

REDUCTION OF PINK COLOR DEVELOPMENT IN COOKED GROUND TURKEY ROLLS USING CITRIC ACID AND SODIUM CITRATE

FARDOUS A.A.WALLY

Meat and Fish. Tech. Res. Dept., Food Tech. Res. Inst., ARC, Giza, egypt

(Manuscript received 19 November 2006)

Abstract

Nowadays in Egypt, turkey rolls are widely spread in supermarkets and restaurants being a part of numerous recipes in fast foods.

The ability of citric acid (0.2%) and sodium citrate (1.0%) to reduce pink color in ground turkey meat was investigated. Sodium nitrite was added to induce pink color formation. In present work, citric acid (CA) at (0.2%) and sodium citrate (SC) at (1.0%) reduced natural, or induced pink color in ground Turkey rolls.

The aim of this study was to investigate the possibility of suppressing the formation of pink color in cooked ground turkey rolls.

Chemical, physical, color, organoleptic evaluation, and storage stability tests were carried out either before or after 1, 2 and 3 weeks storage at (4°C) and after 1, 2 and 3 months storage at (-18°C).

With regard to the gross chemical composition, storage stability, physical, organoleptic and color evaluation, it could be observed that for cooked ground turkey rolls either breast or mixture meat (breast + leg 1:1 w/w) treated with 1.0% SC are recommended. Also, it was found that all products had good scores for organoleptic quality.

INTRODUCTION

The pink color defect of cooked, uncured turkey that gives the appearance of undercooking leads to consumer rejection and thus causes a problem in poultry industry which has faced for many years. Many causes has been blamed for this defect, including nitrite or nitrate contamination (Nash *et al.* 1985), heat stability of cytochrome C (Girard *et al.* 1990), the formation of hemochrome (Ahn and Maurer, 1990), and irradiation (Bagorogoza *et al.* 2001). Even with the large amount of research devoted to the pink color defect, this problem is still prevalent in the industry.

An assortment of ingredients can oppose pink color in cooked turkey. Diethylenetriamine penta acetic acid, ethylene dinitrilo-tetraacetic acid disodium salt, trans 1, 2-diaminocyclohexane-N, N, N, N tetraacetic acid monohydrate were all shown to reduce pink color (Schwarz *et al.* 1997). Non fat dried milk (Slesinski *et al.* 2000) and whey protein concentrates (Slesinki *et al.* 2000, Sammel and Claus, 2003), which are approved in processed meats also exhibited a capability for reducing pink color.

Slesinski *et al.* (2000) found that various dairy proteins reduced the pink color in

ground turkey samples when sodium nitrite and nicotinamide were added.

Sammel and Claus (2003) found that citric acid and sodium citrate (concentrations lower than 0.3%) reduced pink color in cooked intact turkey breasts and ground turkey rolls.

Nowadays in Egypt, turkey rolls are widely spread in supermarkets and restaurants being a part of numerous fast foods recipes.

The objective of this research was to determine the effectiveness of three concentrations of citric acid, sodium citrate to reduce pink color in cooked, ground breast turkey rolls, ground leg turkey rolls and mixture of ground breast and ground leg turkey rolls, without loss in cooking yield.

MATERIALS AND METHODS

Materials and processing:

Fresh turkey meat was the raw material used for this study. Samples of meat were obtained from the Experimental Station of the Faculty of Agric., Cairo Univ. at Giza. The samples were obtained from carcasses slaughtered birds and purchased as breast and leg immediately after slaughter and were transported using-icebox- to laboratory of Meat and Fish Technology Res. Dept., Food Tech. Res. Inst., Agric. Res. Center, Giza, Egypt. turkey meat were boned, skinned and washed, then minced twice using an electric meat mincer.

The turkey mince were treated as breast, leg and breast and leg (1:1 w/w) 500g. each.

Sodium nitrite (NT) was used as pinking causative agent, and each sample was assigned to one of four pinking treatments.

The curing solution about (30% v/w of sample)

* The control solution consisted of :

[10ppm sodium nitrite (NT), 2.0% sodium chloride (NaCl) and 0.5% sodium tripolyphosphate (STP)]

Treatment (1) 0.2% citric acid : [Control solution + 0.2% citric acid (CA)]

Treatment (2) 1.0% sodium citrate (SC): [Control solution + 1.0% sodium citrate (SC)]

Treatment (3) : [Control solution + 0.1% CA + 0.5% (SC)]

Solutions were added to each sample and mixed for 3 min., then rolls packed in aluminum foil, and cooked in preheated oven at 180°C for 60 min. The rolls internal temperature reached 88°C according to the method of Maesso *et al.* (1970). The internal temperature wa measured by (Henna check, temp. °C instrument)

All samples kept at room temp. for 60 min. to cool, and then wrapped in polyethylene bags followed by storage in the refrigerator at 4°C (1).

Analysis was carried out at zero time and at one week intervals (up to 3 weeks), (2)

storage carried out by freezing at -18°C for 3 months, and analysis was carried out at zero time and one month intervals (up to 3 months).

Analytical methods :

1- Chemical composition :

Moisture, crude protein, crude fat and ash contents were determined according to the methods described in the A.O.A.C. (1995).

2- Physical characteristics :

* Cooking losses and cooking yield were measured.

All samples were weighed before and after cooking, after equilibrium to room temperature (20°C) to determine cooking loss.

Cooking loss% = (weight of raw sample – weight of cooked sample) / weight of raw sample \times 100

* Cooking yield was determined as follows : 100 - % cooking loss.

* The water holding capacity (W.H.C.) and plasticity were measured by following the method described by Soloviev (1966). The ground sample (0.3g) was pressed under ashless filter paper (Whatman No. 41) for 10 min. using one Kg/weight. Two zones were formed on the filter paper. The W.H.C. ($\text{cm}^2/0.3\text{g}$) was calculated by subtracting the area of internal zone from that of the outer one. The area of internal zone represented plasticity as $\text{cm}^2/0.3\text{g}$.

Storage stability :

Total volatile nitrogen (T.V.N) was determined using the method published by A.O.A.C. (1995).

Thiobarbituric acid value (T.B.A) was estimated according to Pearson (1995).

The pH value of different samples was measured in slurry according to the method described by Aitken *et al.* (1962) using a Beckman pH-meter as follows : 5.0g of minced sample was blended with 100ml of distilled water for 5 minutes.

Hunter color values : Hunter color values (L^* , a^* and b^*) values were measured on freshly cut surfaces of each sample using colorimeter (Colour Tie PCM color meter, color Tec, NJ, U.S.A). Samples were wrapped in plastic food wrap, and the color was measured. The value L^* the lightness ranged from 0 to 100, a^* was chromatically measured where positive value indicating redness and negative value indicating greenish, while positive value of b^* indicating yellowness and negative value indicating blueness. Four random spots on each sample were measured and the average data was recorded. Whiteness was according to the method of Park (1994).

Whiteness = $100 - \{(100 - L^*)^2 + a^{*2} + b^{*2}\}^{1/2}$

Microbiological analyses :

These included total plate mesophilic count (T.C) and psychrophilic counts (Ps.C). They were performed using plate count agar with incubation at $37^{\circ}\text{C}/48$ hr and $4^{\circ}\text{C}.10$ days, respectively (Harold, 1967).

Organoleptic evaluation :

Organoleptic evaluation of cooked samples were carried out according to Basker (1988). Ranking method was used to find out the best product among the samples which had the lowest sum of ranks.

RESULTS AND DISCUSSION

1082 Table (1) results show that the breast meat had higher protein and ash contents but lower moisture and fat as compared to that of the leg meat. On the other hand, T.B.A values were higher for leg meat than found of breast meat. The reverse was recorded for T.V.N. The increase or decrease of T.B.A or T.V.N contents may be due to the differences in fat and protein contents found in turkey meat. W.H.C. was better for breast than leg meat, this may be ascribed to higher protein content of breast than leg meat. Plasticity was better for leg than breast meat which indicated that leg meat had less connective tissues than breast meat. These results were confirmed by the findings of Patracchi *et al.*, (2001).

Table 1. Chemical and physical attributes of fresh Turkey. meat

Constituents	Breast	Leg
Moisture %	74.40	75.30
Protein %	22.20	19.30
Fat %	2.10	4.20
Ash %	1.30	1.20
T.B.A. (mg/1000g)	0.180	0.210
T.V.N. (mg/100g)	7.02	6.85
pH	6.10	6.10
W.H.C. (cm ² /0.3g)	2.45	1.95
Plasticity (cm ² /0.3g)	3.00	3.10

Data in Table (2) show a slight decrease in moisture content for all samples as compared with control. Samples that were treated with 0.2% CA, 1.0% SC or (0.1% CA + 0.5 SC) had higher protein, fat and ash contents than control. The decrease in moisture content could be attributed to water evaporation, loss of some fluids during cooking, decrease of pH value and protein solubility (Kiffer *et al.*, 2000).

Table (3) shows the pH values, T.B.A (thiobarbituric acid value) as an indication for lipids oxidation due to different treatments of turkey meat and T.V.N during storage at 4°C for three weeks. It could be noticed that citric acid (CA) and sodium citrate (SC) reduced pH, T.B.A and T.V.N for all samples at zero time as compared with control. During cold storage, there were slight increase in pH, T.B.A and T.V.N.

The increase of pH value during cold-storage was explained by proteolysis and increase of free alkaline groups as well as the decrease of lactic acid content in muscles due to its oxidation and breakdown especially at surface parts of meat (Fouda, 1981).

The increase of TBA values may be explained by oxidation of lipids, and the

presence of higher myoglobin content in the leg muscle may accelerate lipids oxidation (Fouda, 1981). The increase of TVN values due to the bacterial decomposition in meat resulting in protein degradation.

During cold storage, values of pH, TBA and TVN being highest at spoilage, which could be possibly due to the formation of ammonia and other alkaline products of protein degradation as explained by Fouda (1981).

Table (4) show plasticity and W.H.C during storage at 4°C for three weeks, also illustrated the cooking loss % and cooking yield % at zero time. Plasticity and W.H.C values decreased progressively as the time of storage increased which could be due to dryness. W.H.C was better for samples treated with 1.0% SC than treated with 0.2% CA or (0.5% SC + 0.1% CA) as compared with the control. This may be ascribed to higher protein content of 1.0% SC samples than 0.2% CA samples which improved the W.H.C of these samples. Fresh as well as cold storage samples showed that the breast was the tenderest. Plasticity for samples treated with 1.0% SC were better than those samples treated with 0.2% CA or (0.1% CA + 0.5% SC). Cooking yields were reduced for all samples treated with 0.2% CA or 1.0% SC or (0.1% CA + 0.5% SC).

Cooking yields were reduced for all samples treated with .02% CA when compared with samples treated with 1.0% SC. The loss of cooking yields may be due to addition of CA to ground Turkey rolls is in agreement with the results of Kieffer *et al.*, (2000).

Table (5) show pH, TBA and TVN contents during frozen-storage at -18°C for 3 months. Although the addition of CA reduced pH at zero time, but by frozen storage there were slight increase for all samples. The increase may be due to partial proteolysis leading to the increase of free alkaline groups (Fouda, 1981). TBA showed an increase in all samples during frozen storage. The increase may be due to the accumulation of malonaldehyde which indicated oxidation of lipids. The samples treated with 1.0% SC had lower values of TBA when compared with control or samples treated with 0.2% CA or samples treated with (0.1% CA + 0.5% SC). During frozen storage, TVN increased progressively indicating the breakdown of protein by the effect of microorganisms and tissue enzymes. Such results agreed with the finding of Fouda (1981).

Data presented in Table (6) shows the plasticity and W.H.C for different treatment of turkey. Plasticity was measured as indication of the meat tenderness. Plasticity decreased progressively as the time of frozen-storage increased. The decrease of tenderness due to frozen-storage may be ascribed to the insolubility and denaturation of proteins as well as the decrease of W.H.C. It was noticed that breast meat more tender than leg, and the sample treated with 1.0% SC were more tenderness than those treated with 0.2% CA or (0.1% CA + 0.5% SC).

During frozen storage, W.H.C decreased in samples treated with 1.0% SC less than

those treated with 0.2% CA and samples with (0.1% CA + 0.5% SC).

Color intensity evaluation CIE L* (lightness). Increases in the lightness of turkey breast products may improve the overall appearance of the product. CIE L* values were consistently increased by 0.2% CA and 1.0% SC compared with the control (Tables 7 and 8) at zero time. Citric acid (0.2%) and 1.0% SC increased b* values (yellowish) and decreased (CIE a*) values (redness) as compared with control, but the increase of storage time revealed that there were a decrease in L* value and increase in a* and b* values. There was an increase in whiteness at zero time in samples treated with 0.2% CA or 1.0% SC than control, but by increasing the storage time the whiteness decrease. Both 0.2% CA and 1.0% SC could significantly reduce pink pigments in ground turkey rolls, SC does not negatively influence cooking yields and therefore, would be more likely candidate for poultry processors to reduce the pink defect (Sammel and Claus, 2003).

From results of Table (9), it could be noticed that control had the highest total count as well as psychrophilic bacteria before storage, or after 3 weeks storage at 4°C and after 3 months storage at -18°C. Samples treated with SC had the lowest count for T.C or P.S.C bacteria. In all parts of turkey, the samples treated with CA had higher T.C and P.S.C than the samples treated with SC. This may indicate that SC salt encouraged the growth and enumeration of bacteria while the acid may inhibit the bacterial activity.

Sensory evaluation :

From the data shown in table (10) it could be noticed that the best eating qualities were for breast treated with SC followed by (breast and leg) SC, Leg SC, Breast CA, (breast + leg) CA, Leg CA, breast M, (breast + leg) M, Leg M, breast C, (breast + leg) C and Leg C, mean sums were 13, 24, 25, 38, 25, 58, 73, 82, 85, 101, 113 and 116. Actually, regardless of differences, all products of the present work were rejected by non of the panelists. It should be noted that the best sample breast treated with SC.

CONCLUSION

Citric acid and SC successfully reduced inherent pink color as well as pink color induced by NT in cooked, ground turkey rolls. It is speculated that CA and SC produced their effects by binding the heme-iron of myoglobin preventing pink color-generating ligands from binding the heme in ground turkey rolls, citric acid significantly reduced pH of ground turkey samples, which in turn reduced cooking yields. However, SC was not detrimental to cooking yields, yet could equally or better reduce the pink color defect due to NT in ground turkey rolls. Therefore, sodium citrate is a superior option over citric acid and may be added during processing to suppress the occurrence of the pink color defect in cooked, uncured, ground Turkey rolls.

Table 2. Chemical composition of cooked ground turkey rolls at zero time (% of wet weight basis)

	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	M*	C*	CA**	SC***	M*	C*	CA**	SC***	M*
Moisture	67.2	65.00	66.15	65.70	66.75	64.26	65.52	64.65	67.25	64.67	66.10	65.85
Protein	28.2	30.05	28.95	29.55	26.8	28.95	27.75	28.50	27.4	29.60	28.05	29.45
Fat	2.70	2.95	2.85	2.90	4.70	4.80	4.85	4.95	3.50	3.78	3.95	2.90
Ash	1.90	2.00	2.05	1.85	1.75	1.99	1.88	1.90	1.85	1.95	1.90	1.80

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium triphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Table 3. Storage stability of pH, lipids and nitrogen compounds of cooked ground turkey rolls products during storage at 4°C for 3 weeks (on wet weight basis)

	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	M*	C*	CA**	SC***	M*	C*	CA**	SC***	M*
pH												
Zero	6.10	6.05	6.20	6.02	6.10	6.00	6.15	5.99	6.10	6.00	6.18	6.00
1 week	6.20	6.10	6.25	6.09	6.22	6.10	6.20	6.06	6.15	6.05	6.24	6.17
2 weeks	6.35	6.20	6.30	6.20	6.35	6.15	6.30	6.14	6.23	6.17	6.30	6.25
(S*) 3 weeks	6.405	6.355	6.345	6.305	6.505	6.335	6.355	6.305	6.455	6.295	6.355	6.345
TBA (mg/kg)												
Zero	0.18	0.15	0.12	0.13	0.21	0.16	0.14	0.15	0.19	0.16	0.13	0.15
1 week	0.46	0.175	0.170	0.175	0.62	0.210	0.190	0.182	0.55	0.205	0.180	0.190
2 weeks	0.75	0.255	0.245	0.280	0.85	0.420	0.306	0.305	0.805	0.412	0.300	0.300
(S*) 3 weeks	1.205	0.955	0.9455	0.9605	1.335	0.9905	0.9055	0.9065	1.2655	0.9755	0.9015	0.9775
TVN (mg/100g sample)												
Zero	7.02	6.95	6.80	6.90	6.85	6.65	6.50	6.55	6.95	6.70	6.75	6.70
1 week	10.35	8.82	8.50	8.65	11.55	9.95	9.45	9.49	10.99	9.35	9.44	9.40
2 weeks	18.75	14.50	13.90	14.20	19.95	16.80	15.55	16.20	19.15	16.20	15.95	16.15
(S*) 3 weeks	25.59	20.30	19.05	19.99	22.45	18.55	17.60	18.10	21.90	18.15	17.80	17.95

S* = Spoilage

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium triphosphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Note : At the 3rd week, green mold growth was observed and viscous layer with off-odour formed on some samples.

Table 4. Physical characteristics of cooked ground turkey rolls products during storage at 4°C for 3 weeks (on wet weight basis)

Plasticity (cm ² /0.3 g.)	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	M*	C*	CA**	SC***	M*	C*	CA**	SC***	M*
Zero	2.30	2.04	2.70	2.20	2.00	1.70	2.60	1.95	1.95	1.82	2.07	1.88
1 week	2.35	2.17	2.85	2.23	2.15	1.83	2.78	2.06	2.07	1.93	2.13	1.97
2 weeks	2.25	2.10	2.55	2.19	1.97	1.75	2.45	1.90	1.85	1.80	1.97	1.85
(S*) 3 weeks	2.05	2.00	2.45	2.02	1.90	1.55	2.37	1.82	1.60	1.72	1.78	1.73
W.H.C (cm ² /0.3 g.)												
Zero	3.75	3.55	3.20	3.34	3.55	3.45	3.03	3.22	3.25	3.60	3.36	3.15
1 week	3.80	3.61	3.24	3.40	3.59	3.47	3.09	3.27	3.30	3.72	3.47	3.40
2 weeks	3.82	3.65	3.26	3.44	3.67	3.53	3.16	3.33	3.36	3.79	3.56	3.60
(S*) 3 weeks	3.20	3.00	2.80	2.92	3.12	3.02	3.00	2.90	3.05	3.31	3.20	3.30
% Cooking losses at zero time	9.70	14.80	11.00	13.30	10.00	15.90	11.40	14.60	9.90	15.30	11.10	14.20
% Cooking yield at zero time	90.3	85.20	89.0	86.70	90.00	84.10	88.6	85.4	90.1	84.7	88.9	85.8

S* = Spoilage

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Note : At the 3rd week, green mold growth was observed and viscous layer with off-odour formed on some samples.

REDUCTION OF PINK COLOR DEVELOPMENT IN COOKED GROUND
TURKEY ROLLS USING CITRIC ACID AND SODIUM CITRATE

Table 5. Storage stability of pH, lipids and nitrogen compounds of cooked ground turkey rolls products during storage at -18°C for 3 months (on wet weight basis)

pH	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	M*	C*	CA**	SC***	M*	C*	CA**	SC***	M*
Zero	6.10	6.05	6.20	6.02	6.10	6.00	6.15	5.99	6.10	6.00	6.18	6.00
1 month	6.00	6.10	6.26	6.07	6.15	6.09	6.20	6.03	6.15	6.05	6.22	6.12
2 months	6.28	6.20	6.32	6.12	6.18	6.15	6.29	6.11	6.18	6.09	6.28	6.20
3 months	6.33	6.27	6.35	6.20	6.30	6.25	6.32	6.20	6.28	6.15	6.35	6.25
TBA (mg/kg)												
Zero	0.180	0.150	0.120	0.130	0.210	0.160	0.140	0.150	0.190	0.160	0.130	0.150
1 month	0.189	0.152	0.123	0.134	0.214	0.163	0.144	0.152	0.194	0.165	0.133	0.154
2 months	0.192	0.155	0.127	0.139	0.219	0.167	0.149	0.157	0.197	0.169	0.138	0.159
3 months	0.195	0.162	0.130	0.142	0.225	0.173	0.155	0.161	0.201	0.172	0.143	0.163
TVN (mg/100g)												
Zero	7.02	6.95	6.80	6.90	6.85	6.65	6.50	6.55	6.95	6.70	6.75	6.70
1 month	7.87	7.50	6.99	7.35	7.69	7.25	6.80	6.95	7.40	7.32	6.99	7.00
2 months	8.05	7.75	7.41	7.70	7.97	7.57	7.34	7.42	7.81	7.62	7.42	7.52
3 months	9.00	8.10	7.86	8.05	8.95	7.95	7.76	7.95	8.13	7.99	7.84	7.90

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Table 6. Physical characteristics of cooked ground turkey rolls products during storage at -18°C for 3 months (on wet weight basis)

	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	M*	C*	CA**	SC***	M*	C*	CA**	SC***	M*
Plasticity (cm ² /0.3 g.)												
Zero	2.30	2.04	2.70	2.20	2.00	1.70	2.60	1.95	1.95	1.82	2.07	1.88
1 month	2.28	2.00	2.60	2.12	1.97	1.62	2.50	1.91	1.93	1.75	2.02	1.79
2 months	2.25	1.98	2.57	2.00	1.95	1.58	2.35	1.86	1.88	1.71	1.98	1.71
3 months	2.21	1.95	2.55	1.97	1.91	1.54	2.31	1.82	1.83	1.56	1.90	1.65
W.H.C (cm ² /0.3 g.)												
Zero	3.75	3.55	3.20	3.34	3.55	3.45	3.03	3.22	3.25	3.60	3.36	3.15
1 month	4.50	4.15	3.95	4.04	4.20	3.99	3.73	3.92	3.85	4.30	3.86	3.80
2 months	4.90	4.70	4.40	4.50	4.61	4.42	4.05	4.48	4.15	4.85	4.25	4.16
3 months	5.25	5.05	4.72	4.85	4.99	4.75	4.35	4.80	4.55	5.15	4.62	4.57

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

REDUCTION OF PINK COLOR DEVELOPMENT IN COOKED GROUND TURKEY ROLLS USING CITRIC ACID AND SODIUM CITRATE

Table 7. Hunter color values (L*, a*, b* and whiteness) of cooked ground turkey rolls products during storage at 4°C for 3 weeks (on wet weight basis)

Indices	Breast				Leg				Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	M*	Control	Citric acid 0.2%	Sodium citrate 1.0%	M*	Control	Citric acid 0.2%	Sodium citrate 1.0%	M*
	C*	CA**	SC***		C*	CA**	SC***		C*	CA**	SC***	
Zero time												
L*	72.00	75.05	74.90	74.90	70.22	74.80	74.00	73.60	71.30	74.50	74.20	73.95
a*	8.50	4.20	4.10	4.30	9.44	5.00	5.15	5.25	9.01	2.20	5.25	5.28
b*	5.00	6.42	7.50	7.30	6.90	6.95	7.90	7.95	6.20	6.65	7.85	7.92
Whiteness	70.31	73.90	73.57	73.51	68.01	73.39	72.34	71.93	69.28	73.13	72.53	72.27
After one week												
L*	71.50	74.30	74.04	74.00	69.80	74.00	73.45	73.03	70.50	73.90	73.65	73.02
a*	8.77	5.20	5.05	5.25	10.30	5.70	5.70	5.40	10.00	5.35	5.54	5.53
b*	5.05	6.82	7.90	8.09	7.40	7.05	8.70	8.09	6.97	7.00	8.56	8.12
Whiteness	69.75	72.91	72.37	72.27	67.25	72.46	71.48	71.33	68.09	72.45	71.75	71.29
After two weeks												
L*	70.20	72.10	73.80	73.65	68.00	73.00	72.00	72.00	68.20	72.06	73.15	71.98
a*	8.90	5.99	5.60	5.69	12.30	6.10	6.60	6.15	12.00	6.00	6.02	5.85
b*	5.80	7.70	8.10	8.02	8.30	9.42	8.04	9.30	7.85	7.90	9.03	8.90
Whiteness	68.58	72.02	72.01	71.82	64.82	70.76	70.13	69.86	65.12	70.35	71.04	70.02
After three weeks												
L*	68.30	71.65	73.95	73.60	67.03	72.07	70.30	70.45	67.97	71.00	72.30	70.52
a*	9.80	6.85	5.66	5.90	12.95	6.80	7.20	7.10	12.56	7.00	6.45	6.95
b*	6.50	8.54	8.54	8.60	9.10	10.04	8.95	9.44	8.35	8.69	9.25	9.66
Whiteness	66.19	69.61	71.08	71.08	63.43	69.55	68.16	68.18	64.60	68.93	70.09	68.21

C* = [10 ppm sodium nitrite (NT) + 2.0% (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2% citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Table 8. Hunter color values (L*, a*, b* and whiteness) of cooked ground turkey rolls products during frozen-storage at -18°C for 3 months (on wet weight basis)

Indices	Breast			Leg			Breast + Leg (1:1 w/w)		
	Control	Citric acid 0.2%	Sodium citrate 1.0% M*	Control	Citric acid 0.2%	Sodium citrate 1.0% M*	Control	Citric acid 0.2%	Sodium citrate 1.0% M*
	C*	CA**	SC***	C*	CA**	SC***	C*	CA**	SC***
Zero time									
L*	72.00	75.05	74.99	74.90	74.80	74.00	71.30	74.50	74.20
a*	8.50	4.20	4.10	4.30	5.00	5.15	9.01	4.90	5.02
b*	5.00	6.42	7.50	7.30	6.95	7.90	6.20	6.65	7.85
Whiteness	70.31	73.90	73.57	73.51	73.39	72.34	69.28	73.20	72.57
After one month									
L*	69.72	73.40	73.50	73.36	73.20	73.00	69.12	73.02	73.10
a*	9.95	4.44	4.35	4.65	5.43	5.35	10.04	5.12	5.20
b*	7.50	6.71	7.72	7.96	7.12	8.05	7.75	6.99	7.99
Whiteness	67.32	72.20	72.06	71.81	71.74	71.32	66.62	71.66	71.46
After two months									
L*	68.03	72.95	72.34	72.00	72.00	72.05	67.88	72.50	72.20
a*	10.87	4.65	4.71	5.00	5.83	5.96	11.09	5.60	5.42
b*	8.75	6.90	7.89	8.64	8.03	8.19	9.00	7.86	8.02
Whiteness	65.12	71.70	70.85	70.27	70.29	70.74	64.85	70.86	70.56
After three months									
L*	66.15	67.00	69.29	68.50	57.20	58.67	54.95	57.98	59.89
a*	9.17	5.02	4.90	5.00	11.21	4.68	7.56	5.86	5.01
b*	8.89	8.47	7.99	8.35	10.52	10.38	10.94	12.20	9.24
Whiteness	63.82	65.56	67.89	67.03	52.50	57.18	53.03	55.85	58.56

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

REDUCTION OF PINK COLOR DEVELOPMENT IN COOKED GROUND TURKEY ROLLS USING CITRIC ACID AND SODIUM CITRATE

Table 9. Microbiological evaluation of cooked ground turkey rolls products during storage at 4°C for 3 weeks and at -18°C for 3 months (cfu/g)

	Breast			Leg			Breast + Leg (1:1 w/w)			
	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%	Control	Citric acid 0.2%	Sodium citrate 1.0%	Citric acid 0.1% + sodium citrate 0.5%
	C*	CA**	SC***	C*	CA**	SC***	C*	CA**	SC***	M*
Total plate count (cfu/g)*										
Zero time										
After 3 weeks at 4°C	5.1 × 10 ³	3.5 × 10 ³	2.1 × 10 ³	2.0 × 10 ⁴	4.1 × 10 ³	2.8 × 10 ³	4.1 × 10 ³	3.9 × 10 ³	2.2 × 10 ³	3.5 × 10 ³
After 3 months at -18°C	6 × 10 ⁶	4.0 × 10 ⁵	2.6 × 10 ⁴	6.5 × 10 ⁶	4.8 × 10 ⁵	3.2 × 10 ⁴	5.2 × 10 ⁶	4.3 × 10 ⁵	3.0 × 10 ⁴	4.2 × 10 ⁴
Psychrophilic bacteria										
Zero time										
After 3 weeks at 4°C	1.2 × 10 ²	1.1 × 10 ²	0.9 × 10 ²	1.3 × 10 ²	1.4 × 10 ²	0.9 × 10 ²	1.2 × 10 ²	1.5 × 10 ²	0.7 × 10 ²	1.2 × 10 ²
After 3 months at -18°C	1.4 × 10 ⁴	1.2 × 10 ⁴	1.0 × 10 ⁴	1.4 × 10 ⁴	1.6 × 10 ⁴	0.95 × 10 ⁴	1.3 × 10 ⁴	1.7 × 10 ⁴	1.2 × 10 ⁴	1.3 × 10 ⁴
	1.0 × 10 ³	1.0 × 10 ³	0.6 × 10 ³	1.9 × 10 ³	1.3 × 10 ³	1.0 × 10 ³	1.2 × 10 ³	1.0 × 10 ³	0.8 × 10 ³	1.0 × 10 ³

(cfu/g)* = Colony forming units/gram

C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].

CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2 citric acid (CA)].

SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].

M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

Table 10. Result of ranking method and critical differences used for evaluation of cooked ground turkey rolls after frozen storage at -18°C for 3 months

	Breast (B*)		Leg (L*)		Breast + Leg (1:1 w/w) (L* + B*)							
	Control	Citric acid 0.2% M*	Sodium citrate 1.0% M*	Citric acid 0.2% M*	Sodium citrate 1.0% M*	Citric acid 0.1% + sodium citrate 0.5% M*						
Sum of ranks (1)	101	36	13	73	116	58	85	113	52	24	82	
Differences vs :												
G	63	88	28	15	43	76	16	12	49	77	19	
CA	25	35	78	20	20	13	47	14	14	14	44	
SC	60	60	103	45	12	72	100	39	39	11	69	
M	43	48	43	15	48	12	21	21	21	49	9	
C	58	58	58	58	31	31	64	92	64	92	34	
CA	33	33	33	33	27	27	6	6	6	34	24	
SC	88	88	88	88	27	27	60	88	27	1	57	
M	28	28	28	28	33	33	61	33	33	61	3	
C	61	61	61	61	61	61	89	61	61	89	31	
CA	28	28	28	28	28	28	28	28	28	28	30	
SC	58	58	58	58	58	58	58	58	58	58	58	
Significance level	P = 0.05											
Critical difference (2)	43											
Products Arranged Descending	B*	SC										a
	B* + L*	SC										a
	L*	SC										a
	B* + L*	CA										a
	L*	CA										a
	B* + L*	CA										a
	L*	M										bc
	B* + L*	M										bc
	L*	M										bc
	B* + L*	M										bc
L*	C										cd	
B* + L*	C										cd	
L*	C										d	

(1) The lowest sum of ranks indicates the best product.
 (2) In the same column the products differ significantly (different letters) when the rank sum differences are greater than or equal to the critical values
 C* = [10 ppm sodium nitrite (NT) + 2.0% sodium chloride (NaCl) + 0.5% sodium tripolyphosphate (STP)].
 CA** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.2% citric acid (CA)].
 SC*** = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 1.0% sodium citrate (SC)].
 M* = [10 ppm (NT) + 2.0% (NaCl) + 0.5% (STP) + 0.1% (CA) + 0.5% (SC)].

REFERENCES

1. Aitken, A., J.C. Casey, I.F. Penny and C.A. Voyle. 1962. Effect of drying temperature in the accelerated freeze-drying of pork. *J. Sci. Food Agric.* August, 439/442.
2. Anh, D.U. and A.J. Marer. 1990. Poultry meat color : pH and the heme-complex forming reaction. *Poultry Sci.* 69 (11) : 2020-2050.
3. A.O.A.C. 1995. *Official Methods of Analysis*, 16th ed. Association of Analytical Chemists. Arlington, Virginia, U.S.A.
4. Bagorogoza, K., J. Bowers and Okot-Kotber. 2001. The effect of irradiation and modified atmosphere packaging on the quality of intact chill-stored Turkey breast. *J. Food Sci.* 66 (2) : 367-372.
5. Baskar, D. 1988. 24-Critical values of difference among sums for multiple comparisons. *Food Technology* (2) : 79-84.
6. Fouda, Z.A.A. 1981. Studies on freezing of poultry. M.Sc. Thesis, Fac. of Agric., Zagazig Univ.
7. Girard, B., J. Vanderstoep and J.E. Richards. 1990. Characterization of the residual pink color in cooked Turkey breast and pork loin. *J. Food Sci.* 55 (5) : 1249-1254.
8. Harold, J.B. 1967. *Microbial Applications*. Wm. C. Brown Company Publishers.
9. Kieffer, K.J., J.R. Claus and H. Wang. 2000. Inhibition of pink color development in cooked uncured ground Turkey by the addition of citric acid. *J. Muscle Foods* 11 (3) : 235-243.
10. Maesso, E.R., R.C. Baker and D.V. Vadehra. 1970. Effect of some physical and chemical treatments on the binding quality of poultry loaves. *J. Food Sci.*, 35 : 440-443.
11. Nash, D.M., F.G. Proudfoot and H.W. Hulan. 1985. Pink discoloration in cooked broiler chicken. *Poultry Sci.* 64 (5) : 917-919.
12. Park, J.W. 1994. Functional protein additives in surimi gels. *J. Food Sci.* (59) : 525-527.
13. Pearson, D. 1995. *The chemical Analysis of food*. National College of Food technology. University of Reading J. and Churchill.
14. Petracci, M., D.L. Fletcher and J.K. Northeutt. 2001. Effect of holding temperature

- on live shrink, processing yield and breast meat quality of broiler chicken. *Poultry Sci.*, 80 (3) : 670-675.
15. Sammel, L.M. and J.R. Claus. 2003. Citric acid and sodium citrate effects on reducing pink color defect and cooked intact Turkey breast and ground Turkey rolls. *J. Food Sci.* 68 (3) : 874-878.
16. Schwarz, S.J., J.R. Claus, H. Wang, N.G. Marriott, P.P. Graham and C.F. Fernandes. 1997. Inhibition of pink color development in cooked, uncured ground Turkey through the binding of non-pink generating legands to muscle pigments. *Poultry Sci* 76 (10) : 1450-1456.
17. Slesinski, A.J., J.R. Claus, C.M. Anderson-Cook, W.E. Eigel, P.P. Graham, G.E. Lenz and R.B. Noble. 2000. Ability of various dairy proteins to reduce pink color development in cooked ground Turkey breast. *J. Food Sci* 65 (3) : 417-420.
18. Soloviev, V.E. 1966. Meat Aging, Food Industry Pub. (In Russian).

التغلب علي اللون الوردي المتكون في منتجات لحم الدجاج الرومي المفروم والمطهي
علي شكل إسطوانات بإستخدام حامض الستريك وسترات الصوديوم

فردوس أحمد أحمد والتي

قسم بحوث تكنولوجيا اللحوم والأسماك - معهد بحوث تكنولوجيا الأغذية - مركز البحوث الزراعية
- الجيزة

إنتشر في مصر حالياً منتج لحم الرومي المفروم والمطهي علي شكل إسطوانات إنتشاراً كبيراً في الأسواق والسوبرماركت والمطاعم كما هو الحال أيضاً في الوجبات السريعة. وقد تم في هذه الدراسة بحث قدرة حمض الستريك (تركيز ٠,٢%) وسترات الصوديوم بتركيز (١%) علي تقليل اللون الوردي المتكون في مفروم لحم الرومي. وقد تم إضافة نترات الصوديوم لتحفيز تكوين اللون الوردي. وفي هذه الدراسة تم إضافة حمض الستريك (CA) بتركيز ٠,٢% وسترات الصوديوم SC بتركيز ١% لخفض وتقليل تكوين اللون الوردي المتكون طبيعياً أو الذي قد تم تحفيزه علي التكون في منتج من مفروم لحم الدجاج الرومي المفروم والمطهي علي شكل إسطوانات.

وكان الهدف من هذه الدراسة هو التغلب علي مشكلة تكون اللون الوردي في لحم الرومي المفروم والمطهي علي شكل إسطوانات.

وقد تم تقدير كلاً من الخواص الكيميائية، الطبيعية، اللونية والحسية بالإضافة إلي قدرة ثبات العينة أثناء التخزين وذلك قبل وبعد أسبوع، أسبوعين وثلاثة أسابيع من التخزين علي (٤م) وبعد شهر وشهرين وثلاثة أشهر من التخزين علي (١٨م).

وقد أوصي بإستخدام سترات الصوديوم بتركيز ١% لمعاملة مفروم لحم الدجاج الرومي المطهي علي شكل إسطوانات سواء أكانت صدور أو خليط من لحم الصدور والأوراك (بنسبة ١ : ١ وزن/وزن) وذلك بناء علي تقدير التركيب الكيماوي، القدرة علي الثبات أثناء التخزين والخواص الطبيعية والحسية وتقدير اللون.

كما قد وجد أن جميع المنتجات حصلت علي تقبل عالي ونقاط عالية أثناء التقييم الحسي لها.