



## PHYSICAL AND SENSORY CHARACTERISTICS OF MARINATED CHICKEN DRUMSTICKS TREATED WITH THE LACTOPEROXIDASE SYSTEM AND THERMAL TREATMENT

Fa-Jui Tan<sup>1</sup> and Herbert W. Ockerman<sup>2</sup>

<sup>1</sup>Department of Diet and Restaurant Management, Chung-Shan Medical University, Taichung, 402 Taiwan

<sup>2</sup>Department of Animal Sciences, The Ohio State University, Columbus, OH 43210, USA

### Background

Marination is a procedure of treating meat with an aqueous mixture of vinegar, salt and spices before cooking. Marination of poultry is practiced to improve product's physical and sensory attributes (Hashim *et al.*, 1999; Lemos *et al.*, 1999; Xiong and Kupski, 1999; Zheng *et al.*, 2000). Thermal or heat treatment, which is one of the most common physical methods to reduce the load of microorganisms, has been widely applied to preserve foods for years. In addition, heating is also involved in many food processes, such as cooking, scalding, pasteurizing, drying, and etc. The lactoperoxidase system (LPS), which consists of lactoperoxidase (LP), thiocyanate (SCN<sup>-</sup>), and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), is an inhibitory system that is present naturally in bovine milk, and has been shown to be inhibitory against some microorganisms (Kamau *et al.*, 1990; Earnshaw *et al.*, 1990; Zapico *et al.*, 1998). Even though LPS has been reported to have little effect on the sensory and physical characteristics of the treated milk and dairy products (Zapico *et al.*, 1998; Martinez *et al.*, 1988), limited information on the contribution of marination, thermal treatment, and LPS to the physical and sensory characteristics of treated poultry products is available.

### Objectives

The objective of this study was to investigate the effects of adding LPS and thermal treatment on some physical and sensory characteristics of the marinated chicken drumsticks.

### Materials and methods

A marinade that contains acetic acid (1%) and salt (3%) was developed as a standardized marinade. LPS consisted of 1 µg/ml of LP, 5.9 mM of KSCN and 2.5 mM of H<sub>2</sub>O<sub>2</sub> (30%) and was added to the marinade for the LPS-added treatment. The pH of the marinade was then adjusted to 4. For the sensory evaluation, flavoring agents (0.3% black pepper and 0.15% garlic powder) were added into the standardized marinade solutions for the marinated treatments 1 through 4; whereas no flavoring agents were added to the treatments 5 and 6 samples. No flavoring agents were added in the marinade for all 6 treatments for the physical evaluation. For the samples without thermal treatment (treatments 1 and 3), drumsticks were marinated in plastic containers with the marinade solution so that all the drumsticks were covered completely by the marinade and stored at 4°C for 18 hr. Treatment 5 control samples were submerged in distilled water. No water or marinade solution was added to treatment 6 samples. For those samples with thermal-marinating treatment (treatments 2 and 4), drumsticks were placed inside a plastic bag with the heated marinade solutions, which was previously heated in a water bath. After holding at 58°C for 2 min, the marinade-drumstick mixes in the bags were cooled by immersing the bags in running tap water. When the marination mix was cooled to 25°C (approximately 10 min), the mixes were moved into plastic containers and then refrigerated at 4°C for 18 hours. Physical characteristics, including the pH values of the marinade solutions and drumsticks, marinade absorption, L\*a\*b\* values of the skin and muscles, cooking loss, and yield were evaluated. The sensory panel evaluated the sensory characteristics of the marinated products. Descriptive analysis was conducted to evaluate the intensities of sensory characteristics of the raw and cooked samples. Attributes of skin color, muscle color, marinated chicken aroma, and off-aroma were evaluated for the raw samples. After cooking, the samples were cooled to room temperature and served. Attributes for skin color, muscle color, marinated chicken flavor, off-flavor, juiciness, and tenderness were evaluated for the cooked samples. The sensory evaluation was conducted using a 1 to 9 scale, with 1 representing the lowest intensity and 9 the highest intensity for all attributes except for color (1 = light color; 9 = dark color), juiciness (1 = not juicy; 9 = very juicy), and tenderness (1 = not tender; 9 = very tender). Three trials were conducted. Data were analyzed using SAS GLM with a 5% level of significance. Means were separated using Duncan's multiple range test.



## Results and discussion

In this study, treatment 1 had no LPS added and no thermal treatment; treatment 2 had no LPS added but with thermal treatment; treatment 3 had LPS added but without thermal treatment; treatment 4 had both LPS added and thermal treatment; treatment 5 had distilled water (instead of the marinade solution) added; treatment 6 had no water and no marinade solution added. After marinating or cooking, there were no significant ( $p > 0.05$ ) differences of muscle pH detected among the 1 through 4 marinated treatments. After marinating, the marinade solution pH values for the marinated treatments 1 through 4 were significant ( $p < 0.05$ ) lower than the solution pH of the control with addition of distilled water samples (treatment 5) as expected. There was no significant ( $p > 0.05$ ) difference of marinade absorption, cooking loss, and yield for the marinated treatments 1 through 4 (Table 1).

Table 2 illustrates the color evaluation of marinade chicken drumsticks with or without thermal treatment and/or addition of LPS. After marinating, all the skin  $L^*$  values of treatments 1 through 5 increased, whereas the control without addition of distilled water (treatment 6) remained approximately the same, which was significant ( $p < 0.05$ ) lower. After cooking, all the skin  $L^*$  values of the samples for treatments 1 through 6 decreased without significant ( $p > 0.05$ ) differences. After marinating, treatment 3 and treatment 4 (LPS added), had significantly ( $p < 0.05$ ) lower skin  $a^*$  values than treatment 1 and 2 (no LPS added). Similarly, after cooking, the skin  $a^*$  values of treatment 3 and treatment 4 were significantly ( $p < 0.05$ ) lower than the values of treatment 1 and 2. This significant reduction of  $a^*$  values of the LPS treated samples was probably due to the addition of hydrogen peroxide, which is one of the components of the LPS treatment, and is a strong oxidizing agent that is occasionally used as a bleaching agent in the food industry. After marinating, the skin  $b^*$  values were without any significant differences ( $p > 0.05$ ) among all 6 treatments. After cooking, the skin  $b^*$  increased without any significant differences ( $p > 0.05$ ). The significant changes of skin  $a^*$  values of the LPS treated samples (treatments 3 and 4) in the current study did not agree with the report by Wolfson (1992). Wolfson (1992) investigated the LPS effect on some physical characteristics of LPS treated poultry. In that study, treated chicken legs and thighs were immersed in a 50°C bath containing the LPS (1µg/ml LP, 5.9 mM KSCN, and 2.5 mM H<sub>2</sub>O<sub>2</sub>) for 5 min, and then stored at 4°C, and no LPS was added for the control samples. Wolfson (1992) reported that there was no significant ( $p < 0.01$ ) difference for the Hunterlab color values ( $L$ ,  $a$ ,  $b$ ) between the LPS treated chicken thigh skin and controls after 24 and 48 hours storage at 4°C. The possible reason of this disagreement between the two studies is probably that the LPS-treated time (18 hours in the current study) was much longer than the time of 5 min in Wolfson's study. After marinating, all the muscle  $L^*$  values of the marinated treatments 1 through 4 increased and were significant ( $p < 0.05$ ) higher than the values of the two control samples (treatments 5 and 6). After marinating, treatments 3 and 4 (LPS added) had significantly ( $p < 0.05$ ) lower muscle  $a^*$  values than the values of treatments 1 and 2 (no LPS added). Similarly, after cooking, the muscle  $a^*$  values of treatments 3 and 4 (LPS added) were significantly ( $p < 0.05$ ) lower than the values of treatments 1 and 2 (no LPS added). After marinating, the muscle  $b^*$  values of treatments 1 through 6 increased without significance ( $p > 0.05$ ). After cooking, there was no significant ( $p > 0.05$ ) difference for the muscle  $b^*$  values for marinated treatments 1 through 4.

In this study, total color difference ( $\Delta E^*_{ab}$ ) is calculated as: Total color difference ( $\Delta E^*_{ab}$ ) = square root of  $[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]$ , where  $L^*$  = light and dark,  $a^*$  = red and green,  $b^*$  = yellow and blue, and  $\Delta$  representing the difference between the two processing steps, and it is commonly applied to evaluate the color changes of samples at the two different processing steps in food science studies. There was no significant ( $p > 0.05$ ) difference for total color difference of skin between before and after marination for the marinated treatments 1 through 4 samples, but the control samples without distilled water added (treatment 6) had a significantly ( $p < 0.05$ ) lower total color differences for skin color. There was no significant ( $p > 0.05$ ) difference for total color difference for skin color between before and after cooking for the all six treatment samples. Similarly, no significant ( $p > 0.05$ ) difference for total color difference for skin between before marination and after cooking for the all 6 treatment samples was obtained. In the current study, the control samples with or without distilled water added (treatments 5 and 6) had significant ( $p < 0.05$ ) lower total color difference in muscle color, when compared with the samples of the marinated treatments 1 through 3. There was no significant ( $p > 0.05$ ) total color difference in muscle between before and after cooking, and between before marination and after cooking for all 6 treatment samples (Table 3).

Sensory evaluation of marinated chicken drumsticks with or without addition of LPS and/or thermal treatment is shown in Table 4. Based on a 1-9 scale, the marinated treatments 1 through 4 samples in this



study had lower sensory raw skin and muscle color scores without any significant differences ( $p>0.05$ ) among the marinated treatments. The lightness of the skin and muscle colors for marinated treatments 1 through 4 when comparing to the samples of the control groups was probably due to the addition of acid.

The marinated treatments 1 through 4 samples had significant ( $p<0.05$ ) higher marinated chicken aroma scores, when compared with the controls probably due to lack of flavoring agents added. Low (1.3-1.6 based on a 1-9 scale) and without significant ( $p>0.05$ ) difference for the sensory off-aroma scores for the raw samples for all treatments 1 through 6 were obtained in this study (Table 3). After cooking, the sensory skin and muscle color scores of the marinated treatments 1 through 4 samples increased. Also, there was no significant ( $p>0.05$ ) difference for the sensory cooked skin and muscle color scores of all treatments 1 through 6. The marinated treatments 1 through 4 samples had significant ( $p<0.05$ ) higher marinated chicken flavor scores. Low (1.1-1.9 based on a 1-9 scale) and without significant ( $p>0.05$ ) difference values were obtained for the sensory off-flavor scores of the cooked samples for all treatments. There was no significant ( $p>0.05$ ) difference for the sensory juiciness score of all treatments 1 through 6. In addition, no significant ( $p>0.05$ ) difference for the sensory tenderness scores of marinated treatments 1 through 4 was observed.

## Conclusions

In conclusion, the treatment consisting of addition of LPS (1  $\mu\text{g/ml}$  of LP, 5.9 mM of KSCN, and 2.5 mM of  $\text{H}_2\text{O}_2$ ) and thermal treatment (58°C for 2 min) did not impair the physical and sensory characteristics for the marinated chicken drumsticks.

## References

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Table 1. Physical evaluations of marinated chicken drumsticks with or without thermal treatment and/or lactoperoxidase system (LPS) added

Parameter	Treatment No.	1	2	3	4	5	6
LPS addition		-	-	+	+	Control	Control
Thermal treatment (58°C, 2 min)		-	+	-	+	(water added)	(no water added)
Raw drumstick pH (before marinating)		6.83	6.81	6.91	6.79	6.88	6.85
Raw drumstick pH (after marinating)		5.60 <sup>a</sup>	5.59 <sup>a</sup>	5.53 <sup>a</sup>	5.54 <sup>a</sup>	6.76 <sup>b</sup>	6.87 <sup>b</sup>
Cooked drumstick pH		5.93 <sup>a</sup>	5.72 <sup>a</sup>	5.82 <sup>a</sup>	5.64 <sup>a</sup>	6.91 <sup>b</sup>	6.97 <sup>b</sup>
Marinade solution pH (after marinating)		4.37 <sup>a</sup>	4.39 <sup>ab</sup>	4.42 <sup>b</sup>	4.40 <sup>ab</sup>	7.22 <sup>c</sup>	ND
Marinade absorption (%)		1.88 <sup>a</sup>	1.72 <sup>a</sup>	1.62 <sup>a</sup>	2.48 <sup>a</sup>	6.19 <sup>b</sup>	ND
Cooking loss (%)		23.1 <sup>a</sup>	22.7 <sup>a</sup>	22.70	22.56 <sup>a</sup>	19.76 <sup>ab</sup>	16.34 <sup>b</sup>
Yield (%)		78.33 <sup>a</sup>	78.37 <sup>a</sup>	78.56 <sup>a</sup>	79.36 <sup>ab</sup>	85.21 <sup>c</sup>	82.65 <sup>bc</sup>

<sup>a, b</sup>Means within a row without the same superscript are significantly different ( $P<0.05$ ). ND: not determined.

<sup>1</sup>Lactoperoxidase system (LPS) = lactoperoxidase (LP, 1  $\mu\text{g/ml}$ ), KSCN (5.9 mM) and  $\text{H}_2\text{O}_2$  (2.5 mM).



Table 2. Skin color evaluation<sup>1</sup> results of marinated chicken drumsticks with or without thermal treatment and/or addition of lactoperoxidase system (LPS).

Parameter No.	Treatment	1	2	3	4	5	6	
	LPS addition <sup>2</sup>	-	-	+	+	Control	Control	
	Thermal treatment (58°C, 2 min)	-	+	-	+	(water added)	(no water added)	
Skin	L* value	Before marinating	71.19	72.44	71.92	74.03	72.57	74.50
		After marinating	79.69 <sup>ab</sup>	84.53 <sup>c</sup>	83.10 <sup>bc</sup>	82.73 <sup>bc</sup>	77.93 <sup>a</sup>	72.06 <sup>d</sup>
		After cooking	63.45	69.29	63.26	62.33	62.73	65.02
	a* value	Before marinating	5.87	6.17	5.80	6.59	5.86	4.89
		After marinating	1.55 <sup>a</sup>	1.03 <sup>a</sup>	-1.73 <sup>b</sup>	-1.44 <sup>b</sup>	3.60 <sup>c</sup>	5.81 <sup>d</sup>
		After cooking	2.06 <sup>a</sup>	1.96 <sup>ab</sup>	0.44 <sup>c</sup>	0.62 <sup>bc</sup>	2.95 <sup>a</sup>	2.39 <sup>a</sup>
	b* value	Before marinating	6.67	7.29	6.84	4.59	8.21	8.68
		After marinating	5.96	7.88	7.40	6.20	7.80	8.05
		After cooking	19.70	22.30	18.51	19.80	21.72	23.69
Muscle	L* value	Before marinating	60.02	63.26	63.39	61.58	63.36	65.23
		After marinating	84.65 <sup>a</sup>	91.21 <sup>ab</sup>	98.10 <sup>b</sup>	85.11 <sup>a</sup>	69.81 <sup>c</sup>	63.13 <sup>c</sup>
		After cooking	66.44 <sup>a</sup>	71.75 <sup>ab</sup>	73.40 <sup>b</sup>	71.69 <sup>ab</sup>	73.47 <sup>b</sup>	69.32 <sup>ab</sup>
	a* value	Before marinating	13.93 <sup>a</sup>	13.02 <sup>ab</sup>	12.48 <sup>ab</sup>	13.26 <sup>ab</sup>	12.70 <sup>ab</sup>	11.69 <sup>b</sup>
		After marinating	3.00 <sup>a</sup>	3.36 <sup>a</sup>	-2.02 <sup>b</sup>	-1.64 <sup>b</sup>	10.83 <sup>c</sup>	12.16 <sup>d</sup>
		After cooking	3.63 <sup>a</sup>	2.73 <sup>ab</sup>	0.59 <sup>c</sup>	0.99 <sup>bc</sup>	7.33 <sup>d</sup>	5.71 <sup>d</sup>
	b* value	Before marinating	8.96 <sup>a</sup>	11.97 <sup>ab</sup>	13.33 <sup>b</sup>	9.21 <sup>a</sup>	9.61 <sup>a</sup>	11.48 <sup>ab</sup>
		After marinating	9.70	11.80	13.18	12.55	10.36	13.13
		After cooking	13.90 <sup>a</sup>	15.57 <sup>a</sup>	16.80 <sup>ab</sup>	16.48 <sup>ab</sup>	18.84 <sup>b</sup>	26.25 <sup>c</sup>

<sup>a, b, c</sup>Means within a row without the same superscript are significantly different (P<0.05).

<sup>1</sup>Color evaluation: L\* = light and dark, a\* = red and green, and b\* = yellow and blue

<sup>2</sup>Lactoperoxidase system (LPS) = lactoperoxidase (LP, 1 µg/ml), KSCN (5.9 mM) and H<sub>2</sub>O<sub>2</sub> (2.5 mM).

Table 3. Total color differences<sup>1</sup> of marinated chicken drumsticks with or without thermal treatment and lactoperoxidase (LPS) added

Parameter	Treatment No.	1	2	3	4	5	6
	LPS addition <sup>2</sup>	-	-	+	+	Control	Control
	Thermal treatment (58°C, 2 min)	-	+	-	+	(water added)	(no water added)
Skin							
Comparison of before and after marination		9.88 <sup>ab</sup>	13.20 <sup>a</sup>	13.57 <sup>a</sup>	11.95 <sup>a</sup>	5.85 <sup>bc</sup>	2.80 <sup>c</sup>
Comparison of before and after cooking		21.37	21.07	22.87	24.76	20.66	17.53
Comparison of before marination and after cooking		16.01	16.09	15.92	20.16	17.31	17.96
Muscle							
Comparison of before and after marination		27.17 <sup>ab</sup>	29.78 <sup>ab</sup>	36.12 <sup>a</sup>	18.02 <sup>bc</sup>	7.00 <sup>c</sup>	3.25 <sup>c</sup>
Comparison of before and after cooking		18.29	20.33	25.07	14.80	12.11	17.94
Comparison of before marination and after cooking		13.12	13.85	16.24	17.50	14.16	16.71

<sup>a, b</sup>Means within a row without the same superscript are significantly different (p<0.05).

<sup>1</sup>Total color difference ( $\Delta E^*_{ab}$ ) = square root of  $[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]$ , where L\* = light and dark, a\* = red and green, b\* = yellow and blue, and  $\Delta$  representing the difference between the two processing steps.

<sup>2</sup>LPS = lactoperoxidase (LP, 1 µg/ml), KSCN (5.9 mM) and H<sub>2</sub>O<sub>2</sub> (2.5 mM).

Table 4. Sensory characteristic and intensities<sup>1</sup> of marinated chicken drumsticks with or without addition of lactoperoxidase system (LPS) and/or thermal treatment

Parameter	Treatment No.	1	2	3	4	5	6
	LPS addition (1µg/ml LP, 5.9mM KSCN, 2.5mM H <sub>2</sub> O <sub>2</sub> )	-	-	+	+	Control	Control
	Thermal treatment (58°C, 2 min)	-	+	-	+	(water added)	(no water added)
Raw samples							
Skin color		2.7 <sup>a</sup>	2.6 <sup>a</sup>	2.6 <sup>a</sup>	2.1 <sup>a</sup>	5.1 <sup>b</sup>	6.1 <sup>b</sup>
Muscle color		2.3 <sup>a</sup>	2.6 <sup>a</sup>	2.7 <sup>a</sup>	2.3 <sup>a</sup>	5.0 <sup>b</sup>	6.4 <sup>b</sup>
Marinated chicken aroma		4.3 <sup>a</sup>	4.9 <sup>a</sup>	4.9 <sup>a</sup>	5.1 <sup>a</sup>	1.6 <sup>b</sup>	1.3 <sup>b</sup>
Off-aroma		1.3	1.3	1.1	1.0	1.0	1.0
Cooked samples							
Skin color		5.6	5.3	5.3	4.7	5.4	5.6
Muscle color		4.7 <sup>ab</sup>	3.9 <sup>a</sup>	4.0 <sup>a</sup>	3.4 <sup>a</sup>	5.7 <sup>bc</sup>	6.4 <sup>c</sup>
Marinated chicken flavor		4.6 <sup>a</sup>	6.0 <sup>a</sup>	5.3 <sup>a</sup>	5.1 <sup>a</sup>	1.6 <sup>b</sup>	2.0 <sup>b</sup>
Off-flavor		1.1	1.9	1.3	1.3	1.1	1.3
Juiciness		3.4	3.3	3.6	3.4	3.3	4.4
Tenderness		4.1 <sup>ab</sup>	3.3 <sup>a</sup>	3.7 <sup>ab</sup>	4.0 <sup>ab</sup>	4.3 <sup>ab</sup>	5.0 <sup>b</sup>

<sup>a, b, c</sup>Means within a row without the same superscript are significantly different (P<0.05).

<sup>1</sup>1 to 9 scale (1 = the lowest intensity and 9 = the highest intensity)