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Assessment The Resistance and Survival of Staphylococcus aureus under Different Environmental Stresses (Temperature Variations and Salinity levels) in Domestic and Imported Poultry Meat Marketed

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Abstract— The aim of this study was to assess the resistance and survival of S. aureus under different environmental stresses (temperature variations and Salinity levels) in domestic and imported poultry meat marketed. Staphylococcus aureus (S. aureus) had been increasingly highlighted due to both its capability of eliciting food poisoning and its ability of causing invasive infections in human beings. The extraordinary ability of this bacterium for surviving under variable environmental conditions such as temperature variations, salinity changes stress results in its being an enduring risk within the chain of poultry production and supply systems. A total of one hundreds poultry meat samples were collected as frozen meat from local markets and fresh meat from butchers (fifty for each one) in Karbala province / Iraq. The period of collection beginning from October 2025 and till the end February 2026, all samples were collected by sterile cold containers, and immediately transport in ice boxes to microbiological laboratory in the university of Karbala, College of Veterinary Medicine for bacteriological investigation. The results were shown a great effect of refrigeration on 8̊ C (0.50 log) for 2 days and cooking at 75̊ (>6.26 log) for 5 mins and low effect of freezing and there is impact effect of salinity (Na Cl) 10 %(4.28 log) on bacterial growth. This study demonstrated that the cooking and salinity of poultry meat products are unfavorable for S. aureus survival and growth and that the thermal process used during manufacture can limit staphylococcal contamination. This study concluded that ,levels of contamination of the poultry meat products are low when refrigerated temperature or absent in salinity is used for storage of the final product, and killing bacteria in cooking products before consumption.

Keywords — Assessment, Resistance, Staphylococcus aureus, Temperature, Salinity.

INTRODUCTION

poultry meat is one of the most popular products of animal protein worldwide due to its high nutritive value, affordability, and availability. Nevertheless, poultry meat also serves as a significant carrier of foodborne pathogens that seriously endanger human health (1). Amongst these pathogens, Staphylococcus aureus (S. aureus) has been increasingly highlighted due to both its capability of eliciting food poisoning and its ability of causing invasive infections in human beings (2). The extraordinary ability of this bacterium for surviving under variable environmental conditions such as temperature variations, salinity changes stress results in its being an enduring risk within the chain of poultry production and supply systems (3).

Temperature exerts a direct influence on S. aureus cellular physiology by modulating membrane fluidity, enzyme kinetics, protein stability, and gene regulation, thereby determining whether the organism undergoes growth inhibition, stress adaptation, or cell death (4). Exposure to sublethal temperatures may act as a selective pressure that promotes the expression of stress-response and virulence-associated genes rather than complete bacterial elimination (5). Consequently, temperature should be regarded not only as a control measure but also as a factor capable of reshaping bacterial behavior in poultry meat systems (6). Recent evidence suggests that refrigeration may even promote the upregulation of specific virulence regulators, such as pyk and purR, in enterotoxigenic S. aureus cultured on chicken meat, highlighting a complex adaptive response rather than simple growth inhibition (7).

From a public health standpoint, these findings emphasize that refrigeration should be viewed as a bacteriostatic intervention that reduces proliferation but does not guarantee microbial safety, especially in the event of subsequent temperature abuse during handling or thawing (8). Although freezing can potentiate the antimicrobial efficacy of certain natural compounds, such as thymol, by exacerbating membrane damage and oxidative stress, freezing alone cannot be relied upon as a bactericidal intervention against S. aureus in poultry meat (9).

At cooking temperatures around 65 °C, partial inactivation may occur, but survival of stressed cells remains possible, particularly when bacterial loads are high or when protective food matrices are present (10). Increasing temperatures to 70–75 °C substantially enhances bacterial destruction by promoting protein denaturation, membrane disruption, and irreversible enzyme inactivation; however, complete safety cannot be assured if enterotoxins have been produced prior to cooking (11).

Staphylococcal enterotoxins are notably heat-stable and may retain biological activity even after exposure to cooking temperatures sufficient to kill bacterial cells, thereby posing a persistent risk of food poisoning (11). Furthermore, post-cooking contamination and improper handling during cooling, storage, or thawing can facilitate bacterial reintroduction and growth, undermining the effectiveness of thermal treatment (9).

Staphylococcus aureus exhibits notable halotolerance, enabling survival in salted poultry products. This tolerance was largely mediated through the accumulation of compatible solutes such as proline and glycine betaine, which stabilize intracellular proteins and maintain osmotic balance under hypertonic conditions (12). Such adaptation is not uniform; certain poultry-derived strains display higher salt resilience, reflecting selective pressures within processing and storage environments (13). From a practical perspective, lightly salted chicken meat (2–5% NaCl) may not inhibit S. aureus growth completely, allowing sublethal proliferation and toxin production. In contrast, concentrations exceeding 10–12% NaCl significantly reduce viable counts, but do not guarantee complete elimination of halotolerant or biofilm-associated strains.

The halotolerance of S. aureus highlights the limitations of traditional salt-based preservation. In commercial settings, the persistence of viable bacteria despite salting can lead to toxin accumulation if other parameters such as temperature control or pH are suboptimal (14).

The aim of study assessment the resistance and survival of S. aureus under different environmental stresses, including temperature (refrigeration, cooking, freezing) and salinity levels.

MATERIALS AND MTHODS

SampleCollection

A total of one hundreds poultry meat samples were collected as frozen meat from local markets and fresh meat from butchers (fifty for each one) in Karbala province / Iraq. The period of collection beginning from October 2025 and till the end February 2026, all samples were collected by sterile cold containers, and immediately transport in ice boxes to microbiological laboratory in the university of Karbala, College of Veterinary Medicine for bacteriological investigation.

Bacterial isolation

A 25 g of sample was homogenized using a meat grinder under aseptic conditions and it was added to 225 mL of sterile Buffered Peptone Water and incubated at 37˚C for 24 hours in order to culture the organisms. Then, 0.1 mL of sample was inoculated on mannitol salt agar and incubated at 37˚C for 18-24 hours, colonies appeared as mannitol non-fermenters were purified by sub-culturing staphylococcus medium 110 for further identification(15), sub-cultured on 5% sheep blood agar to isolate single colonies.

Cultural characteristics

Cultural characteristics were studied depending on colony morphology (color, size, density, consistency) on the growth media; also the type of hemolysis (α, γ or β hemolysis) on blood agar (16).

Biochemical tests:

Coagulase Test

a. Slide Coagulase test:

A clean dry microscopically slides were divided into two sections, one drop of rabbit plasma was placed on each section, one colony from an agar plate of the test isolates was emulsified in each of the two drops to make a smooth suspension, mixed gently with bacteriological loop.

b. Tube Coagulase Test:

Citrated rabbit plasma was diluted 10 times with isotonic saline, 0.5 ml of the diluted plasma was added into small serology tube (containing, culture of S.aureus) and the test tube was put in the water bath for 3hrs. Coagulase formation indicates that isolate is coagulase positive, (17).

Oxidase Test:

A clean dry filter paper was used and applying of 1-2 colonies of bacteria mixed with (Tetraethyl-p-phenylenediamin-dihydro-chloride) by a sterile wood stick (18).

Catalase test:

The growth from nutrient agar was placed on glass slide, the cells were mixed with a drop of 3% H2O2 (2-1-5-4). Immediate bubbling indicates a positive catalase test (15).

Microscopic Examination

This include the examination of shape, Gram-stain reaction and arrangement of cells.

Experiment Consisted of Two Steps

The experiment involved two steps:

Meat Contamination According to Temperature

After isolating S.aureus from thigh, ,minced ,back and breast meat the bacteria were cultured on Mannitol salt agar and incubated at the specified temperatures as outlined in the Refrigeration (4 ℃) for 24 and 48 hours, Refrigeration (8 ℃) for 24 and 48 hours, Freezing (-18 ℃) for 1 and 7 days and Cooking (65,70,75 ℃) for 5 mins.

Samples of tight,minced ,back and breast meat were each inoculated with S. aurous 106. A quantity of 5 grams or 5 milliliters of each food product was used for the inoculation. The inoculated samples then incubated under controlled conditions at refrigerated temperatures of 4°C and 8°C for 24h to 48h .At Freezing temperatures of -18°C for 1 and7 days and cooking temperatures of (65,70 and 75) °C for 5 mins. Following incubation, microbial analysis was carried out to evaluate bacterial growth. Each sample was subjected to serial dilution up to 10^6 to estimate the concentration of bacteria. From each dilution, aliquots were plated on mannitol salt agar and incubated under appropriate conditions to allow colony development. Colony-forming units were observed and counted to determine whether the bacterial population had increased, decreased, or remained stable over the incubation period. The presence or absence of colonies in the agar plates was used to assess whether each food product served as a suitable medium for the growth of Staphylococcus aureus under the tested conditions. Uninoculated control samples were maintained in parallel to rule out external contamination and confirm the accuracy of the observations(19)

Meat Contamination According to Salt Concentration

The Sodium Chloride solutions were prepared according to the specified concentrations, and the bacteria were diluted in them before being cultured on Mannitol salt agar and incubated at the designated temperatures, as outlined in the following tables. To assess the individual effect of each salt concentration on Staphylococcus aureus, 50 µl of an 18–24-hour broth culture was inoculated into 20 ml of the respective treatment tubes. The inoculated tubes were vortexed and maintained at room temperature (25 ºC) for the specified contact times. At intervals of 1 hour, 12 hours, 24 hours, and 96 hours, 1 ml from each tube was serially diluted in 9 ml of sterile 0.1% peptone water, and viable counts were determined using the spread plate method. The experiment was conducted in triplicate. Bacterial counts were recorded as CFU/ml or CFU/g. At the end of the incubation period, only petri plates containing Staphylococcus aureus colonies ranging between 15 and 150 were considered for bacterial enumeration. Plates with more than 150 colonies were classified as "too many to count" (TMTC) and were excluded from analysis, while those with fewer than 15 colonies were labeled "too few to count" (TFTC). Colonies on each plate were counted using a Quebec colony counter the bacteria were cultured on mannitol salt agar and incubated at the specified Sodium cholride as outlined in the 0% NaCl to 24h and 48h ,2% NaCl to 24h and 48h 5% NaCl to 24h and 48h and 10% NaCl to 24h and 48h .

To evaluate the effect of sodium chloride concentration on the growth of Staphylococcus aureus, samples of tight, minced, back and breast poultry meat inoculated with 106. Each product was supplemented with varying concentrations of NaCl, specifically 0, 2, 5 and 10% after 24h and 48h. Following the addition of salt, 5 grams or 5 milliliters of each treated product were inoculated and incubated at 37°C for periods of three and seven days. After incubation, the samples were subjected to serial dilution, reaching up to a 10^6 dilution level, to estimate bacterial concentration. Aliquots from each dilution were plated onto mannitol salt agar and incubated under appropriate conditions to allow colony development. The number of colony-forming units was recorded to assess the effect of salt concentration on bacterial survival and proliferation. Growth patterns were analyzed to determine whether higher salt concentrations inhibited bacterial development or allowed for persistence and adaptation. Uninoculated control samples with corresponding salt levels were maintained to confirm the sterility of the products and exclude the possibility of external contamination(19).

Statistical Analysis

All data were analyzed using two way ANOVA through the General Linear Models procedure , one way anova and Chi-Square test , an interactive calculation tool for chi-square tests of goodness of fit and independence(20).

RESULT AND DISCUSSION

Effect of Temperature on S. aureus Bacterial Growth

In tight, minced, back and breast poultry meat, temperature effects on the growth of Staphylococcus aureus were studied after 24h and 48h of refrigeration at 4 and 8 °C. After 48h of refrigeration, temperature had there is impact effect on bacterial growth in all types of meat as shown (Table 3.2). Freezing (-18 ℃) for after 7 days, heavy growth was observed on all products, with the highest counts recorded on all type products except for tight and back meat after 7 days , there is impact effect on bacterial growth as shown (Table 3.3). Cooking at (65 and 70 ℃) for 5 mins ,there is impact effect on bacterial growth of breast meat where is cooking at 70 ℃ for 5 mins of normal meat, there is impact effect on bacterial growth .There was no growth at 75°C after 5 mins cooking in all sample as shown (Table 3.4).

Table 1. Effect of Refrigeration at 4°C and Time on Staphylococcus Survival in Different Meat Types (log_{10} CFU/g ± SD)

Meat Type	4°C - 24h Mean±SD	4°C - 48h Mean±SD
Tight Meat	5.98 ± 0.13 A a	5.89 ± 0.16 A a
Minced Meat	6.15 ± 0.10 A a	6.08 ± 0.14 A a
Back Meat	5.92 ± 0.14 A ab	5.82 ± 0.18 A ab
Breast Meat	5.78 ± 0.16 A b	5.68 ± 0.20 A b

Different capital letters (A–D) within the same row indicate significant differences among types of meats collection.Different small letters (a–b) within the same column indicate significant differences among meat types at two point of times (Two-way ANOVA followed by post hoc test, $p \leq 0.05$).

Table 2. Effect of Refrigeration at 8°C and Time on Staphylococcus Survival in Different Meat Types (log_{10} CFU/g ± SD)

Meat Type	8°C - 24h Mean±SD	8°C - 48h Mean±SD
Tight Meat	5.82 ± 0.15 A a	5.52 ± 0.21 B a
Minced Meat	6.02 ± 0.12 A a	5.78 ± 0.18 B a
Back Meat	5.75 ± 0.16 A ab	5.42 ± 0.23 B ab
Breast Meat	5.62 ± 0.18 A b	5.28 ± 0.26 B b

Different capital letters (A–D) within the same row indicate significant differences among types of meats collection. Different small letters (a–b) within the same column indicate significant differences among meat types

at two point temperatures (Two-way ANOVA followed by post hoc test, p ≤ 0.05).

Table 3. Comparison between 24 h and 7 days Freezing (-18OC) Effects on Staphylococcus Surviva**l.**

Meat Type	-18°C at 24h Mean±SD	-18°C at 7 Days Mean±SD
Tight Meat	6.61 ± 0.13 A a	4.33 ± 0.16 B b
Minced Meat	6.31 ± 0.12 A a	5.52 ± 0.14 A a
Back Meat	5.15 ± 0.11 A a	4.39 ± 0.17 B a
Breast Meat	5.48 ± 0.15 A a	5.39 ± 0.14 A a

Different capital letters (A–D) within the same row indicate significant differences among types of meats collection. Different small letters (a–b) within the same column indicate significant differences among meat types at two point temperatures (Two-way ANOVA followed by post hoc test, p ≤ 0.05).

Table 4: Effect of Cooking Temperature and Meat Type on Staphylococcus Survival after 5 Minutes (log_{10} CFU/g ± SD**).**

Meat Type	Uncooked Control Mean±SD	65°C Cooking Mean±SD	70°C Cooking Mean±SD	75°C Cooking Mean±SD
Tight Meat	6.25 ± 0.11 A a	3.28 ± 0.28 A b	2.05 ± 0.38 A c	0.00 ± 0.00*
Minced Meat	6.42 ± 0.09 A a	3.52 ± 0.24 A b	2.28 ± 0.34 A ab	0.00 ± 0.00*
Normal Meat	6.18 ± 0.13 A a	3.15 ± 0.31 A b	1.85 ± 0.42 B c	0.00 ± 0.00*
Breast Meat	6.05 ± 0.15 A a	2.95 ± 0.35 B b	1.65 ± 0.48 B c	0.00 ± 0.00*

Different capital letters (A–D) within the same row indicate significant differences among types of meats collection. Different small letters (a–b) within the same column indicate significant differences among meat types at four point of cooking (Two-way ANOVA followed by post hoc test, p ≤ 0.05). *75°C: All samples showed 0 colonies (detection limit: 10 CFU/g = log_{10} 1.0).

A significant effect of 8°C refrigerated temperature on bacterial growth over a two-day period was observed across the various types of meat products. Bacterial growth, measured in colony forming units (CFU), was found to be highly dependent on the specific temperature condition. For tight, minced, back and breast poultry meat, the heaviest growth, quantified as 1000 (1x10^6 CFU). This limit assumes that the initial population of S. aureus will likely be no more than 1,000 CFU/g of food and that a minimum of 1,000,000 CFU/g.

These results were agree with the results obtained by Montanari et al., who reported that complete destruction of Staphylococcus aureus isolated from poultry meat cannot be achieved during processing temperature of 75 °C for 5 min(21). The results in table (3.4) showed that the mean values of S. aureus count (cfu/g) in tight, minced, back and breast poultry meat samples were nearly similar to the results obtained by Morshdy et al. (4.3x102)/g in minced meat(22).

Critical limits were established for each bacterial species to determine the safety level of food. For S. aureus to induce poisoning symptoms(23). Provided the food was initially contaminated needs to be heated at 70 or 75°C for more than at 75°C for more than 5 min to reach a bacterial population below 105 CFU. g−1. However, S. aureus levels in food should not exceed 103 CFU. g−1 to remain “acceptable” for consumption and should neither exceed 102 CFU.g−1 to be considered “good” for consumption according to the FDA(24) .

Growth at 7.8°C did occur in that food. However, in other instances, the organism failed to grow at temperatures higher than these, presumably because of physico-chemical properties of the food. It should be noted that these data are for growth and not toxin production. The data available suggested that a refrigerated temperature of more than 8°C for 48h is required for this to occur. This is not an absolute as one paper reports the absence of toxin when incubation was at -18°C (25). The cooking treatment ended when the meat reached 75 °C at their thermal center which is generally recognized safe temperature for chicken(26). Cooking is represented the only wide spread and most effective methods to prevent food borne diseases caused by vegetative pathogenic microorganisms from contaminated meat(27). The best method to keeping meat from bacteriological view is cooking, then refrigeration and finally the freezing method. The boiling was the best due to the internal thermal temperature of the core of the meat reached to 75 °C during cooking for 5 mins in which the food was cooking and boiling destroy a large number of the microorganism so, food become safe for consumption but in frying and roasting the temperature may not penetrate the core of the meat but act on the superficial part of the meat so, do not affect the microorganism in the internal part of meat so the cooked meat not well done so, represent health hazard to a human health. A previous study demonstrated that S. aureus could continue to grow in freezed and refrigerated meats without the addition of effective inhibitors, highlighting the importance of using appropriate salt concentrations or effective preservation techniques to limit the growth of this bacterium(28).

Effect of Sodium Chloride on S. aureus Bacterial Growth

After a forced infection of S. aureus bacterial growth was determined in thigh, minced, back and breast poultry meat, after 24h and 48h days of incubation at various NaCl concentrations (0, 2, 5 and 10%) (See tables 3.5 , 3.6 , 3.7 and 3.8).It was noted that 2%,5% and 10% salt after 24h and 48h reduced bacterial growth, which was bacteria-free.

Table 5. Effect of NaCl Concentration and Meat Type on Staphylococcus Counts after 24 Hours (log_{10} CFU/g).

Meat Type	NaCl 0% Mean± SD	NaCl 2% Mean± SD	NaCl 5% Mean± SD	NaCl 10% Mean± SD
Tight Meat	6.25 ± 0.11 A a	5.92 ± 0.14 B ab	4.45 ± 0.23 C ab	3.35 ± 0.29 D ab
Minced Meat	6.42 ± 0.09 A a	6.08 ± 0.12 B a	4.85 ± 0.19 C a	3.62 ± 0.25 D a
Back Meat	6.18 ± 0.13 A ab	5.85 ± 0.16 B ab	4.38 ± 0.24 C b	3.28 ± 0.31 D b

Breast Meat	6.05 ± 0.15 A b	5.72 ± 0.18 B b	4.22 ± 0.27 C b	3.12 ± 0.34 D b

Different capital letters (A–D) within the same row indicate significant differences among NaCl concentrations for each meat type. Different small letters (a–b) within the same column indicate significant differences among meat types at the same NaCl concentration (Two-way ANOVA followed by post hoc test, p ≤ 0.05).

Table 6. Effect of NaCl Concentration and Meat Type on Staphylococcus Counts after 48 Hours (log_{10} CFU/g).

Meat Type	NaCl 0% Mean± SD	NaCl 2% Mean± SD	NaCl 5% Mean± SD	NaCl 10% Mean± SD
Tight Meat	6.58 ± 0.10 **A a**	5.42 ± 0.19 **B a**	3.08 ± 0.34 **C a**	1.95 ± 0.41 **D a**
Minced Meat	6.75 ± 0.08 **A a**	5.65 ± 0.16 **B a**	3.52 ± 0.29 **C a**	2.25 ± 0.38 **D a**
Back Meat	6.45 ± 0.12 **A ab**	5.28 ± 0.21 **B ab**	2.95 ± 0.37 **C ab**	1.82 ± 0.44 **D b**
Breast Meat	6.32 ± 0.14 **A b**	5.15 ± 0.23 **B b**	2.78 ± 0.42 **C b**	1.65 ± 0.48 **D b**

Different capital letters (A–D) within the same row indicate significant differences among NaCl concentrations for each meat type.Different small letters (a–b) within the same column indicate significant differences among meat types at the same NaCl concentration (Two-way ANOVA followed by post hoc test, p ≤ 0.05).

Table 7. Comparison of between 24 and 48 hr with different NaCl concentration.

Parameter	24 Hours Mean± SD	48 Hours Mean±S D	Chang e (48h - 24h)	P value *	Interpretatio n
Control (0% NaCl)	6.23 ± 0.15 **A a**	6.53 ± 0.19 **A a**	**+0.30 log**	**0.16**	Growth in all meat types
2% NaCl	5.89 ± 0.17 **AB a**	5.38 ± 0.24 **A a**	**-0.51 log**	**0.22**	Moderate reduction
5% NaCl	4.48 ± 0.27 **B a**	3.08 ± 0.37 **B b**	**-1.40 log**	**0.031**	Strong reduction
10% NaCl	3.34 ± 0.32 **B a**	1.92 ± 0.45 **C b**	**-1.42 log**	**0.027**	Very strong reduction

Different capital letters (A–D) within the same row indicate significant differences among NaCl concentrations for each meat type. Different small letters (a–b) within the same column indicate significant differences among meat types at two point of times (Two-way ANOVA followed by post hoc test, p ≤ 0.05).

Table 8. Comparison with all Treatments

Treatment	Best Condition	Log Reduction	Time Required
10% NaCl	48 hours	4.28 log	48 hours
75°C Cooking	5 minutes	>6.26 log	5 minutes
8°C Refrigeration	48 hours	0.50 log	48 hours

The results indicated that S. aureus has a remarkable ability to grow and multiply in environments with low salt concentrations. Extensive growth was observed in products such as thigh, minced, back and breast poultry meat at a salt concentration of 0%,2%,5%. In contrast, a significant decline in growth was observed at 10% salt concentrations, and complete reduced of growth at 10% salt concentrations. These results indicate that S. aureus exhibits a clear sensitivity to high salt concentrations, which inhibits its growth. This inhibition was attributed to the osmotic effect, which hinders nutrient absorption and causes cellular dehydration. A previous study sodium chloride (NaCl) could be effective alternatives to salt in inhibiting the growth of S. aureus in food products. These compounds reduce the water activity and acidify the internal environment of the bacterial cell, thus hindering its growth and multiplication(12).

When analyzing the effect of different salt concentrations on S. aureus growth after days 2, it was found that in absence of Nacl (0%) allowed intense bacterial growth, while higher concentrations gradually inhibited growth. This suggested that the bacteria are capable of adapting to moderately salty environments, but were adversely affected by a increasing in salt concentration. Another study showed that S. aureus could not survive in highly salty environments for extended periods(29).

This is attributed to its low water activity and the absence of a moist environment, which is essential for the growth of these facultative anaerobic bacteria. A recent study demonstrated that low water activity in food products inhibits the growth of facultative anaerobic bacteria such as S. aureus, making meat an unsuitable environment for their proliferation(30). For meat, especially back meat, intense growth was observed at 2% concentrations, with a significant decrease at 5%, and reduced bacterial growth at 10%. This reflects a protein-rich environment that is may reduced as inhibitory concentrations gradually increase. P values for most products indicate a significant relationship (<0.05) between concentrations and S. aureus growth, underscoring the importance of using inhibitors to control bacterial contamination rates. These results support the recommendation to use inhibitor or salt concentrations ≥7%, or more to apply heat/preservative treatments, to ensure that S. aureus colonies do not develop in food products. A previous study had shown that the use of salt substitutes on NaCL could be effective in inhibiting the growth of S. aureus, providing multiple options for the food industry to control the growth of these bacteria(31). The analogous results were observed Since the bacteria were unable to grow under such high concentration of sodium chloride (9 %) normally(32). With no growth at any salt level, Generally, the salt concentration in salted food needs to be higher than 15% to inhibit bacterial growth. The research on the mechanism of S. aureus salt tolerance is mainly limited to the low salt concentration range(33). When microorganisms have to engage in strong metabolic alterations for survival under severe salinity, they downregulate the effort directed to cellular functions which are not of core significance for survival, such as virulence(34). Herein, we believe that virulence was downregulated to reduce the depletion of nonessential cellular functions to survive in a highly salt-stressed environment. Previous studies reported that after undergoing low-concentration salt stress, S. aureus accumulates a great amount of L-proline for osmotic regulation(35). This mechanism was also reported in foodborne bacteria such as Staphylococcus aurous(36). The large cells emerged at the post-exponential phase and the proportions of these large cells to normal-sized cells gradually increased with prolonged cultivation time (microscopic observation). Most of these large cells were entirely spherical and existed singly. In addition , the large cells could easily be ruptured by lowering the osmotic pressure of the culture or by contact with dilute sodium chloride (NaCl) solution microscopic observations), suggesting that they were either protoplasts or spheroplasts resulting from cell wall degradation(37).

In conclusion, our results demonstrated that the cooking and salinity of poultry meat products are unfavorable for S. aureus survival and growth and that the thermal process used during manufacture can limit staphylococcal contamination. This study suggests that ready to- eat poultry meat products are relatively safe. However, when the levels of contamination of the raw minced meat are high and/or when an incorrect temperature is used for storage of the final product before consumption, such precooked products may represent a potential risk for consumers.

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