

Identifying Causes that Develop the Pink Color Defect in Cooked Ground Turkey Breasts and Red Discoloration of Turkey Thighs Associated With the Bone

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Introduction

Cooked uncured turkey occasionally exhibits an undesirable pink color even when cooked to temperatures ensuring food safety. It has been estimated that this pink color defect affects 1-2% of the turkeys harvested each year resulting in serious economic losses to processors and retailers of poultry products. Much is known about the factors affecting the formation of the pink color defect (Cornforth et al., 1986; Ahn & Maurer, 1990; Froning, 1995) and some success has been reported in limiting the degree of pink through the use of non-meat ingredients (Schwarz et al., 1997; Sammel & Claus, 2003, 2007). A challenge with studying the pink color defect is its sporadic occurrence. To overcome this problem, many have created a pink defect by adding nitrite, nicotinamide, or other pink generating ligands. Although this has value, it may not be indicative of the actual sporadic pink pigment. This research explored a model to reproduce a more natural pink defect without having to add a pink generating ligand. Based on industry observations, storage of ground turkey appeared to be more prone to causing a pink defect, particularly when presalted. The objectives of this research were to: (1) characterize the pink pigments associated with storing presalted and ground turkey breast; (2) evaluate the ability of pink inhibiting ingredients to control the pink discoloration in cooked ground turkey breast produced from presalted stored and ground turkey; (3) investigate the difference in cooked color and pigment characteristics associated with turkey breast trim locations in cooked ground turkey; and (4) evaluate the chemical and physical differences between turkey thighs with and without red around the bone.

Materials and Methods

Experiment 1. Fresh, skinless ground turkey breasts (1 day PM, 3.2 mm plate) were provided by Jennie-O Turkey Store. This ground turkey was used to prepare the following four treatments: Treatment 1 (no salt, stored 7 days before cooked), Treatment 2 (NaCl, stored 7 days before cooked), Treatment 3 (NaCl added and immediately cooked), and Treatment 4 (stored 7 days before salted and cooked). At the time of salt (2%) addition, the ground meat was mixed for 3 min, stored under refrigerated temperature (2-3 °C) and then stuffed into conical centrifuge tubes (50 g each). Tubes were cooked (71.1, 73.9, 76.7, 79.4 °C), cooled (20 min) in ice and stored (2 °C) overnight in the dark until further analysis.

Experiment 2. The processing procedure from experiment 1 that produced the most intense and consistent pink color defect was used (Treatment 2). The starting raw material (ground salted turkey breasts) was tested independently with and without sodium tripolyphosphate (STP, 0.5%). A control without a pink inhibiting ingredient (PII) was compared to product formulated with one of four PII (calcium chloride, sodium citrate, citric acid, EDTA) added at two to three levels of addition. PII and STP were dissolved in water to deliver a 20% added solution (meat weight basis). Ground meat was cooked (76.7 °C) using a fast and slow heating rate, cooled and stored (14 days) before analysis.

Experiment 3. Fresh, skinless and boneless turkey breasts from 20 birds per replication were used. Trim from four anatomical locations (anterior, posterior, dorsal, and ventral) was tested. To manufacture cooked ground turkey breast samples, a standardized processing procedure from experimental 1 (Treatment 2) was selected.

Experiment 4. Two groups of turkey thighs were collected; one group had red around the bone and the other group without red ($n= 24$ per replication). Most of the determinations were performed at different distances from the bone (three, 0.5 cm wide sections starting from the bone).

All experiments were completed with four replications. Dependent variable data were analyzed using PROC MIXED Model of SAS. When significance ($P<0.05$) was found in the model, differences in least square means were reported.

Results

Experiment 1. Processing conditions affected pink discoloration in cooked ground turkey breast (Table 1). Undenatured myoglobin in salted meat (Treatment 2, 3, 4) still remained (17-19 %) after cooking. Salted and stored meat (Treatment 2) had the most reducing condition (lowest ORP) and redness (CIE a^* value). Final internal temperature had limited effects on pigment properties. ORP was similar across the cooking temperature while CIE a^* value decreased with temperature (Table 2). Even at 175 °C, 15 % undenatured myoglobin remained. Cooking yield decreased with temperature as expected (92.8-89.5%).

Experiment 2. Pink inhibiting ingredients (PII) without STP influenced all variables. Citric acid treatment had lower cooking yield, pH, CIE a^* value, and myoglobin content in cooked products. Fast cooking rate caused higher CIE a^* value, cooking yield, PMD, and redness reflectance indicators (R650/R570, R537/R553; data not shown). Similarly, PII with STP influenced all variables for cooked products. CIE a^* values were reduced by adding PII and slow cooked samples were more red than fast cooked samples (Table 3). Citric acid reduced redness parameters (CIE a^* , R650/R570 ratio, R537/R553 ratio) but caused the lowest cooking yield at both cooking rates.

Experiment 3. In raw ground turkey breast, no significant effects on nitrite content, CIE a^* value, R650/R570, and R537/R553 ratio at different trim locations were found. Raw

meat from the anterior location had higher pH and myoglobin content than other locations whereas samples from posterior had lowest pH value (data not shown). When ground turkey breasts were cooked, no significant difference in nitrite content, PMD, CIE a^* value, nitrosylhemochrome, total pigment, R650/R570, and R537/R553 ratio at different trim locations was observed. However, products from posterior had lower cooking yield, pH, and ORP compared to others (Table 4).

Experiment 4. Turkey thighs with red around the bone had higher pH, myoglobin content, but did not yield differences in CIE a^* value compared to non-red samples (Table 5). The pH and hemoglobin content in the bone marrow from with and without red around the bone were similar.

Discussion

To limit the degree of the pink color development processors should avoid storage of ground turkey, particularly when mixed with salt. Significant amounts of undenatured myoglobin remained even when cooked to 79.4 °C. Extending the cooking times would be expected to further denature this pigment. The pink color associated with storage of presalted ground turkey can be reduced by the incorporation of citric acid or calcium chloride, although incorporation of citric acid will increase cooking losses. Use of sodium citrate would offer some control with less of a negative impact on cooking losses. Anatomical location of breast trim does not appear to play a significant role in the generation of a pink defect. Bone marrow constituents have the potential to raise the pH in the surrounding muscle and therefore preserve the red color of myoglobin. However, this may only be of practical significance near artery entrances or with fractured bones.

References

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Table 1. Effects of processing conditions on oxidation reduction potential, CIE a^* and percentage myoglobin denaturation in cooked ground turkey breast

Treatments	Dependent Variables ¹		
	ORP (mV)	CIE a^*	PMD (%)
1- No salt, stored 7 days before cooked	-58.08 ^c	7.17 ^b	86.8 ^a
2- NaCl, stored 7 days before cooked	-65.85 ^a	7.49 ^a	81.4 ^b
3- NaCl added and immediately cooked	-60.83 ^b	6.83 ^c	81.8 ^b
4- Stored 7 days before salted and cooked	-63.13 ^b	7.46 ^a	83.2 ^b

¹ Dependent variables: ORP (oxidation reduction potential), CIE a^* (redness), PMD (Percentage myoglobin denaturation). S.E.: 3.59 ORP, 0.28 CIE a^* , 0.59 PMD.

^{a-c} Means within a column with unlike superscript letters are different ($p < 0.05$).

Table 2. Effects of endpoint temperature on oxidation reduction potential (ORP) and CIE a^* in cooked ground turkey breast

Temperature	Dependent Variables ¹	
	ORP (mV)	CIE a^*
71.1 °C (160 °F)	-62.36	7.47 ^a
73.9 °C (165 °F)	-61.60	7.30 ^{ab}
76.7 °C (170 °F)	-61.77	7.18 ^{bc}
79.4 °C (175 °F)	-62.15	7.00 ^c

¹ Dependent variables: CIE a^* (redness). S.E.: ORP 3.59, CIE a^* 0.28

^{a-c} Means within a column with unlike superscript letters are different ($p < 0.05$).

Table 3. Effects of pink inhibiting ingredients with sodium tripolyphosphate (STP), cooking rate, and storage day on color properties in cooked ground turkey breast

Main effects	Dependent Variables ¹		
	CIE a^*	R650/R570	R537/R553
<u>Treatments</u>			
Control	5.12 ^a	1.29 ^a	1.011 ^a
Citric acid, 0.1%	4.51 ^{cd}	1.24 ^{de}	1.002 ^b
Citric acid, 0.2%	3.91 ^{fg}	1.19 ^f	0.995 ^c
Citric acid, 0.3%	3.64 ^g	1.17 ^g	0.990 ^c
Calcium chloride, 250 ppm	4.44 ^{cd}	1.25 ^{cd}	1.006 ^{ab}
Calcium chloride, 500 ppm	4.02 ^{ef}	1.22 ^e	1.003 ^b
EDTA, 50 ppm	4.75 ^{bc}	1.27 ^{bc}	1.010 ^a
EDTA, 100 ppm	4.88 ^{ab}	1.27 ^{ab}	1.009 ^a
Sodium citrate, 0.5%	4.36 ^{de}	1.24 ^{de}	1.009 ^a
Sodium citrate, 1.0 %	4.02 ^{ef}	1.23 ^{de}	1.008 ^{ab}
(S.E.)	(0.28)	(0.015)	(0.006)
<u>Cooking rate</u>			
Slow	4.67 ^a	1.25 ^a	1.008 ^a

Fast (S.E.)	4.06 ^b (0.26)	1.22 ^b (0.013)	1.001 ^b (0.006)
Storage day			
Day 1	4.34	1.23 ^b	1.007 ^a
Day 14 (S.E.)	4.39 (0.26)	1.24 ^a (0.013)	1.001 ^b (0.006)

¹ Dependent variables: CIE a^* (redness), reflectance R650/R570 (reflectance estimator of nitrosyl hemochrome, %R650nm/%R570nm), R537/R553 (reflectance estimator of nicotinamide hemochrome, %R537nm/%R553nm).

^{a-g} Means within a column with unlike superscript letters are different ($p < 0.05$).

Table 4. Effects of different trim locations on cooking yield, pH, oxidation reduction potential, CIE a^* , and pigment properties in cooked ground turkey breast

Trim locations	Dependent Variables ¹					
	Cooking Yield (%)	pH	ORP (mV)	CIE a^*	Nitrosyl hemochrome (ppm)	Total pigments (ppm)
Anterior	97.3 ^a	6.10 ^a	-37.24 ^b	6.37	0.44	19.00
Posterior	96.5 ^b	6.01 ^c	-39.30 ^a	6.10	0.48	17.76
Dorsal	97.6 ^a	6.05 ^b	-36.91 ^b	6.17	0.56	18.37
Ventral	97.4 ^a	6.06 ^b	-36.68 ^b	6.50	0.50	19.33
(S.E)	(0.27)	(0.017)	(3.53)	(0.28)	(0.064)	(0.93)

¹ Dependent variables: ORP (oxidation reduction potential), CIE a^* (higher value more red).

^{a-c} Means within a column with unlike superscript letters are different ($p < 0.05$).

Table 5. Chemical and physical differences between fresh turkey thighs with and without red around the bone

Dependent variables	Distance (cm)	Status		Overall mean
		Red	Non-red	
pH	0.5	6.30	6.27	6.28 ^a
	1.0	6.21	6.17	6.19 ^b
	1.5	6.19	6.14	6.17 ^c
	Overall mean	6.24 ^x	6.19 ^y	
Myoglobin (mg/g)	0.5	2.32	2.07	2.20 ^a
	1.0	2.21	1.99	2.10 ^a
	1.5	2.12	1.87	2.00 ^b
	Overall mean	2.22 ^x	1.98 ^y	
CIE a^*	0.5	12.49	12.10	12.29 ^b
	1.0	13.00	12.92	12.96 ^a
	1.5	12.52	12.23	12.37 ^b
	Overall mean	12.67	12.41	

^{a-c} Means within a column with unlike superscript letters are different ($p < 0.05$).

^{x-z} Means within a row with unlike superscript letters are different ($p < 0.05$).