PHYSICAL AND SENSORY CHARACTERISTICS OF MARINATED CHICKEN DRUMSTICKS TREATED WITH NISIN AND THE LACTOPEROXIDASE SYSTEM

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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 a product's physical and sensory attributes. Nisin, which is a natural, nontoxic, heat stable polypeptide produced by *Lactococcus lactis*, has been shown to inhibit many microorganisms and has been approved for use in some dairy products. Even though some studies involving nisin in poultry products have been reported (Mahadeo and Tatini, 1994), most of these studies focused on the effect of nisin toward the microbial quality of the treated samples. The lactoperoxidase system (LPS), which consists of lactoperoxidase (LP), thiocyanate (SCN^-), and hydrogen peroxide (H_2O_2), is an inhibitory system that is present naturally in bovine milk, and has been shown to be inhibitory against some microorganisms (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 (Martinez *et al.*, 1988), limited information on the contribution of marination, nisin, 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 nisin and LPS on some physical and sensory characteristics of the marinated chicken drumsticks.

Methods

A marinade that contains acetic acid (1%), salt (3%), and 20mM disodium EDTA with pH adjusted to 4 was developed as a standardized marinade. A 100 IU/ml of nisin and a LPS consisted of 1 μg/ml of lactoperoxidase (LP, EC 1.11.1.7; purity index 0.82 (A_{412}/A_{280}), 5.9 mM of KSCN, and 2.5 mM of H_2O_2 (30%) were added to the marinade. For the marinated samples (treatments 1 through 4), drumsticks were placed and marinated in plastic containers with marinade solution so that all the drumsticks could be covered completely by the marinade solution and stored at 4°C for 18 hr. Instead of the marinate solution, the treatment 5 control samples were stored with distilled water. No water or marinade solution was added to treatment 6 samples. Physical characteristics, including the pH values of the marinade solutions and drumsticks, marinade absorption, color (L*a*b*) of the skin and muscles, cooking loss, and yield were evaluated. For the sensory evaluation, 0.3% black pepper and 0.15% garlic powder were added to the solutions for marinated treatments 1 through 4, whereas no flavoring agents were added to treatments 5 and 6. No flavoring agents were added to the solution for all six treatments for the physical evaluation. The panel of seven members evaluated the sensory characteristics of the marinated products made with the standardized marinade solution with flavoring agents (0.3% black pepper and 0.15% garlic powder) with or without the addition of nisin and/or LPS. 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.

Result and Discussion

In this study, treatment 1 had no nisin added and no LPS added. Treatment 2 had no nisin added, but with LPS added. Treatment 3 had nisin added, but without LPS added. Treatment 4 had both nisin added and LPS added Treatment 5 had distilled water (instead of the marinade solution) added. Treatment 6 had no water and no marinade solution added. Either after marinating or cooking, there were no significant (P>0.05) differences of muscle pH detected among these 1 through 4 marinated treatments. There was no significant (P>0.05) difference of marinade absorption, cooking loss, and yield for the marinated treatments 1 through 4 marinated samples (Table 1). After marinating, all the skin L* values increased without significant (P>0.05) differences among the marinated and water added treatments, except for the control without addition of distilled water (treatment 6), was significantly (P<0.05) smaller (Table 2). After cooking, all the skin L* values of the samples decreased without significant (P>0.05) difference. After marinating, the skin a* values of the marinated treatments 1 through 4 decreased without any significant difference (P>0.05), but the skin a* values of the control with or without addition of distilled water (treatments 5 and 6) had significant (P<0.05) higher values. Samples with LPS added (treatments 2 and 4) had lower skin a* values, when compared with the samples without LPS added (treatments 1 and 3) probably because of the addition of H_2O_2 for the LPS-added treatments 2 and 4. Hydrogen peroxide, which is one of the components of the LPS treatment, is a strong oxidizing agent that is occasionally used as a bleaching agent in the food industry. After cooking, the skin a* values of the marinated treatments 1 through 4 increased without any significant difference (P>0.05), but the skin a* values of the control with or without addition of distilled water significantly (P<0.05) decreased. After marinating, the skin b* of the marinated treatments 1 through 4 increased without any significant difference (P>0.05) among marinated treatments. After cooking, the skin b* increased without any significant differences (P>0.05) among all 6 treatments. After marinating, the muscle L* values of the marinated treatments 1 through 4 and treatment 5 (water added) increased, whereas, the treatment 6 (no water added) remained approximately the same. After cooking, there were no significant (P>0.05) differences for the muscle L* values among the six treatments. After marinating, samples with the LPS added (treatments 2 and 4) had significantly (P<0.05) lower muscle a* values, when compared with the samples without LPS added (treatments 1 and 3) and also, the control samples with and without distilled water added (treatments 5 and 6). After cooking, there was no significant (P>0.05) difference for the muscle a* values of the marinated treatments 1 through 4. After marinating, the muscle b* values of the marinated treatments 1 through 4 increased without any significant (P>0.05) difference among the marinated treatments 1 through 4. After cooking, the muscle b* values of the marinated treatments 1 through 4 increased without any significant (P>0.05) differences among the marinated treatments 1 through 4. Based on a 1 to 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 significantly (P<0.05) higher marinated chicken aroma scores, when compared with the controls probably due to lack of flavoring agents added. Low (1.1 to 1.6 based on a 1 to 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 (1.1-1.6 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. In the current study, no significance (P>0.05) difference for the sensory juiciness and tenderness scores were detected for the marinated treatments 1 through 4 samples (Table 3).

Conclusion

In conclusion, the treatment consisting of addition of nisin (100 IU/ml) and LPS (1 µg/ml of LP, 5.9 mM of KSCN, and 2.5 mM of H_2O_2) did not impair the physical and sensory characteristics for the marinated chicken drumsticks.

References

Mahadeo, M., and S. R. Tatini. 1994. Letters in Applied Microbiology. 18(6)323-326.
Martinez, C. E., P. G. Mendoza, F. J. Alacron, and H. S. Garcia. 1988. J. Food Prot. 51:558-561.
Zapico, P., M. Medina, P. Gaya, and M. Nunez. 1998. International J. Food Micro. 40:35-42.

Table 1. Physical evaluation of marinated chicken drumsticks with or without addition of nisin and/or lactoperoxidase system (LPS)

Parameter Treatment No.	1	2	3	4	5	6
Nisin addition (100 IU/ml)	–	–	+	+	Control (water added)	Control (no water added)
LPS addition (1µg/ml LP, 5.9mM KSCN, 2.5mM H_2O_2)	–	+	–	+		
Raw drumstick pH (before marinating)	6.95	6.94	6.87	6.94	6.89	6.88
Raw drumstick pH (after marinating)	5.33^a	5.28^a	5.23^a	5.43^a	6.82^b	6.92^b
Cooked drumstick pH	5.64^a	5.51^a	5.53^a	5.74^a	6.98^b	7.07^b
Marinade solution pH (after marinating)	4.39^a	4.39^a	4.39^a	4.38^a	7.14^b	ND
Marinade absorption (%)	1.05^a	0.86^a	1.48^a	0.48^a	7.47^b	ND
Cooking loss (%)	27.05^a	27.21^a	25.69^a	25.29^a	23.92^a	15.90^b
Yield (%)	73.71^a	73.41^a	75.41^a	75.08^a	81.77^b	82.30^b

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

Table 2. Skin and muscle color evaluation[1] results of marinated chicken drumsticks with or without addition of nisin and/or LPS

Parameter Treatment No.			1	2	3	4	5	6
Nisin addition (100 IU/ml)			–	–	+	+	Control (water added)	Control (no water added)
LPS addition[2]			–	+	–	+		
Skin	L* value	Before marinating	72.63^{ab}	70.25^{bc}	71.16^{bc}	70.02^c	70.13^{bc}	74.26^a
		After marinating	84.13^a	81.21^a	81.28^a	84.39^a	80.58^a	74.47^b
		After cooking	69.66	65.97	65.93	66.23	66.44	65.74
	a* value	Before marinating	5.76	4.83	5.03	5.15	5.42	5.50
		After marinating	0.80^a	-1.65^a	0.32^a	-1.86^a	3.73^b	5.97^b
		After cooking	1.32^a	0.42^a	1.18^a	1.40^a	3.62^b	4.09^b
	b* value	Before marinating	8.67	9.49	9.58	8.49	8.61	7.97
		After marinating	11.49^a	12.36^a	10.78^{ab}	12.96^a	7.72^c	8.80^{bc}
		After cooking	23.24	24.41	23.43	24.57	24.78	25.29
Muscle	L* value	Before marinating	62.09	60.19	60.37	58.00	58.77	60.92
		After marinating	79.32^{ab}	77.07^b	80.95^{ab}	88.20^a	71.34^{bc}	62.77^c
		After cooking	75.70	75.55	76.08	77.21	73.64	74.01
	a* value	Before marinating	12.42	13.58	10.54	10.38	10.21	10.33
		After marinating	3.69^a	-0.80^b	3.17^a	-2.71^b	10.69^c	14.57^d
		After cooking	2.34^a	0.35^a	2.06^a	0.33^a	4.92^b	5.83^b
	b* value	Before marinating	12.42	13.58	10.54	10.38	10.21	10.33
		After marinating	12.42^{ab}	14.51^{ab}	11.61^{ab}	15.11^a	10.06^b	12.05^{ab}
		After cooking	17.19^a	19.64^{ab}	17.99^{ab}	19.25^{ab}	18.26^{ab}	22.89^b

$^{a, b, c}$Means within a row without the same superscript are significantly different (P<0.05).
[1]Color evaluation: L* = light and dark, a* = red and green, and b* = yellow and blue
[2]Lactoperoxidase system (LPS) = lactoperoxidase (LP, 1 µg/ml), KSCN (5.9 mM) and H_2O_2 (2.5 mM).

Table 3. Sensory characteristic intensities[1] of marinated chicken drumsticks with or without addition of nisin and LPS

Parameter Treatment No.		1	2	3	4	5	6
Nisin addition (100 IU/ml)		–	–	+	+	Control (water added)	Control (no water added)
LPS addition (1µg/ml LP, 5.9mM KSCN, 2.5mM H_2O_2)		–	+	–	+		
Raw samples	Skin color	2.7^a	3.0^a	2.0^a	2.6^a	5.1^b	6.7^c
	Muscle color	3.0^a	2.4^a	2.4^a	2.1^a	6.6^b	7.0^b
	Marinated chicken aroma	5.6^a	5.3^a	4.9^a	6.1^a	1.4^b	1.0^b
	Off-aroma	1.6	1.1	1.4	1.4	1.4	1.3
Cooked samples	Skin color	4.7	4.1	4.0	3.7	3.9	4.0
	Muscle color	3.9	4.1	3.0	2.9	4.4	4.3
	Marinated chicken flavor	5.4^a	4.0^b	5.0^{ab}	5.7^a	1.3^c	1.9^c
	Off-flavor	1.3	1.3	1.1	1.3	1.6	1.3
	Juiciness	4.3^{ab}	3.3^b	4.3^{ab}	3.9^{ab}	5.1^{ab}	5.7^a
	Tenderness	4.7^{ab}	4.1^b	4.4^b	3.9^b	4.7^{ab}	6.3^a

$^{a, b, c}$Means within a row without the same superscript are significantly different (P<0.05).
[1]1 to 9 scale (1 = the lowest intensity and 9 = the highest intensity)