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Occurrence of *Staphylococcus aureus* in chicken breast meat and the influence of different thawing techniques on its survival rate

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ABSTRACT

In view of the great demand for frozen poultry meat, particularly chicken breasts, it's necessary to warrant its suitability and safety for human consumption when subjected to thawing in various ways. *Staphylococcus aureus* (*S. aureus*) poses an increasing risk to public health, poultry production, and meat industry due to its pathogenicity and food poisoning exacerbated by multi-drug resistance. *S. aureus* was isolated from 46.8 % (29/62) of meat samples and 93 % (27/29) of these isolates showed coagulase reactivity. The 23S rRNA gene was found in 6/10 isolates. Two or Three of these isolates was used to study the effect of different thawing practices on the sensory and physicochemical features and safety of frozen chicken breast meat. Both visual inspection and bacteriological re-isolation revealed a strong efficacy of microwave oven in fast thawing and reduction of *S. aureus* count with a 99.6% inhibitory effect. Fridge showed good efficiency in reducing drip loss, keeping water holding capacity (WHC), decreasing pH, and lowering *S. aureus* count by 35%. Water streaming and 25°C elevated the drip loss, WHC, and massively multiplied the bacterial number. This reflects the importance of thawing practice for meat quality and safety.

INTRODUCTION

Globally, there is a sharp increase in the demand for chicken meat with a preference in consuming cut-up pieces, especially breasts, rather than the whole bird due to their beneficial nutritional and dietary qualities, as well as low sodium and cholesterol levels **(Whitnall and Pitts, 2019)**. Broiler chicken meat is one of the most popular frozen meals, which can account for up to 35% of all frozen food consumption **(Tsiboe et al. 2024)**. The meat of chicken breast has a perishable nature highlighting the significance of a well-functioning production, storage, and handling procedures. Freezing is one of the approaches that ensure and maintain meat quality until it is consumed **(Ren et al. 2022 and Rinwi et al. 2024)**. Exposure of frozen chicken meat to thawing pro-

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cess can be risky to consumer and causes true financial losses through affecting its traits such as pH, drip loss, WHC, and microbial load **(Hessel et al. 2019)**.

Several thawing techniques including soaking in cold water, cold air circulation, slightly warmed air, room temperature, microwave oven, and high voltage electrostatic technology were encountered. Nevertheless, there is lack in approved official technical standard for this purpose **(Cai et al. 2019)**. Some of these techniques may encourage microbial flourishing and increase drip loss, rendering meat unfit for human consumption. Others can significantly reduce a number of nutrients, especially protein and minerals found in poultry meat **(Abdel -Aziz et al. 2016)**. Improper thawing may spoil meat and damage it as well as increases the potential for consumer food-borne diseases by a variety of bacteria (**Wang et al. 2022)**.

Staphylococcal food poisoning is one of the most prevalent foodborne outbreaks globally which caused by *S. aureus.* Poultry meat and related byproducts are one of the major food vectors implicated in these outbreaks **(Buzón-Durán et al. 2017)**. *S. aureus* is a zoonotic Gram-positive pathogen that triggers bacteremia, soft tissue infections, osteomyelitis, and endocarditis in both people and animals **(Hu et al. 2023)**. PCR-based techniques are commonly used tools for identification of this bacterium due to their easiness, fastness, and cost-effectiveness. The 23S rRNA-encoding gene was found to be more sensitive confirmatory element for identifying *S. aureus* isolates in the clinical samples **(Kadiroğlu, 2013)**.

It compromises food safety, which have detrimental effects on public health and noted by the World Health Organization as "Priority pathogen". This bacterium is often implicated in food poisoning outbreaks because of its ability to produce several toxins including stable enterotoxins, lipases, hemolysins, and coagulases especially in suitable temperature, pH, and water activity. Less than 1.0 µg staphylococcal enterotoxins is sufficient for intoxication, which is reached when *S. aureus* population exceeds 100,000 bacterium/g of food **(Freitas et al. 2023)**. *S. aureus* can be transmitted to human after the handling or consuming contaminated food. The illness is expressed by a rapid onset of nausea, intense vomiting, abdominal cramps, 24 - 48 h diarrhea, and complete recovery within 1–3 days however; severe cases require hospitalization. Moreover, it was stated that 10^6 cfu/gram of this bacterium are skin infective (**Nacer et al. 2024)**.

In that connection, this study aimed at validating the extent of *S. aureus* presence in fresh chicken breast meat and the effect of thawing under water streaming, at 25 ^{o}C, in high frequency microwave oven, and in fridge on its safety and quality.

MATERIAL AND METHODS

Screening the extent of *S. aureus*

1. Sampling

Sixty-two (62) fresh broiler chicken breast samples (250 ± 8.7g) were aseptically collected from chicken slaughtering and cleaning shops in Assiut City, Egypt. Each sample was put in a separate sterile plastic bag, transported under health requirements to the laboratory and examined bacteriologically.

2. *S. aureus* isolation and biochemical analysis

S. aureus was isolated by direct broth and plate culture method from the fresh breast samples according to **Hu *et al.* (2023)**. Single colonies were catalase tested and gram stained. Catalase reactive and gram-positive isolates were biochemically identified by coagulase testing as described by **Kitai et al. (2005)**.

3. Molecular analysis

For molecular identification of *S. aureus*, presence of the 1250 bp *23S rRNA* PCR product was considered a positive indicator (**Prihandani et al. 2024)**. Ten (10) coagulase reactive *S. aureus* isolates were ascertained by PCR using the primer set; ACGGAGTTACAAAGGACGAC (Forward) and AGCTCAGCCTTAACGAGTAC (Reverse) **(Metabion, Germany)**. DNA was extracted from the bacterial colonies following QIAamp

DNA Mini kit's instructions (Qiagen, Germany, GmbH) with some modifications. Briefly, 10 µl proteinase K and 200 µl lysis buffer were added to 200 µl of the colony suspension and incubated at 56 °C for 10 min. The lysate was mixed with 200µl ethanol (100%), washed, and centrifuged. Nucleic acid was eluted with 100 µl of elution buffer. Template DNA was amplified using the primer set and EmeraldAmp Max PCR Master Mix (Takara, Japan), in applied biosystem 2720 thermal cycler following the cycling condition of **Bhati et al. (2016)**. Precisely, an initial hot start at 94°C for 5 minutes, followed by 35 cycles, each consisting of 94°C for 30sec, 55°C for 40sec, and 72°C for 1.5min and the step of final extension at 72°C for 12min. The amplified products (5µl) were visualized on 1.5% agarose gel stained with ethidium bromide (Applichem, Germany, GmbH) by UV light in comparison to molecular size of 100-1.500bp DNA ladder (Qiagen, Gmbh, Germany).

Effect of thawing methods on the physicochemical properties of chicken breast and *S. aureus* vitality

***S. aureus* isolate**

Two or Three strains of *S. aureus* used in the experiment were the previously isolated and molecularly identified strains.

They were propaged in sodium chloride broth at 37°C for 24-48 hours and tenfold serial dilution was made, the tube(1 x 10^6cfu/ml) were matched to 0.5 x 10^8cfu/ml (0.5 Mcferland) and further confirmed by counting in a specific agar plates.as described by **Göksoy et al. (2000)**.

2. Chicken breasts

Twenty-five broiler chickens breast meat each weighs approximately 250 g, were freshly brought. Each breast was trimmed by cutting out any observable fat and connective tissues. The organoleptic characters (Color, Smell, Texture, and flexibility), general acceptance of each breast, and pH were considered before starting the experiment. Contamination by *S. aureus* was excluded by UV sterilization for 15 min/side as recommended by **Morsy et al. (2018)**.

3. Chicken breasts manipulation and experimental design

Each breast meat was randomly cut into parts using a sterile knife. The weight of each part was recorded (weight before treatment, WBT). Breast samples were divided into 4 groups. Each group was soaked in nutrient broth containing *S. aureus* (1x10^6 CFU /ml broth). Each group was separately (in sealed moisture-resistant polyethylene bags) frozen at -18 °C for 7 days till triggering thawing procedures.

The meat parts were submitted to four different thawing approaches: T1 (water streaming under tap water); T2 (at room temperature of 25 °C); T3 (in a microwave oven, 2.45 Ghz, 850W, Mod. MWL 110, KENWOOD, China); and T4 (cold thawing in fridge at 4 °C). A –ve control group was considered for each treatment while the breast meat cuts were immersed in sterile non-inoculated nutrient broth. The temperature changes were monitored by using a digital thermometer (measurement capacity from – 20 ± 0.1°C to +150 ± 0.1°C). Thawing was stopped after meat center's temperature reached 10 °C in all practices. Thawing duration (TD) was recorded for each approach. The sensory characters (Color, Smell, Texture, and flexibility) were scored from 1 to 5, with 1 as the lowest score and 5 as the highest.

This experiment was repeated three times (n = 3), then calculate mean values for statistical analysis **(Lu et al. 2015)**.

Assessing the physicochemical properties of thawed meat

After thawing; pH, weight and drip (syneresis) loss (%), and water holding capacity (WHC) were determined as documented by the official methods (**Oliveira et al. 2015 and Masoumi et al. 2018**).

Adjusting the effect on *S. aureus* vitality

The "dilution plate" method according to **Kuncara et al. (2021**) was followed to assess the vitality of *S. aureus* under different thawing practices by counting the visible bacterial colonies on agar plates. Ten-fold serial dilu-

tions of the thawed meat saline homogenate (1 g grinded meat/5 ml) were dispensed evenly by a hockey stick over the surface of "Baird-Parker agar" plates and incubated at 37°C for 24h. The number of bacterial colonies was estimated using a counting device equipped by an electronic counter (SUNTEX, CC-570), a 1.5 magnification lens, and a black background illumination system.

Statistical analysis

The bacterial colony count was transformed into log 10 of CFU/g. Data were expressed as means ± SE and analyzed using a one-way ANOVA procedure conjugated with Tukeys' multiple comparison test (SPSS Inc., Chicago, Illinois, The USA) and a 0.05 *P*-value.

RESULTS

S. aureus was isolated from 29 samples (46.8 %) of the examined 62 chicken breast meats by conventional bacteriological examination showing circular yellow colonies surrounded by yellow area spreading into the medium. Only, 93% of the isolates (27/29) were coagulase positive. The gene encoding 23S rRNA was detected in 6 *S. aureus* isolates out of ten **(Fig. 1)**.

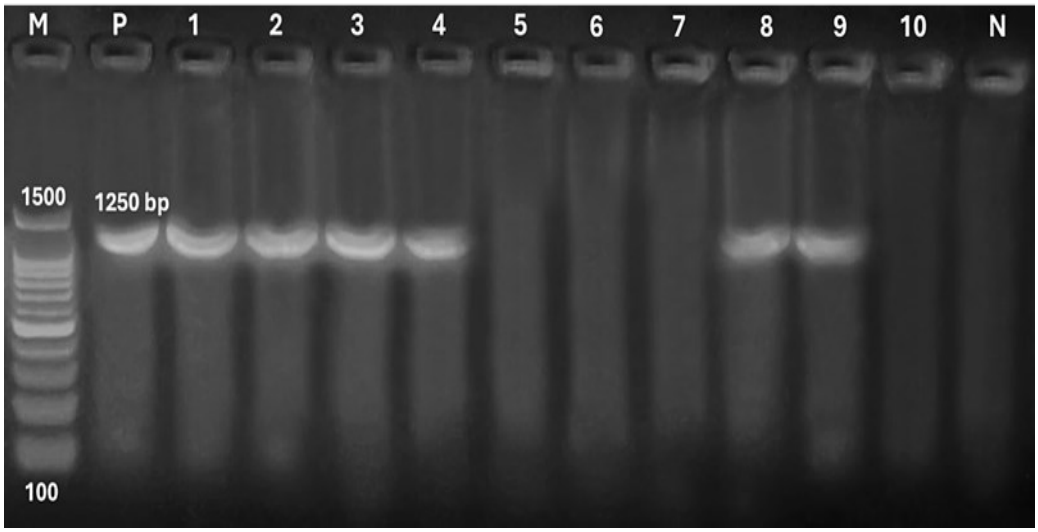

Fig. 1: Agarose gel electrophoresis image showing the 23S rRNA of *S. aureus*'s amplicon. M: 1500 bp DNAmarker; P: Positive control for *S. aureus* (amplicon size 1250 bp); Lanes 1-4 and 8-9: Positive samples. N: Negative control (Nuclease free water). Lanes 5-7 and 10: Negative samples.

Effect of thawing methods on the physico-chemical properties of chicken breast meat and *S. aureus* vitality

1. Thawing duration (TD)

A highly significant differences (*P*-value = 3.39E-35) were observed in the thawing duration (min) among meat thawed by the applied thawing methods **(Table 2)**. The longest thawing time was observed at the fridge followed by 25 °C and water streaming (180±0.0 min, 75±0.0 min, and 5.33±0.37 min, respectively) while the fastest thawing occurred inside the microwave (1±0.0).

2. Acceptability

The various thawing practices affected the sensory qualities of chicken breast meat differently (**Table 1**). There was a significant differ-

ence (*P*-value < 0.05) between all thawing practices in their effect on color, smell, texture, flexibility, and the overall acceptability of thawed chicken breast as compared to fresh meat. The smell score was non-significantly lesser after water streaming (4.54±0.2), microwaving (4.8±0.1), and refrigerating (4.78±0.09) in comparison to fresh meat (5±0.00). The score was significantly less after meat thawing at 25 °C (3.74±0.12).

The color scores of meat being microwave thawed revealed non-significant low score (4.52±0.18) in comparison to fresh (5.00±0.00). For thawing in fridge, water streaming, and 25 °C, the scores were lower significantly (*P*-value = 1.40E-05) with mean values of 4.02±0.14, 3.76±0.19, and 3.5±0.2, respectively, in the same time, no significant statistical difference between the scores obtained after microwave and fridge thawing.

Texture mean scores of the thawed meat decreased insignificantly microwaving (4.52 ± 0.17) and significantly after refrigerating and water streaming (3.92 ± 0.15 and 3.8 ± 0.10, respectively) in comparison to fresh (5 ± 0.01). Meanwhile, keeping at 25 °C, meat mean texture scored 3.18 ± 0.11 which was highly significant low.

The flexibility mean scores of breast meat thawed in microwave (4 ± 0.01), fridge (4.12 ± 0.25), and water stream (3.56 ± 0.14) were significantly lower than the fresh (5 ± 0.01). Thawing at 25 °C decreased the flexibility score in a highly significant manner (3 ± 0.31).

The overall acceptability scores of microwave- and fridge- thawed meat were non-significantly lesser than fresh with mean scores of 4.46±0.17 and 4.6±0.19, respectively. Score of water streaming thawed meat was significantly lesser (3.92±0.21). Thawing at 25 °C decreased the score to highly significant degrees (3.36 ± 0.16).

Table 1. Acceptability of chicken breast meat thawed with various thawing practices depending on its sensory attributes

Criteria	Fresh meat	Water streaming	25 °C	Microwave	Fridge	*P*-value
Smell	5±0.00^{a}	4.54±0.2^{a}	3.74±0.12^{b}	4.8±0.1^{a}	4.78±0.09^{a}	5.00E-06
Color and luster	5±0.00^{a}	3.76±0.19^{c}	3.5±0.2^{c}	4.52±0.18^{ab}	4.02±0.14^{bc}	1.40E-05
Texture*	5±0.00^{a}	3.8±0.10^{b}	3.18±0.11^{c}	4.52±0.17^{a}	3.92±0.15^{b}	1.93E-08
Flexibility	5±0.00^{a}	3.56±0.14^{bc}	3±0.31^{c}	4±0.00^{b}	4.12±0.25^{b}	7.00E-06
Overall acceptance	5±0.00^{a}	3.92±0.21^{b}	3.36±0.16^{c}	4.46±0.17^{a}	4.6±0.19^{a}	7.30E-03

Data are expressed in mean ± standard error.

*Texture: Viscosity of appearance.

$^{a-d}$: Averages, within a row and a certain test condition, followed by a different superscript are significantly different (P<0.05).

3. pH

The results indicated significant changes (*P*-value = 1.98E-07) in pH between the thawed meat groups **(Table 2)**. The pH changed non-significantly (*P*-value > 0.05) after thawing under the conditions of water streaming and microwave in comparison to fresh meat (5.8 ± 0.0, 5.8 ± 0.0, and 5.8±0.4, respectively). The pH of samples thawed in 25 °C and fridge decreased significantly to 5.4±0.0 and 5.53 ± 0.07, respectively.+

Table 2. Physicochemical characters and *S. aureus* viability for chicken breast meat thawed under water streaming, at 25 °C, in microwave, and at the fridge:

	Fresh meat	Water streaming	25 °C	Microwave	Fridge	*P*-value
WBT (g)	-	8.85±0.23	8.73±0.37	8.73±0.10	8.53±0.16	0.95
WAT (g)	-	4.4±0.05^{b}	5.78±0.28^{a}	4.83±0.43^{b}	5.85±0.10^{a}	6.6E-03
Drip loss (%)	-	49.9±1.9^{a}	33.8±1.5^{b}	44.4±4.8^{ab}	31.3±0.7^{c}	3.90E-04
TD (min)	-	5.33±0.37^{c}	75±0.0^{b}	1±0.0^{d}	180±0.0^{a}	3.39E-35
pH	5.8±0.4^{a}	5.8±0.01^{a}	5.4±0.0^{b}	5.8±0.0^{a}	5.53±0.07^{b}	1.98E-07
WHC	16.7±1.9^{b}	30.8±7.5^{ab}	46.7±5.2^{a}	32.6±5.6^{ab}	28.8±1.2^{ab}	0.02002
Staph count (x10^{7}CFU)	0.1	1.94±0.05^{b}	36.8±6.62^{a}	4E-04 ±5.0E-05^{b}	0.065±0.015^{b}	3.31E-08
Staph multi./red. (%)	-	(+1840±0.5^{b}	(+)36700±66^{a}	(-)99.6±4.9E-04^{b}	(-)35±0.15^{b}	3.42E-8

Data are expressed in mean ± standard error. WBT (g): Weight before thawing in gram, WAT (g): Weight after thawing in gram, TD (min): Thawing duration in minute, WHC (%): Water holding capacity percentage, CFU: Colony forming unit.
[a-c:] Averages, within a row and a certain test condition, followed by a different superscript are significantly different (p<0.05-0.001).
-: Value not measured. Staph multi./red. (%): *S. aureus* multiplication or reduction percentage. (+): multiplied by. (-): reduced by

4. Weight and drip (syneresis) loss (%)

The rate of drip loss (%) varied significantly among breast meat thawed using the various thawing techniques (*P*-value = 3.90E-04). The rate was significantly greatest after thawing under water streaming conditions (49.9±1.9%) followed by microwave (44.4±4.8 %). Thawing at 25 °C showed a significantly lesser drip loss rate (33.8±1.5 %) that wasn't statistically various from that of microwave meanwhile the rate was significantly the least after thawing at fridge (31.3±0.7%) **(Table 2)**.

5. Water holding capacity (WHC)

The percentage of WHC in fresh chicken breast meat averaged 16.7±1.9%. This percentage was affected significantly (*P*-value = 0.02002) by the different thawing practices. Thawing under water streaming, in microwave, and in fridge raised the WHC percentages non-significantly (30.8±7.5%, 32.6±5.6%, and 28.8±1.2%, respectively), while increased it significantly at 25 °C (46.7±5.2%) **(Table 2)**.

Effect on *S. aureus* vitality

The applied thawing practices varied significantly in the number of *S. aureus* count (*P*-value= 3.31E-08). During thawing at 25°C, the total number of *S. aureus* increased significantly from 0.1x10^{7} CFU to 36.8±6.62 x10^{7} CFU i.e. the bacterial number doubled up to 36700±66 %. By thawing under water streaming, the number of *S. aureus* bacteria increased non-significantly to 1.94±0.05 x10^{7} CFU and the number doubled over to 1840±0.5%. Thawing under the microwave and fridge conditions decreased significantly the *S. aureus* bacterial growth and created an inhibitory percentage of 99.6±4.9 % and 35±0.15 %, respectively **(Table 2)**.

4. DISCUSSION

S. aureus is a food poisoning bacterium requiring facultative anaerobic conditions to multiply. It contaminates chicken meat products commonly during handling and at any processing step causing severe food poisoning hazards in human, particularly, after secreting their thermo-stable toxins. Moreover, it resists various antimicrobials even penicillin **(Hamad et al. 2022)**. In this study, a total of 46.8 % of broiler chicken breast meats were positive for *S. aureus* by conventional bacteriological isolation and 93 % of the detected staph isolates were coagulase positive. This is concerning to the effects which can adversely impacts public health due to heat-stable and proteases-resistant enterotoxins might be secreted by this bacterium into food **(Freitas et al. 2023 and Nacer et al. 2024)**. The gene encoding 23S rRNA is sensitive for identifying *S. aureus* and associated with its increased antimicrobials resistance **(Besier et al. 2008)**. This gene was detected in 60% (6/10) of the isolates obtained from this study.

The presence of *S. aureus* in chicken breast meats may be due to contamination anywhere in the supply chain from farm to market which can occur via contact with the equipment and chicken meat handlers. Chicken meat is abundant in nutrients (proteins, carbohydrates, fats, and vitamins) and has high WHC delivering it vulnerable for *S. aureus* contamination and growth **(Hamad et al. 2022)**. Accordingly, strict measures are required to decrease the access and replication of such bacterium during chickens slaughtering and their meat handling processes, stressing the importance of checking the prevalence of *S. aureus* colonization among personnel working in poultry slaughterhouse. Fewer *S. aureus* prevalence rates were recorded in previous studies. **Momtaz et al. (2012)** isolated it from 22.77% of fresh raw chicken meats in Isfahan province, Iran. **Akbar and Anal (2013)** documented 18.18% S. *aureus* prevalence rate in fresh broiler chicken meat of Thailand. **Khallaf et al. (2014)** and **Nacer et al. (2022)** found *S. aureus* in 16.66% and 15.92%, respectively, of poultry meat samples in the Slaughterhouses of Morocco. On the other hand, **Hamad et al. (2022)** documented a higher prevalence rate of *S. aureus* in chicken breast samples reached 92% in Alexandria, Egypt.

Freezing is one of the most popular techniques to protect meat by delaying metabolic activities, keeping nearly all its features, storing them over extended periods, and stopping germ growth (**Oliveira et al. 2015**). However, several studies proved the effect of thawing on changing the quality and microbial population in frozen meat **(Mohammed et al. 2021)**. In this study, four thawing approaches (water streaming, 25 ^{o}C, microwave, and the fridge) were studied. All expressed variable effects on the characteristics of thawed chicken breast meat and vitality of *S. aureus* contaminating it.

These thawing approaches exhibited variable thawing durations. Thawing in the fridge took the longest time followed by 25 ^{o}C and water streaming. Prolonged thawing times permits more fluid oozing from the thawed meat which can alter the physicochemical traits of meat and allows microbial proliferation. Also, slow thawing damages cell structure due to protein denaturation and reduction in WHC (**Kim et al. 2011; Park and Kim, 2024**). Meanwhile, microwave induced the fastest thawing delivering no sufficient time for microbial growth. Microwave is household device that is widely used in food processing, preparation, browning, drying, enhancing food quality, and shelf life **(Kaewkot et al. 2023)**.

The sensory attributes of thawed chicken breast meats varied differently by the various thawing practices as compared to fresh meat which agreed with **Augustyńska-Prejsnar et al. (2018)**. The odor of thawed meat showed non-significant change after water streaming, microwaving, and refrigerating indicating suitability of these methods for retaining the flavor of chicken breast meat. On the other hand, thawing at 25 oC changed significantly the thawed meat smell, which may be due to the affection of muscular cells at this temperature by intracellular ice crystals created during freezing and hence protein loss. This protein loss elevates by increasing the thawing temperature and undergoes transformations in the thawing leakage producing abnormal odors (**Augustyńska-Prejsnar et al. 2018**).

Meat color is an imperative assessment criterion. In this study, meat color was non-significantly lighter than fresh after microwaving but significantly darker after thawing in fridge, water streaming, and 25 °C reflecting the dark appearance. In the same time, no significant statistical difference between the scores obtained after microwave and fridge thawing. These results this agreed with **Lee and Park (1999)**. The change in meat color extent is mainly affected by access to oxygen **(Augustyńska-Prejsnar et al. 2018)**. The color darkness of meat during thawing at 25 °C and water streaming is conveyed to metmyoglobin formation resulted from oxidation of oxymyoglobin and deoxymyoglobin. The metmyoglobin percent decreases in the microwave than that of the fresh meat **(Kim et al. 2011)**.

Texture mean scores of the thawed meat decreased significantly after refrigerating, water streaming, and keeping at 25 °C. This significant decrease in texture scores reflects occurrence of chemical changes during thawing processes using these methods (**Altunakar et al. 2004**). Meanwhile, the texture score of the microwaved breast meat was non-significantly lesser than fresh which agreed with **kim et al. (2011)**.

Concerning meat flexibility, the mean scores decreased significantly in fridge, microwave, and water stream. These meat parts recovered bit slower than fresh establishing that meat is still fresh. On other hand, thawing at 25 °C adversely affected the meat freshness by reducing the flexibility score significantly and showing slower meat recovery (**Lu et al. 2017**).

Overall, thawed meat from the microwave and fridge had better acceptability rates than water streamed- and 25 °C-thawed meat. These findings supported the effectiveness of microwaves and refrigerators for thawing food, as suggested by **Kim et al. (2011)** and **Jie et al. (2023)**.

Meat pH can directly affect the efficiency of muscle myofibrillar proteins to bind and entrap water. The ideal meat pH ranges from 5.8 - 6.3 which may be due to glycogen breakdown and lactic acid formation **(Barbut, 2024)**. In this study, the pH of the chicken breast meat that was thawed by water streaming and microwave didn't change much, but thawing it at 25 °C and in the refrigerator caused a significant drop. This decrease can be explained by loss of water from meat after thawing which may increase solutes concentration. In addition, denaturation of proteins may cause the release of hydrogen ions **(Ali et al. 2015)**.

Drip loss indicates the potential for meat to lose moisture as exudate during raw meat storage which could reduce juiciness (**Barbut, 2024**). In this study, the water streaming and microwaving increased the rate of drip loss significantly, which may reduce meat quality as described elsewhere (**Barbut, 2024**). The increased drip loss following microwave thawing may be caused by increased protein denaturation (**Oliveira et al. 2015**). However, thawing at 25 oC lessened the drip loss rate significantly that wasn't statistically different from that of the microwave, while the rate was significantly the least after thawing at the fridge. The low drip loss of meat thawed at the fridge indicates greater moisture content and tenderness compared to the other thawing methods. This can be attributed to the little damage of muscle cell structures resulted from slow melting of the intracellular ice crystals inside the fridge **(Oliveira et al. 2015)**. These results are constant with the findings of **Pires et al. (2002)** and **Xia et al. (2013)**.

WHC of chicken meat breasts reveals the ability of meat to maintain natural or added water during processing and storage that is closely correlated with important quality criteria like texture and color of meat and affects product processing. It is affected by the muscle cells' integrity but not closely related to the total moisture content (**Fengou et al. 2024**). The various thawing techniques in this study resulted in increasing in the WHC %. This agreed with **Oliveira et al. (2015)**. Increasing WHC in the thawed meat is probably due to decreasing proteins denaturation derived from inhibiting activity of proteolytic bacteria after freezing (**Masoumi et al. 2018**) particularly in meat

thawed at 25 °C and in fridge that was accompanied by low pH. **Barbut (2024**) explained that increasing WHC specifies changing the chemical and structural characteristics of the muscle myofibrillar proteins which affect its ability to bind water as meat freezing-thawing cycle upsets the integrity of muscle cells mechanically.

After microwave thawing the runaway heating may raise WHC via impairing muscle protein structure and protein denaturation. This agreed with the study of **Kim et al. (2011)**. It was suggested that the increase in thawing rate resulted in an increase the WHC (**Yun et al. 1998**).

In the present study, thawing under water streaming and at 25 °C doubled over the total number of *S. aureus* up to 1840±0.5% and 36700±66 %, respectively. This reflects that thawing under water streaming and at 25 °C used temperature range (20 - 30 °C) encouraging for microbial flourishing which renders meat unfit for human consumption (**Oliveira et al. 2015**).

On the other hand, thawing in the microwave and fridge not only inhibited *S. aureus* but also killed it by 35±0.15 % and 99.6±4.9E-04 %, respectively. These findings highlight how thawing chicken breast meat in microwave and fridge might improve its safety. The ability of thawing in fridge to reduce *S. aureus* count and hence keeping meat safety came in line with **Ordonez's (2005)**. It was recommended that meat parts should ideally thaw slowly at a low temperature because under this condition water slowly returns to its original place in the tissues. In addition, protein repositioning is more thorough when thawing is done gradually at a low temperature **(Colla and Prentice-Hernandez, 2003)**.

The great reductive potential of microwave to *S. aureus* count can be accredited to its combined dynamic heat electromagnetic irradiation which interfere biological systems viability after inducing internal fractions within the foodstuff. This agreed with **Krifi et al. (2014)** who documented the success of microwave in developing promising aspects of pasteurization and even sterilization, which supports their classification as "cold pasteurization technologies" because of their deadly effects.

In conclusion, *S. aureus* is prevalent among chicken meat breasts. Thawing frozen chicken meat breasts under water streaming and at 25 °C is very hazardous and negatively affect their quality. Microwave demonstrated a significant lethal effect on *S. aureus* and so, it is a reliable and efficient technology for reducing microbial hazards and produce safer products. Also, thawing in fridge condition showed somewhat acceptable meat quality and reduced *S. aureus* count.

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