °C then cooled to 50 °C in an ice bath and stored overnight at 2 to 4 °C. Internal temperature of the products was monitored throughout the cooking process using a data logger (model 5100; Electronic Controls Design, Milwaukee, Ore., U.S.A.) attached to thermocouple-containing samples randomly located throughout the water bath. Duplicate samples were made for each treatment combination.

Instrumental evaluation

Color measurements. Duplicate color measurements (CIE L*, a* and b* values) were made on the cut surface of each sample using a chroma meter (model CR-310; Minolta Corp., Osaka, Japan) with a 1-cm aperture at a right angle to the cut surface rotating the sample 90° between measurements. The chroma meter was calibrated using a white plate (L* 97.91, a* -0.68, b* 2.45).

CIE L* is a measure of lightness in samples on a scale from 0 to 100 with high values being very light. CIE a* is a measure of the green (negative values) or red (positive values) color. CIE b* relates to the blue (negative) or yellow (positive) color. From these measurements, hue angle and chroma were calculated using the following formulas:

\[
\text{hue angle (hangle)} = \tan^{-1} \left( \frac{b*}{a*} \right)
\]

\[
\text{chroma (C*)} = \sqrt{(a*)^2 + (b*)^2}
\]

When chroma values are similar, the hue angle is a good measure of the red color. Values near 90° relate to yellow color, whereas smaller values (closer to 0°) relate to very red samples. Chroma is a measure of the color saturation.

Pigment determination. Two spectrophotometric reflectance measurements were taken on the freshly cut surface using a ultra-violet/visible scanning spectrophotometer (model 2101PC; Shimadzu Inc., Kyoto, Japan) from 400 to 700 nm. The instrument was configured for a sampling interval of 1.0 nm, slit width of 2.0 nm and fast scan speed and was calibrated using a white calibration plate (L* 97.91, a* -0.68, b* 2.45).

The reflectance (R) ratio of %R at 537 nm divided by %R at 553 nm was used to predict nicotinamide hemochrome (NICHHEME) in the no-ligand and nicotinamide-treated samples (Schwarz and others 1998). Nitrosyl hemochrome (NITHHEME) was determined in the no-ligand and nitrite-containing samples by the reflectance ratio of %R at 650 nm divided by %R at 570 nm (AMSA, 1991; Erdman and Watts, 1957; Kraft and Ayres, 1954).

pH determination

The pH of raw samples was measured using a pH electrode (item 13-620-298; Fisher Scientific, Pittsburgh, Pa., U.S.A.) and a pH meter (model AR25; Fisher Scientific), by diluting 15-g samples with 150 mL distilled water. The diluted meat samples were homogenized (20 mm shaft, part number 225318; Virtis Co. Inc., Gardiner, N.Y., U.S.A.) for 20 s prior to pH measurement.

Yield determination

The cooking yield was determined by the following formula:

\[
\text{cooking yield (%) = (1 - raw product weight - cooked product weight)/raw product weight) × 100}
\]

Statistical analysis

Statistical analysis was performed using the 1-way analysis of variance procedure of SAS (1990) to identify statistical differences between dairy protein treatments within ligand treatments. Differences among means for the responses of yield, pH, and color measurements were determined using the Tukey’s Least Significant Difference procedure.

References


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