

## Quality Change of Marinated Chicken Drummettes as Affected by Vacuum Packing, 'Rub', Storage Temperature and Additives

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### Abstract

The effects of preparation methods, packaging, and additives on shelf life of appetizer chicken drummettes were investigated. Initial microbial loads of appetizer drummettes affected their refrigerated shelf life. Drummettes cooked to 93.3°C had lower initial microbial loads and longer shelf life when compared to those cooked to 82.2°C. However, this advantage was not observed when 'rub' was applied during the marinating process. No apparent effect ( $P>0.05$ ) on the growth of psychrotrophs was found when samples were stored at  $3\pm 1^\circ\text{C}$  and  $7\pm 1^\circ\text{C}$  with or without vacuum packaging. Adding sorbic acid (0.5%) or sodium benzoate (0.5%) in the marinade mixture extended the refrigerated shelf life. The addition of 50 ppm sodium nitrite further enhanced the shelf life. The increased TBA values of drummettes can be reduced by the application of vacuum packaging. The addition of sorbic acid or sodium benzoate in the marinade was not as effective as vacuum packaging in retarding TBA value increase.

Key words : marinated chicken drummettes, packaging, additives, TPC, TBA.

### Introduction

Recent concern for caloric and fat levels of deep-fat fried chicken parts has created a demand for non-fried food products. Marinated poultry products can meet these requirements, since they can be processed without deep-fat frying, are low in calories, and are more juicy and flavorful. Recently, the top 400 food service companies in America emphasized that marinated, precooked, nonbreaded wing joints will be the newest trend among consumers.<sup>(1)</sup>

The growth of microorganisms during refrigeration is the most critical factor limiting shelf life. The increase in bacterial numbers might possibly be due to an effect of elevated product temperature, storage temperature, and increased nutrient availability to microorganisms. Manufacturing processes and handling could affect microbial loads, which in turn affect the quality and refrigerated shelf life of precooked products. However, the cooking procedure was also effective in reducing bacterial numbers.<sup>(2)</sup> Several methods have been used to extend the shelf life of

refrigerated poultry products, such as the use of irradiation, packaging, storage conditions, antimicrobial additives, etc.

Relatively few of the chemicals known to inhibit growth of bacterial spores are used in foods. Benzoate, sorbate, and nitrite have been used as antimicrobial additives for foods.<sup>(3)</sup> Huhtanen and Feigberg<sup>(4)</sup> indicated that potassium sorbate and sorbic acid were influential in delaying *Clostridium botulinum* growth in chicken and turkey frankfurters formulated without nitrite. A reduction in bacterial growth (4-10 days) was demonstrated with 100 and 150 ppm nitrite in chicken patties.<sup>(5)</sup> The use of sorbate in combination with reduced levels of nitrite was as effective as higher concentration of nitrite. Chemical inhibitors also are usually more effective when used in conjunction with other treatment such as low temperature processing, storage conditions, etc. It is also difficult to accurately predict inhibitory levels of chemicals required in precooked marinated poultry on the basis of reported investigations. Studies on the antimicrobial activity of sorbate, benzoate, or sorbate in combination with nitrite in precooked marinated chicken products are limited thus far.

Warmed-over flavor (WOF) has been characterized as the rapid rancidity developed in precooked meat

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during refrigerated or frozen storage. Phospholipids are the primary contributors to WOF<sup>(6)</sup> Miller *et al.*<sup>(7)</sup> found that precooked pork chops had higher TBA values and lower flavor scores than uncooked samples when stored at  $-18^{\circ}\text{C}$  for 3 months. Igene *et al.*<sup>(8)</sup> showed a high correlation of WOF with TBA values and indicated that TBA values can be indicators for WOF formation in cooked chicken.

The purpose of this study was to determine the effects of rubbing, internal cooking temperature, storage temperature, packaging, and use of different additives on the refrigerated shelf life of precooked marinated chicken drummettes.

## Materials and Methods

### Sample preparation

Commercial frozen chicken drummettes (first wing joint) were obtained. After thawing at  $7\pm 1^{\circ}\text{C}$  for 24 hr, the drummettes were marinated in a solution containing 20% marinade. For each 100 g of raw drummettes, 20 g of marinade were used. A commercial rub (containing starch, seasoning, etc.) was added at 18.6% (based on solution weight) to study the rubbing treatment effect. Marinade containing sorbic acid (0.5%) or sodium benzoate (0.5%) with or without addition of sodium nitrite (50 ppm) were tested separately. The drummettes were marinated in a hexagonal shape drum (101.5 cm  $\times$  38 cm) rotated at 31.5 rpm for 10 min and an additional 5 min for the rub added treatments.

The marinated drummettes were cooked in a convection oven (Model CTB-1, Blodgett Oven Co., Burlington, VT, USA) at  $237.7^{\circ}\text{C}$  to an internal endpoint temperature of  $82.2^{\circ}\text{C}$  and  $93.3^{\circ}\text{C}$ . Copper constantan thermocouple wires connected to a Speedomax Multipoint Recording potentiometer (Leeds and Northrup Co., North Wales, PA, USA) were used to record the temperatures.

After cooking, the chicken drummettes were cooled at room temperature for approximately 30 min before packaging in polyethylene bags. The drummettes were also vacuum skin packaged with Cryovac LDX 2699 film (Top Web) and Cryovac T 6040 B film (Bottom Web) on a Cryovac VS 44 Series II packaging machine. The prepared drummette samples were stored at  $3\pm 1^{\circ}\text{C}$  and  $7\pm 1^{\circ}\text{C}$  for shelf life studies.

### Total plate counts

Total psychrotrophic plate counts for samples sto-

red at  $3\pm 1^{\circ}\text{C}$  and  $7\pm 1^{\circ}\text{C}$  were measured for a period of 24 days at 4-day intervals for the chicken drummettes.

Hand-deboned drummettes were ground aseptically through a homestyle grinder and 30 g of the samples were blended with 270 ml of sterilized 0.1% Bacto peptone (Difco) solution in a sterile Waring blender at high speed for 1 min. Serial dilutions of the samples were plated on plate count agar (PCA) (Difco).

The PCA plates were incubated at  $20\pm 1^{\circ}\text{C}$  for 72 hr for total psychrotrophic plate counts. The average number of colonies from the duplicate plates were reported as number of colony forming units (CFU) per gram of samples.

### 2-Thiobarbituric acid values

The TBA values of the samples were obtained by a distillation method.<sup>(9)</sup> Briefly, 10 g of finely minced samples were added to a Kjeldahl flask containing 97.5 ml distilled water and 2.5 ml 4 N HCl. One or two drops of antifoam and 2 to 3 glass beads were added. The flasks were connected to a Kjeldahl distillation apparatus and 50 ml of the distillate was collected. Five ml of each distillate was transferred to a test tube containing 5 ml of TBA reagent, stoppered, mixed, and placed in a boiling water bath for 30 min. After cooling, the absorbance was measured against a reagent blank at a wavelength of 538 nm. The TBA value (mg of malonaldehyde/1,000 g of sample) was obtained by multiplying the absorbance by a constant 7.8.

### Statistical analysis

The results were analyzed using analysis of variance (ANOVA) for a completely random design<sup>(10)</sup> with four replications per treatment. Duncan's New Multiple Range Test<sup>(11)</sup> was used to separate the means, determine significant differences, and the occurrence of all possible interactions between the means.

## Results and Discussion

Initial microbial loads of appetizer drummettes affected the refrigerated shelf life. As expected, samples with lower initial microbial loads had a longer refrigerated shelf life. Minimum contamination before and during packaging or processing is important for an extended storage shelf life.<sup>(12)</sup> Mast and MacNeil<sup>(13)</sup> extended the shelf life of the mechanically-

**Table 1. The growth of psychrotrophic microorganisms in marinated chicken drummettes as affected by internal cooking temperature and rubbing at 3±1°C storage<sup>a</sup>**

Treatment	Initial loads	log CFU/g <sup>b</sup>		
		Days required to reach		
		6	7	8
With 'rub'				
Cooked to 82.2°C	2.11 <sup>c</sup>	9.73 <sup>a</sup>	11.40 <sup>a</sup>	15.83 <sup>ab</sup>
Cooked to 93.3°C	2.01 <sup>bc</sup>	10.80 <sup>a</sup>	12.18 <sup>a</sup>	16.23 <sup>ab</sup>
Without 'rub'				
Cooked to 82.2°C	1.72 <sup>b</sup>	10.00 <sup>a</sup>	12.90 <sup>a</sup>	15.30 <sup>a</sup>
Cooked to 92.3°C	1.46 <sup>a</sup>	19.10 <sup>b</sup>	22.02 <sup>b</sup>	>24.00 <sup>c</sup>

<sup>a</sup> Means within a column followed by unlike letters differ significantly ( $P < 0.05$ )

<sup>b</sup> Each number is a mean of 4 observations

**Table 2. The growth of psychrotrophic microorganisms in marinated chicken drummettes as affected by packaging and storage temperature<sup>a</sup>**

Treatment	Initial loads	log CFU/g <sup>b</sup>		
		Days required to reach		
		6	7	8
Non-vacuum				
Stored at 7±1°C	2.15 <sup>a</sup>	10.80 <sup>a</sup>	12.18 <sup>a</sup>	18.23 <sup>a</sup>
Stored at 3±1°C	2.09 <sup>a</sup>	10.00 <sup>a</sup>	11.83 <sup>a</sup>	17.50 <sup>a</sup>
Vacuum				
Stored at 7±1°C	2.05 <sup>a</sup>	11.20 <sup>a</sup>	14.30 <sup>b</sup>	18.83 <sup>a</sup>
Stored at 3±1°C	2.11 <sup>a</sup>	10.58 <sup>a</sup>	13.08 <sup>ab</sup>	18.65 <sup>a</sup>

<sup>a</sup> Means within a column followed by unlike letters differ significantly ( $P < 0.05$ )

<sup>b</sup> Each number is a mean of 4 observations

deboned poultry meat by heat pasteurization, since the initial bacterial loads were greatly reduced.

Cunningham and Bowers<sup>(14)</sup> studied the stability of chicken patties and indicated that total microbial counts of the patties ranged from  $9 \times 10^3$  to  $7 \times 10^6$  g after 10 days storage at 3°C. Wang *et al.*<sup>(15)</sup> reported that the log number of mesophilic bacteria counts for the commercial frozen fried chicken samples ranged from 2.90 to 4.78/g. In general, slime formation and off-odor were detected when log psychrotrophic counts of appetizer drummettes reached 8.0/g of sample.

Cooking appetizer drummettes to an internal temperature of 93.3°C decreased the initial microbial loads when compared to those cooked to an internal temperature of 82.2°C (Table 1). An internal cooking temperature of 71.1°C is required by the USDA (United States Department of Agriculture) for poultry or meat patties to be labeled "fully-cooked", while 68.3°C is required for cured-cooked poultry products.<sup>(16-18)</sup> Dawson *et al.*<sup>(19)</sup> reported that properly

cooked meat products presented few health problems, since total bacterial counts were low and essentially no coliforms survived the cooking processes.

Appetizer drummettes at a 93.3°C internal cooking temperature had longer refrigerated (3±1°C) shelf life than those at a 82.2°C internal cooking temperature. However, this shelf life advantage was not observed when 'rub' (a mixture of starches, seasoning, and flavoring additives) were applied during the marinated process (Table 1). It was suspected that the 'rub' on marinated products may protect the microorganisms from destruction or inactivation during the cooking process and/or may provide an ideal environment for bacterial growth.

No apparent effect on shelf life extension for appetizer drummettes by vacuum packaging was observed. No difference ( $P > 0.05$ ) in the microbial growth pattern was observed for appetizer drummettes stored at either 3±1°C or 7±1°C with or without vacuum packaging (Table 2). It was reported that vacuum pa-

**Table 3. The growth of psychrotrophic microorganisms in marinated (without 'rub') chicken drummettes as affected by sorbic acid, sodium benzoate and with/without sodium nitrite at 3±1°C storage<sup>a</sup>**

Treatment	Initial loads	log CFU/g <sup>b</sup>		
		Days required to reach		
		6	7	8
Control	1.83 <sup>b</sup>	10.00 <sup>a</sup>	12.90 <sup>a</sup>	15.30 <sup>a</sup>
Sorbic acid (0.5%)	0.64 <sup>a</sup>	16.95 <sup>b</sup>	18.55 <sup>b</sup>	21.70 <sup>b</sup>
Sodium benzoate (0.5%)	0.54 <sup>a</sup>	16.38 <sup>b</sup>	18.33 <sup>b</sup>	22.68 <sup>b</sup>
Sorbic acid (0.5%) and sodium nitrite (50 ppm)	0.61 <sup>a</sup>	19.50 <sup>b</sup>	21.70 <sup>c</sup>	>24.00 <sup>c</sup>
Sodium benzoate (0.5%) and sodium nitrite (50 ppm)	0.68 <sup>a</sup>	18.70 <sup>b</sup>	21.20 <sup>c</sup>	24.00 <sup>bc</sup>

<sup>a</sup>Means within a column followed by unlike letters differ significantly (P<0.05)

<sup>b</sup>Each number is a mean of 4 observations

**Table 4. The TBA values of marinated chicken drummettes cooked to internal temperature 82.2°C as affected by storage time, packaging method, storage temperature, rubbing and use of additives<sup>a,b</sup>**

Treatment	Storage time (day) <sup>c</sup>					
	0	4	8	12	16	20
With 'rub'						
7±1°C storage	0.23 <sup>b</sup> A	0.26 <sup>c</sup> B	0.39 <sup>b</sup> C	0.42 <sup>b</sup> D	0.52 <sup>b</sup> E	0.89 <sup>E</sup>
3±1°C storage	0.18 <sup>a</sup> A	0.26 <sup>c</sup> B	0.37 <sup>b</sup> C	0.39 <sup>ab</sup> D	0.48 <sup>b</sup> E	0.65 <sup>d</sup> F
'Rub' vacuum						
7±1°C storage	0.18 <sup>a</sup> A	0.30 <sup>d</sup> B	0.35 <sup>b</sup> E	0.31 <sup>a</sup> C	0.33 <sup>a</sup> D	0.38 <sup>a</sup> F
3±1°C storage	0.18 <sup>a</sup> A	0.18 <sup>a</sup> A	0.32 <sup>ab</sup> C	0.33 <sup>a</sup> D	0.34 <sup>a</sup> E	0.44 <sup>ab</sup> F
Sorbic acid (3±1°C storage)	0.32 <sup>b</sup> B	0.27 <sup>c</sup> A	0.36 <sup>b</sup> C	0.46 <sup>b</sup> D	0.47 <sup>b</sup> E	0.49 <sup>bc</sup> F
Sodium benzoate (3±1°C storage)	0.22 <sup>b</sup> B	0.20 <sup>ab</sup> A	0.25 <sup>a</sup> C	0.33 <sup>a</sup> D	0.33 <sup>a</sup> E	0.36 <sup>a</sup> F
Without 'rub'						
7±1°C storage	0.22 <sup>b</sup> B	0.22 <sup>b</sup> A	0.31 <sup>ab</sup> C	0.32 <sup>a</sup> D	0.47 <sup>b</sup> E	0.78 <sup>c</sup> F
(3±1°C storage)	0.30 <sup>b</sup> B	0.27 <sup>c</sup> A	0.32 <sup>ab</sup> C	0.42 <sup>b</sup> D	0.50 <sup>b</sup> E	0.58 <sup>cd</sup> F
Sorbic acid (3±1°C storage)	0.32 <sup>b</sup> B	0.27 <sup>c</sup> A	0.36 <sup>b</sup> C	0.46 <sup>b</sup> D	0.46 <sup>b</sup> E	0.49 <sup>bc</sup> F
Sodium benzoate (3±1°C storage)	0.22 <sup>b</sup> B	0.20 <sup>ab</sup> A	0.25 <sup>a</sup> C	0.33 <sup>a</sup> D	0.34 <sup>a</sup> E	0.39 <sup>ab</sup> F

<sup>a</sup>Means within a column followed by a to f unlike letters differ significantly (P<0.05)

<sup>b</sup>Means within a row followed by A to F unlike letters differ significantly (P<0.05)

<sup>c</sup>Each number is a mean of 4 observations

ckaged cut-up fresh broilers and prefried chicken patties did not delay or prevent increases in total psychrotrophic counts as compared to non-vacuum packaged samples during refrigerated storage.<sup>(20,21)</sup>

Addition of sorbic acid (0.5%) or sodium benzoate (0.5%) in the marinade mixture significantly (P<0.05) extended the refrigerated shelf life of appetizer drummettes (Table 3). The shelf life extension effect was further enhanced by the addition of 50 ppm of sodium nitrite (Table 3). Sorbic acid has been reported

to suppress the growth of *Salmonella*, *Staphylococcus*, *Escherichia*, *Pseudomonas*, and *Clostridium* and to extend chicken product shelf life<sup>(22-24)</sup> Sodium benzoate is also considered to be effective against yeast and bacterial growth.<sup>(3)</sup> Ivey and Robach<sup>(25)</sup> reported that low levels of nitrite (50 ppm) and sorbic acid (0.1% or 0.2%) greatly retarded botulinal growth and toxin formation. The effectiveness of sorbic acid (0.2%) and nitrite (40-150 ppm) combination on the botulinal safety of cured meat products was also verified by So-

fos *et al.*<sup>(26)</sup> and Tompkin.<sup>(27)</sup>

Effects of storage temperature, 'rub' application, vacuum packaging, and antimicrobial additive on the TBA values of appetizer drummettes are summarized in Table 4. The TBA values of appetizer drummettes increased as the storage time progressed. The increase in TBA value can be retarded by the application of vacuum packaging. The addition of sorbic acid sodium benzoate in the marinade was not as effective as vacuum packaging in retarding TBA value increase. Igene *et al.*<sup>(28)</sup> showed that TBA-reactive substances in the distillate of cooked chicken is an indicator for warmed-over flavor. Miller *et al.*<sup>(7)</sup> reported that pork chops seasoned with nitrite (40-120 ppm) were effective in inhibiting this warmed-over flavor. The data on vacuum packaging support the report of Baker *et al.*<sup>(29)</sup> who indicated that vacuum-packaged chicken frankfurters developed fewer changes in flavor and acceptability during storage, while non-vacuum samples resulted in faster flavor deterioration.

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## 진공포장, 'Rub', 저장온도와 첨가물에 따른 Marinated 닭 Drummettes의 품질변화

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진공포장, 'rub', 저장온도와 첨가물에 따른 marinated 닭 drummettes의 품질변화를 조사했다. Drummettes의 초기 미생물 수에 따라 제품 품질수명은 영향을 받았다. 내부온도가 93.3°C로 조리된 제품은 82.2°C로 조리된 제품보다 품질수명이 길었다. 하지만 marinated 과정에서 'rub'가 이용된 경우 위와 같은 장점은 나타나지 않았다. 냉장저장(3±1°C와 7±1°C)중 진공과 비진공 포장된 제품의 미생물 총균수는 현저한 차이가 없었다(P>0.05). Marinated 용액에 솔빈산(0.5%)이나 안식향산 나트륨(0.5%)을 첨가하여 제품 품질수명은 연장 되었으며 아질산 나트륨 50 ppm을 첨가하여 좀더 연장 되었다. 진공포장과 marinated 용액에 솔빈산이나 안식향산 나트륨을 첨가하여 제품의 TBA값 증가를 둔화시켰다.