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EFFECT OF NEUTRAL ELECTROLYZED WATER ON SHELF LIFE OF COLD CHICKEN MEAT

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ABSTRACT

This investigation aimed to assess the impact of 50, 100, and 200 ppm of neutral electrolyzed water (NEW) on the sensory characteristics, chemical composition, and microbiological quality of fresh chicken breast meat kept for six days at 4±1ºC. The results showed that dipping chicken breast meat samples in NEW at three concentrations (50, 100 and 200 ppm) can improve storage stability and reduce microbial populations compared with the control group. The results on the sixth day of storage revealed that the pH values were 6.41±03, 6.34±02c and 6.32±02d, respectively, and the TBARS values were 0.79±0.02, 0.68±0.05 and 0.50±0.02 respectively. While aerobic plate counts, *E. coli,* and *S. aureus* counts were 5.58±0.23, 4.54±0.29, 3.92±0.06; 1.82±0.15, 1.65±0.04, 1.38±0.12 and 1.62±0.07, 1.50±0.01, 1.32±0.02 log CFU/g, respectively, which was lower than the control group in all treatments on day 6. As storage duration extended relative to the control group, dipping chicken breast flesh samples in neutral electrolyzed water, especially at a concentration of NEW200 ppm, obtained the greatest score in sensory characteristics. Over the course of six days of storage, the pH and TBARS values of the meat samples rose in control and all treated groups, but lower values were obtained by treating with 50,100 ppm, while the lowest values were obtained by treating with 200 ppm of NEW. This study found that 200 ppm of NEW is more effective than 50 or 100 ppm. It can be a promising way to increase the shelf life of chicken meat without leaving any hazardous residues and is regarded as a healthy antimicrobial preservative agent for chilled chicken meat kept in a refrigerator.

Keywords: Chicken meat, neutral electrolyzed water, microbial quality, decontamination, shelf life.

INTRODUCTION

Chicken meat is one of the main sources of vital polyunsaturated fatty acids, vitamins, minerals, and protein; its consumption has been rising over the past few decades (Alonso-Hernando *et al.,* 2013; OECD-FAO, 2016). In processing plants, contamination of chicken meat can occur throughout processing, packaging and storage until the meat is sufficiently cooked and consumed (Mensah *et al.,* 2002). It may get tainted with harmful and spoiling microbes, turning it into food that is hazardous and unpalatable for customers. The initial count of spoiling microorganisms and the temperature during the production

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and storage processes determine how long poultry meat will last on the shelf (Yashoda *et al.,* 2001). Chemical, physical, and biological methods are used in certain nations to decrease bacterial contamination and increase shelf life. To reduce or eliminate germs and improve the quality of the goods, numerous chemical treatments based on phosphates, chlorine, and organic acids have been developed for the meat and poultry industries (Loretz *et al.,* 2010).

In food sectors, electrolyzed water (EW) is a safe and effective sanitizer that can lower microbiological hazards (Hricova *et al.,* 2008; Huang *et al.,* 2008). The only substance utilized in the creation of electrolyzed water is sodium chloride. Trihalomethanes, a possible carcinogen, can be produced by aqueous or gaseous chlorine reacting with proteins and carbohydrates in food (WHO, 2000; Huang and Batterman, 2009). In contrast to other sanitizers like hypochlorite, which are not only extremely corrosive but also detrimental to consumer health, NEW is safe for use and has little corrosive effects. Neutral electrolyzed water (NEW) has garnered a lot of attention in recent years as a potential disinfectant. It is safe for the environment, easy to use, and has no negative effects on the user, in addition to being an excellent sanitizer (Shirahata *et al.,* 2012).

Neutral electrolyzed water (NEW), which has been shown in numerous studies to be effective as an antimicrobial agent in the food industry, can eliminate or reduce pathogens, including *Salmonella typhi, Escherichia coli, and Campylobacter jejuni*, in samples of fresh chicken meat (Saengkrajang *et al.,* 2011) or even reduce them logarithmically (Kim *et al.,* 2000; Han *et al.,* 2018). Additionally, according to Abadias *et al.* (2008), its broad-spectrum efficacy may eradicate *Listeria monocytogenes, Staphylococcus aureus, E. coli, S. typhimurium*, and *Enterococcus faecalis*. In the food industry, this chemical has even been effectively utilized to disinfect and sanitize surfaces (Jiménez *et al.,* 2016).

The food's natural physical-chemical conditions, pH, free chlorine concentration, oxidation reduction potential (ORP), type of microorganism present and its microbial load, length of time the electrolyzed water was in contact with the food, and concentration all have impacts on how well the water disinfects (Guerra- Sierra *et al.,* 2019). To achieve the anticipated disinfection of samples without endangering the public's health, it would be convenient to use a lower concentration of neutral electrolyzed water and extend the contact duration of the NEW during the chilling stage (4°C). In the chicken breast flesh samples, the microbial load of *S. aureus* and *E. coli* is greatly reduced by neutral electrolyzed water. Its usage is risk-free and is not harmful or corrosive (Guerra Sierra *et al.,* 2022 and Patricia *et al.,* 2023).

The primary cause of the quest for novel alternatives for the preservation of chicken meat is its contamination by harmful bacteria, such as *Salmonella* or *Listeria monocytogenes* (CDC, 2023). Chlorine usage in the food business is prohibited in several European nations, including Germany, Denmark, and Belgium (Ramos *et al.,* 2013). By electrolyzing a NaCl solution, Neutral Electrolyzed Water (NEW) is a germicide that produces stable hypochlorous acid under regulated conditions. NEW has previously been used on surfaces and surroundings, as well as to disinfect food items such as pork, strawberry, broccoli, and squid, with positive outcomes (Athyde and Associates, 2017). Its production process is inexpensive, and since it doesn't need handling potentially hazardous chemicals, its use is an environmentally friendly choice. The bacterial wall's amino acid groups and sulfhydryl (-SH) oxidation impact are what cause the drug's antibacterial action, as reported by Kim *et al.* (2000) and Rivera-Garcia *et al.* (2019). This impairs the respiration and feeding processes of the bacterium. Therefore, the objective of this

study was to assess the effect of different concentrations of neutral electrolyzed water (NEW) at (50, 100, and 200 ppm) on the shelf life, sensory, chemical, and microbiological quality of fresh chicken breast meat stored at 4±1ºC for 6 days.

MATERIALS AND METHODS

1. Collection and preparation of samples:

The experiment was conducted in the Animal Health Research Institute - Damanhur city. One kilogram of raw, fresh, boneless chicken breast fillet samples was collected from nearby poultry abattoirs in the province of El Behera, sealed in sterile polyethylene bags, and carefully delivered to the laboratory. Within an hour, in separate boxes with cooling packs, and stored at 4±1ºC until they are needed for this inquiry. The samples were split into four groups, each weighing 250 g. The first group served as the control group, and the other three groups of chicken meat samples were used to assess the effects of 50, 100, and 200 ppm concentrations of neutral electrolyzed water (NEW) on the sensory, chemical, and microbiological quality of the samples.

2. Production of neutral electrolyzed water (NEW) (Rahman et al., 2016; Guerra Sierra *et al.*, 2022):

To prepare electrolyzed water (EW), a membrane exchange device (Lbeg01-17) was utilized. Using Milli-Q water at a pH of 6.7 ± 0.1, which was confirmed with a pH meter (Thermo Scientific Orion 3 Star), the EW was produced from a 5% NaCl solution. The membrane exchange device was run through the salt solution. According to manufacturer recommendations, the obtained electrolyzed water showed an oxide reduction potential (ORP) of 1030 mV (Thermo Scientific Orion Star A221), pH-6.7, and 360 ppm of free chlorine (measured spectrophotometrically using a Merck Pharo-300 and the Spectroquant®Chlorine test-Merck® technique). This electrolyzed water was dissolved into solutions and kept in 220 L drums with threaded lids at concentrations of 50, 100, and 200 ppm (Ref. BR22) for use within 8 h.

3. Processing and treatment of samples (Moghassem Hamidi *et al.*, 2021):

Three of the four groups were treated with neutral electrolyzed water (NEW) at concentrations of 50, 100, and 200 ppm for 15 minutes at room temperature, followed by storage at 4±1ºC for six days. The control group was submerged in sterile distilled water. Fresh chicken breast meat samples from all groups were tested right away for sensory evaluation, chemical (pH and TBARS value), and initial microbial load of aerobic plate count (APC), *E. coli* and *S. aureus*, sp counts, at zero-day and on days 2, 4, and 6 of storage at 4ºC. The proportion of treatment solutions to chicken breasts was 1:1 (w/v). Subsequently, each was packaged separately into sterile zippered polyethylene bags and kept at 4±1ºC.

4. Microbiological analysis:

4. 1. Preparation of serial dilutions (APHA, 1992):

25 grams of meat samples were weighed and put into a sterile homogenizer flask that contained 225 milliliters of peptone water (0.1%) under aseptic circumstances. The contents of each flask were homogenized at 14000 rpm for 2.5 minutes in order to yield a 10^{-1} dilution. After that, a sterile pipette was used to transfer 1 ml to a sterile test tube containing 9 ml of (0.1%) peptone water. Subsequently, a decimal serial dilution was made in increments of 10^{-10} to accommodate the entire range of anticipated sample contamination. The following formula was used to count and record the number of colonies in colony forming units per gram (cfu/g) of meat samples for microbial counting: cfu/g = level of dilution plated x number of colonies counted/volume plated. These were further expressed in mean colony forming units per gram (mean cfu/g) and converted to log10 base values (log10cfu/g).

4.2. Total aerobic plate count (APC) (Jay, 2002):

After being weighed and placed into a sterile stomacher bag containing 0.1% sterile buffered peptone water (1:9 W/V), the treated chicken breast meats were gently washed for two minutes. Then, 0.1% sterile buffered peptone water was used to serially dilute the rinse solution 10 times. 1 ml of the suitable diluent was plated in triplicate using the pour-plate technique on the plate count agar (Merck, Germany) for the enumeration of (APC). The plates were then incubated at 32^{o}C for 48 hours and 7^{o}C for 10 days, respectively.

4.3. *E. coli* count

Using a sterile bent glass spreader, 100 µl of each previously prepared serial dilution was evenly distributed over duplicate plates of Eosin methylene blue (EMB) agar (OXOID, CM0 069). For twenty-four hours, the control and inoculation plates were incubated at 37 °C (FDA, 2001). The greenish metallic colonies suspected to be *E. coli* had a dark purple center. The number of colonies and their expression as log CFU/g of material were recorded.

4.4. *Staphylococcus aureus* count:

According to (FDA, 2001) the serial dilution was distributed on Baird-Parker Agar medium (CM 215) supplemented with egg yolk tellurite emulsion (SR54) plates at 35^{o}C for 48 hours. Colonies that looked suspiciously black and glossy, with a halo zone surrounding them, were selected for morphological analysis and biochemical identification.

5. Chemical analysis:

On days 0, 2, 4, and 6 of the storage, the following chemical analyses of every treatment were performed:

5.1. Measurement of pH (ES 63-11/2006):

We confirmed with a Digital Jenco 609 pH meter. By mixing a 10 g sample with 90 ml deionized water for two minutes, the pH was determined. A digital pH meter was used to determine pH.

5.2. Measurement of Thiobarbituric acid reactive substance (TBARS) (ES 63-9/2006):

A ten-gram sample and forty-eight milliliters of distilled water were combined. Add two milliliters of 4% ammonium chloride (to raise the pH to 1.5) to the previously mentioned components, blend for two minutes, and let the mixture sit at room temperature for ten minutes. After being put into Kjeldal flasks, the mixture was rinsed with a further 50 mL of distilled water, an antifoaming solution, and a few glass beads. After the flask was heated to 50 °C, the Kjeldal distillation apparatus was put together. Ten minutes after the boiling started, distillates were collected. A stopped glass tube was filled with the distillates (50 ml), which had been mixed. After adding 5 milliliters of TBA reagent (0.2883/100 milliliters of glacial acetic acid), the tube was sealed, shaken, and left in a bath of boiling water for 35 minutes. Similar to the sample, a blank was made by mixing 5 mL of TBA reagent with 5 mL of distilled water, and it was handled the same way. The tube was heated and then allowed to cool for ten minutes under tap water. A section was moved to a curette, and then a spectrophotometer (Perkin Elmer, 2380, USA) was set to read the sample's optical density (D) against the blank at a wavelength of 538 nm. When comparing the sample to the blank, the TBA value (mg malondialdehyde/Kg of the sample) is equal to Dx7.8 D.

6. Sensory evaluation (Moghassem Hamidi *et al.*, 2021)

Six trained sensory panelists performed the sensory evaluation of the chicken breast flesh on days 0 and 6 of storage. Every sample was assessed three times. A straightforward four-point scoring system was used to assess color, odor, and texture following the guideline table. The following formula was used to determine the sensory index.

$$SI = \frac{(2\,X\,C) + (2\,X\,O) + T}{5}$$

Where C stands for colour, O for odour, T for texture, and SI for sensory index. Assessing the colour, texture, and odour of chicken breast flesh to determine its sensory quality score Qualities 4 (Highest quality) 3 (Good quality) 2 (Fair quality) 1 (Poor quality)

Terms used to describe breast chicken flesh used to assess its sensory qualities

	Score			
Attributes	**4 (Highest quality)**	**3 (Good quality)**	**2 (Fair quality)**	**1 (Poor quality)**
Color	Pink (natural color)	Increased turbidity	A few color changes	Color changes completely (yellow-gray)
Odor	Good odor of fresh chicken	Loss of good odor	Bad odor	Obvious putrefaction odor
Texture	Tight and elastic	Decreased stiffness and elasticity	Soft texture with no elasticity	Loose texture

2.7. Statistical Analysis:

For every property, three duplicate samples (n = 3) were examined. The mean and standard deviation (SD) of the mean were used to describe the results. Using SPSS software version 17.0, the means were compared using One Way ANOVA and then Duncan's Multiple Range Test (Duncan, 1955). Data presented as three replicates' mean ± SD. A column's means that are separated by distinct letters differ significantly from one another ($P < 0.05$).

RESULTS

Table 1): The mean scores for the sensory attributes of samples of chicken breast flesh stored at 4±1ºC for six days while being treated with varying amounts of neutral electrolyzed water (NEW).

Parameter	Control	NEW50 ppm	NEW100 ppm	NEW200 ppm
Odor				
Day 0	3.50±0.00a	3.62±0.02c	3.80±0.54a	4.00±0.00a
Day 2	2.13±0.40b	2.55±0.01a	2.70±0.52a	3.00±0.00a
Day 4	1.70±0.30b	2.19±0.01a	2.33±0.52b	2.81±0.01f
Day 6	1.00±0.01c	1.37±0.06a	1.66±0.51b	1.97±0.06d
Color				
Day 0	3.56±0.25a	3.62±0.02b	3.85±0.54a	4.00±0.00a
Day 2	2.53±0.30b	2.65±0.03b	2.74±0.43a	3.20±0.00a
Day 4	1.65±0.50b	2.25±0.01c	2.45±0.72b	2.86±0.07c
Day 6	1.00±0.05c	1.42±0.06a	1.75±0.51b	1.99±0.09f
Texture				
Day 0	3.62±0.00a	3.75±0.05a	3.87±0.84a	4.00±0.00a
Day 2	2.43±0.60b	2.65±0.02c	2.77±0.72a	3.30±0.01a
Day 4	1.73±0.90b	2.36±0.05a	2.65±0.12b	2.91±0.08d
Day 6	1.00±0.06b	1.67±0.01b	1.78±0.71b	1.95±0.04f

Table 2: Pattern of pH of chicken breast meat samples treated with different concentrations of neutral electrolyzed water (NEW) during refrigerated storage at 4±1ºC for 6 days.

Storage days/ groups	pH values ± SE			
	Zero day	2nd day	4th day	6th day
Control	6.26±0.02a	6.35±03a	6.43±02a	6.57±02a
NEW50 ppm		6.30±02b	6.35±02b	6.41±03b
NEW100 ppm		6.26±03c	6.30±02c	6.34±02c
NEW200 ppm		6.20±01d	6.25±02d	6.32±02d

Table 3: The TBARS values (mg/kg) of chicken breast flesh samples treated with varying concentrations of neutral electrolyzed water (NEW) were analyzed after six days of refrigeration at 4±1ºC.

Storage days/ groups	TBARS (Malonaldehyde) mg/Kg ±SE			
	Zero day	2nd day	4th day	6th day
Control	0.43 ± 0.05^{a}	0.65 ± 0.02^{a}	0.92 ± 0.04^{a}	1.13 ± 0.03^{a}
NEW50 ppm		0.51 ± 0.02^{a}	0.58 ± 0.02^{d}	0.79 ± 0.02^{a}
NEW100 ppm		0.45 ± 0.02^{a}	0.55 ± 0.05^{a}	0.68 ± 0.05^{b}
NEW200 ppm		0.42 ± 0.02^{c}	0.45 ± 0.03^{a}	0.50 ± 0.02^{a}

Table 4: Chicken breast flesh samples treated with varying concentrations of neutral electrolyzed water (NEW) during six days of refrigeration at 4±1ºC were examined for patterns of aerobic plate (bacterial) count APC (log10cfu/g).

Storage days/ groups	Total aerobic plate count APC (log_{10}cfu/g)			
	Zero day	2nd day	4th day	6th day
Control	3.17±0.06a	4.95±0.02a	5.64±0.05a	6.93±0.02a
NEW50 ppm		3.77±0.02b	4.65±0.01b	5.58±0.23b
NEW100 ppm		3.68±0.06c	4.07±0.01c	4.54±0.29c
NEW200 ppm		3.05±0.01d	3.38±0.01d	3.92±0.06d

Table 5: Pattern of *E.coli* count (log_{10}cfu/g) in chicken breast meat samples treated with different concentrations of neutral electrolyzed water (NEW) during refrigerated storage at 4±1ºC for 6 days.

Storage days/ groups	Total *E. coli* count (log_{10}cfu/g)			
	Zero day	2nd day	4th day	6th day
Control	1.69 ± 0.12^{b}	1.83 ± 0.15^{a}	1.93 ± 0.05^{d}	1.99 ± 0.07^{a}
NEW50 ppm		1.57 ± 0.13^{c}	1.67 ± 0.12^{a}	1.82 ± 0.15^{a}
NEW100 ppm		1.45 ± 0.05^{a}	1.55 ± 0.09^{a}	1.65 ± 0.04^{b}
NEW200 ppm		1.24 ± 0.12^{a}	1.33 ± 0.05^{a}	1.38 ± 0.12^{a}

Table 6: Pattern of *S.aureus* count (log_{10}cfu/g) in chicken breast meat samples treated with different concentrations of neutral electrolyzed water (NEW) during refrigerated storage at 4±1ºC for 6 days.

Storage days/ groups	Total *S. aureus* count (log_{10}cfu/g)			
	Zero day	2nd day	4th day	6th day
Control	1.24±0.01[a]	1.45±0.03[c]	1.72±0.02[a]	1.86±0.05[a]
NEW50 ppm		1.32±0.04[a]	1.55±0.07[a]	1.62±0.07[a]
NEW100 ppm		1.25±0.07[a]	1.37±0.02[a]	1.50±0.01[d]
NEW200 ppm		1.12±0.10[a]	1.21±0.03[a]	1.32±0.02[a]

DISCUSSION

1. Sensory Evaluation:

The panelists discovered that the newly prepared chicken breast samples (day 0) in both the treated and untreated samples with neutral electrolyzed water (NEW) were well in all sensory qualities, as can be seen from the findings shown in Table (1) which displays the results of the sensory analysis performed on the treated chicken breast meat samples from days 0 to 6 of storage. Throughout storage, all of the treatments' sensory indices for odour, colour, and texture declined. In contrast to the control group, which had the lowest score at the end of storage (day 6), the chicken breast meat samples treated with neutral electrolyzed water (NEW) at concentrations (200 ppm) had the highest sensory index score on day 0, when all treatments were observed to have higher scores than the control group. According to Rasooli, (2007), sensory profiles enable us to assess meat quality and occasionally spot undesired impurities. The sensory assessment findings showed that the chicken breast samples treated with neutral electrolyzed water (NEW) scored higher than the control samples in every sensory category. Neutral electrolyzed water (NEW) is added at concentrations of 50, 100, and 200 parts per million. Up to the end of the sixth storage day, there was a noticeable improvement in the chicken breast meat's appearance, softness, and flavour, notably at the concentration (200 ppm).

After four days of storage, the sensory quality of the chicken breast samples, particularly the control sample, markedly declined and was no longer fit for cooking. Sensory attribute alterations were less noticeable in the samples of chicken breasts treated with NEW (200 ppm), compared to control samples and other treatment groups.

These findings concur with those of (Moghassem Hamidi *et al.*, 2021) who found that chicken meat stored in a refrigerator had improved sensory qualities due to the application of neutral electrolyzed water (NEW). Also, (Guerra-Sierra *et al.*, 2022) reported that neutral electrolyzed water enhances the favorable sensory qualities of chicken meat, such as taste, colour, odour, texture, and the overall acceptability in chillers. Furthermore, other foods treated with neutral electrolyzed water (NEW) during refrigeration have been shown to retain their sensory qualities. This means that NEW can extend the shelf-life of food items, in addition to providing them with the proper colour and flavor (Patricia et al., 2023). Because of the physicochemical stability of chickens, the obtained findings indicated that NEW may be employed throughout the preparation of chicken meat.

4.2. Chemical analysis of treated chicken meat:

2.1. Hydrogen ion concentration (pH)

According to Hernandez-Pimentel *et al.* (2020), lipid/protein degradation brought on by chemicals, microbes, and physical

damage resulted in a rise in pH values in the chicken breast meat samples (control or treated groups) throughout the refrigerator storage period until the end of the sixth day. The obtained results in Table (2) showed the changes in the pH value of the chicken breast meat samples, the initial pH on zero-day was 6.26±0.02 in group I (control). While at the end of storage (day 6), the control group had the highest pH value of 6.57±02 while the last treated group with 200 ppm had the lowest value of 6.32±.02 and treated groups with 50 and 100 values were 6.41±03 and 6.34±02 respectively.

The action of microbial or endogenous enzymes like lipase and protease, which raise the concentration of volatile bases over extended storage, may be the source of rising pH readings (Hernández Pimentel *et al.*, 2020). Furthermore, a statistically significant difference was seen on day six between the groups who received treatment and the control group. This is supported by the findings of Rahman *et al.* (2012) and Sheng *et al.* (2018). The rise in pH during storage might be attributed to the microbial production of ammonia and the degradation of protein components (Gill, 1983). The control group experienced a higher pH value than the other treatment groups, and on day six of storage at 4^{o}C, when the pH value reached >6.5, the first signs of spoiling were noticed.

2.2. Thiobarbituric acid reactive substances (TBARs):

The thiobarbituric acid reactive substances (TBARS) test is a widely used method for the identification of secondary oxidation products. Malondialdehyde (MDA) is the primary product of oxidative rancidity and is responsible for the off flavour of oxidized fat. Products made from chicken breast flesh have low quantities of antioxidants and high levels of polyunsaturated fatty acids, which make them vulnerable to oxidative degradation (Dawson and Gartner, 1983). It was shown by the data in Table (3) that the TBA of control samples' mean values were increased from 0.43±0.05 at day zero to 1.13±0.03 at day 6 of storage. While TBA values of the chicken breast treated with neutral electrolyzed water (NEW) at concentrations (50, 100 and 200 ppm) increased to 0.79±0.02, 0.68±0.05 and 0.50±0.02 mg MDA/kg respectively at day 6 of storage.

Regardless of treatment, TBARS progressively rose as storage time increased, but TBA levels in treated samples dramatically lowered malondialdehyde (MDA) levels in comparison to the control sample. The control and treated chicken samples exhibited modest levels of lipid oxidation, with lipid oxidation levels below 0.5 mg MDA/kg, indicating no oxidative rancidity throughout the storage period. TBA in chicken meat shouldn't exceed 0.9 mg/kg of chicken meat, according to (ES 1651/2005). Samples treated with (NEW) at (50 ppm and 100 ppm) are good for consumption until day 4; samples in the control group are valid until day 2 only. On the other hand, the samples treated with (NEW) at concentration (200 ppm) were safe to eat up to day 6 of storage. According to the obtained data, the optimum group for minimizing TBA level was that treated with neutral electrolyzed water (NEW) at concentration (200 ppm). These samples had the lowest TBA value compared to other treated groups. When compared to the control group, the groups treated with neutral electrolyzed water (NEW) exhibited considerably ($P<0.05$) less lipid oxidation. NEW may have a higher antioxidant capacity because of the high concentration of phenolics it contains. These findings concur with the findings of Patricia *et al.* (2023).

3. Microbiological analysis

3.1 Total aerobic plate count (APC):

High APC may be attributed to the contamination of the chicken meat from different sources or unsatisfactory processing, as well as unsuitable conditions during storage (Zahran, 2004). NEW has an antibacterial impact on a variety of microorganisms, including pathogens,

according to the findings of many researches. The product and kind of microbe determine the antibacterial action. In addition to being very caustic, some sanitizers, including hypochlorite, are harmful to consumers' health. In contrast, NEW is safe for consumers and has low corrosive effects. Data presented in Table (4) showed that aerobic plate count mean values were increased from day zero to day 6 of storage. The control APC mean values ranged from 3.17±0.06 at day zero to 6.93±0.02 log10 cfu/g at day 6 of storage. While APC mean values of the chicken breast treated with neutral electrolyzed water (NEW) at concentrations (50, 100 and 200 ppm) reached 5.58±0.23, 4.54±0.29 and 3.92±0.06 at day 6 of storage. Compared to the control group, samples treated with NEW exhibited a substantial reduction in the count of aerobic bacteria, particularly at concentrations of 200 ppm. The overall bacterial count should not be more than 10^5/g (ES 1651/2005). On day 2, the APC count for the control samples was 4.95±0.02, which was almost at the maximum recommended limit, while on day 4, the APC count for control samples was 5.64±0.05 which was over the maximum recommended limit and indicated that the untreated control chicken breast samples had a shelf-life of less than six days. The treated samples exhibited a delayed growth for APC till day 6, and a larger decreasing impact on total bacterial count was noted in (NEW 200 ppm) when (NEW) concentrations were raised to 100 ppm and 200 ppm. This indicates that under chilled storage, the samples' shelf life was extended to six days. The APC values for the samples treated with (NEW 50 ppm) were still valid for consumption until day 4 of storage. Moghassem Hamidi *et al.* (2021) found that (NEW 200 ppm) significantly reduces the total viable count of chicken breast flesh during refrigerated storage, which lends credence to this conclusion.

Treated chicken samples with (NEW) at concentrations 100 ppm and 200 ppm do not exceed the permissible limit 10^5 cfu/g even after storage for 6 days. The bacterial wall's amino acid groups and sulfhydryl (-SH) oxidation impact, which influences bacterial respiration and feeding is the source of NEW's antibacterial activity (Rivera-Garcia *et al.,* 2019 and Kim *et al.,* 2000). The bactericidal activity of NEW is also produced by the controlled electrolysis of NaCl solution, resulting in the regulated generation of stable hypochlorous acid (Rahman *et al.,* 2011; Athayde *et al.,* 2017; Hernández-Pimentel *et al.,* 2020).

3.2. *E. coli* count:

E. coli is a natural inhabitant of the intestinal tracts of humans and warm-blooded animals, its presence in chicken meat reliably reflects fecal contamination. Moreover, it indicates a possible contamination by enteric pathogens. Undercooked or raw chicken meat contamination either during primary production as slaughtering or further processing and handling, e.g. cross contamination during processing, human-to-food contamination by food handlers (Adeyanju and Ishola, 2014). The results mentioned in Table (5) demonstrated that on day six of storage, the mean values of *E. coli* counts in the control samples increased from 1.69±0.12 log10 cfu/g on day zero to 1.99±0.07 log10 cfu/g.at day 6 of storage. While *E. coli* counts in treated chicken breast meat treated with NEW at concentrations (50, 100, and 200 ppm) rose to 1.82±0.15, 1.65±0.04, and 1.38±0.12 at day 6 of storage, respectively, the number of *E. coli* was significantly reduced after treatment with NEW at various doses, especially treated with NEW 200 ppm, which considered the beast group compared with the control group. These findings concur with the findings of Patricia *et al.* (2023). Similar findings have also been reported by Al-Holy *et al.* 2015 and Guerra-Sierra *et al.* 2022, who found that NEW dramatically reduced the *E. coli* count in treated poultry flesh. The bactericidal action of NEW against *E. coli* is attributed to its high hypochlorous (HOCl) content, which makes it more effective than hypochlorite (ClO^-) at penetrating microbial cell walls

and oxidatively attacking them (Veasey and Muriana 2016). As a result, NEW can serve as a suitable disinfectant in place of sodium hypochlorite. It is shown that the reason for HOCL's action is, in comparison to water, its tiny molecular size and electrical neutrality allow it to penetrate materials. The ability of HOCl, or hypochlorite ions (ClO^-) to impede the action of enzymes necessary for microbial development, damage their membranes and DNA, and perhaps impair their membrane transport capability, gives it its germicidal effect (Rahman *et al.*, 2016).

4.3.3 *S.aureus* count:

The emergence of multi-resistant zoonotic strains of pathogenic foodborne bacteria, such as *S. aureus*, from foods originating from animals, has led to a significant problem of food poisoning in underdeveloped countries, causing tremendous economic losses and public health issues (Guerra Sierra *et al.*, 2022). The presence of *S.aureus* in chicken meat indicates its contamination by food handlers and inadequately cleaned equipment (ICMSF, 1996). From results given in Table (6) *S. aureus* count of control samples was increased from 1.24±0.01 at zero day to 1.86±0.05 log10 cfu/g at day 6 of storage. For chicken breast meat treated with NEW at concentration (50, 100 and 200 ppm), *S. aureus* counts underwent incremental increases during day 6 of storage for all examined samples. They were 1.62±0.07, 1.50±0.01 and 1.32±0.02, respectively. However, significantly lower *S. aureus* counts ($P<0.05$) were recorded for treated samples with NEW at the concentrations (50, 100 and 200 ppm) during the storage period under refrigeration compared with the control group and the highest reduction of *S.aureus* was observed in treated samples with NEW 200 ppm. These findings support the findings of Guerra Sierra *et al.* (2022) and demonstrate the broad range and good efficacy of NEW in the removal of *S. aureus.* So, this agent has even been successfully used to sanitize and disinfect surfaces in the food industry, according to Jiménez *et al.* (2016).

CONCLUSION

It is possible to conclude that NEW can postpone microbiological and chemical alterations, increase the chicken meat shelf life, and improve the flavour, colour, texture, and acceptability of chicken breast meat in general. In comparison to control and other treated groups, treatments with (NEW 200ppm) significantly reduced the count of aerobic microorganisms and is thought to improve the microbiological quality, extend shelf life, and help maintain oxidation stability of chicken breast meat samples during storage at 4°C. The microbial burden of *S. aureus* and *E. coli* in the chicken breast meat samples is greatly reduced by NEW. In light of this, NEW offers a practical, secure, and efficient solution to get rid of germs which are thought to be a serious public health concern. The decomposition of chicken flesh may be slowed down using NEW without compromising any of its physical, chemical, or sensory qualities, including texture, look, or fragrance. The study's encouraging findings indicate that NEW could be a viable substitute for preserving chicken flesh without altering its sensory qualities, but further research is necessary before using it.

REFERENCES

Abadias, M.; Usall, J.; Oliveira, M.; Alegre, I. and Viñas, I. (2008): Efficacy of neutral electrolyzed water (NEW) for reducing microbial contamination on minimally-processed vegetables, Int. J. Food Microbiol. 123 (1–2) (2008) 151–158.

Adeyanju, G.T. and Ishola, O. (2014): Salmonella and Escherichia coli

contamination of poultry meat from a processing plant and retail markets in Ibadan, Oyo State, Nigeria. Springer Plus., 3:139-147.

Al-Holy, M.A. and Rasco, B.A. (2015): The bactericidal activity of acidic electrolyzed oxidizing water against Escherichia coli O157:H7, Salmonella typhimurium, and Listeria monocytogenes on raw fish, chicken, and beef surfaces, Food Control 54 (2015) 317–321.

Alonso-Hernando, A.; Alonso-Calleja, C. and Capita R. (2013): Growth kinetic parameters of gram-positive and gram-negative bacteria on poultry treated with various chemical decontaminants. Food Control 33: 429–432.

APHA (American Public Health Association) (1992): Compendium of Methods for the Microbiological Examination of Foods, 3rd Ed. (edited by C. Vanderzant and D.F. Splittsloesser). pp: 533-550. Washington, DC: APHA.

Athayde, D.R.; Flores, D.R.M.; Da Silva, J.S.; Genro, A.L.G.; Silva, M.S.; Klein, B.; Mello, R.; Campagnol, P.C.B.; Wagner, R. and De Menezes, C.R. (2017): Application of electrolyzed water for improving pork meat quality. Food Res. Int. 2017, 100, 757–763.

CDC. List of Multistate Foodborne Outbreak Notices. (2023): Available online:https://www.cdc.gov/foodsafety/outbreaks/lists/ (accessed on 5 May 2023)

Dawson, L.E. and Gartner, R. (1983): Lipid oxidation in mechanically deboned poultry. Food Technology 37: 112–115

Duncan, D.B. (1955): Multiple range and multiple F tests. Biometrics 11:1–42.

ES (Egyptian Organization for Standardization) (1651/2005): Egyptian Standards for Chilled Poultry and Rabbits: Egyptian Organization for Standardization and Quality Control. Ministry of Industry, Arab Republic of Egypt, Cairo, Egypt.

ES (63/11-2006): Egyptian Organization for Standardization and quality control. Egyptian Standards for poultry meat products treated with heat. Methods of analysis and testing for meat and meat products Part: 11 Measurement of pH.

ES (63/9-2006): Egyptian Organization for Standardization and quality control. Egyptian Standards for poultry meat products treated with heat. Methods of analysis and testing for meat and meat products part: 9, determination of thiobarbituric acid

FDA "Food and Drug Administration" (2001): Center for Food safety and applied nutrition. www.FDA.org.

Guerra-Sierra, B.E.; Sandoval-Meza, A.X. and García-Sánchez, L.T. (2019): Antifungal activity of acidic electrolyzed water against strawberry postharvest molds (Fragaria x ananassa Duch cv. Camarosa), Acta Agron. 68 (2) (2019) 126– 133

Guerra Sierra B.E; Villalba R. Deicy; Contreras Sandra; Debasis Mitra and Sandoval Adriana (2022): Neutral electrolyzed water in chillers: A viable option in the microbiological disinfection of giblets chicken. Energy Nexus 7 (2022) 100096. www.elsevier.com/locate/nexus.

Han, D.; Hung, Y.C. and Wang, L. (2018): Evaluation of the antimicrobial efficacy of neutral electrolyzed water on pork products and the formation of viable but nonculturable (VBNC) pathogens, Food Microbiol. 73 (2018) 227–236

Hernández-Pimentel, V.M.; Regalado-González, C.; Nava-Morales, G.M.; Meas-Vong, Y.; Castañeda-Serrano, M.P. and Gar-cía-Almendárez, B.E. (2020): Effect of neutral electrolyzed water as antimicrobial intervention treatment of chicken meat and on trihalomethanes formation. J. Appl. Poult. Res. 2020, 29, 622–635.

Hricova, D.; Stephan, R. and Zweifel, C. (2008): Electrolyzed water and its application in the food industry. Journal of Food Protection 71: 1934–1947.

Huang, Y.R.; Hung, Y.C.; Hsu, S.Y.; Huang, Y.W. and Hwang, D.F. (2008): Application of electrolyzed water in the food industry. Food Control 19: 329–345.

Huang, A.T. and Batterman, S. (2009): Formation of trihalomethanes in foods and beverages. Food Additives and Contaminants 26(7): 947–957.

International Commission on Microbiological Specificans for Foods "ICMSF" (1996): Microorganisms in food, Ill-microbial specification of food pathogens. Vol.2, Chapman and Hall, London, New York.

Jay, J.M. (2002): A review of aerobic and psychrotrophic plate count procedures for fresh meat and poultry products. Journal of Food Protection 65: 1200–1206.

Jiménez, P.R.; Regalado, C.; Castaño, T.E.; Meas, V.Y.; Santos, C.J. and García, B.E. (2016): Evaluation of electrolyzed water as cleaning and disinfection agent on stainless steel as a model surface in the dairy industry, Food Control 60 (2016) 320–328.

Kim, C.; Hung, Y.-C. and Brackett, R.E. (2000): Efficacy of electrolyzed oxidizing (EO) and chemically modified water on different types of foodborne pathogens. nt. J. Food Microbiol. 2000, 61, 199–207.

Kim, C.; Hung, Y.-C. and Brackett, R.E. (2000): Roles of oxidation-reduction potential in electrolyzed oxidizing and chemically modified water for the inactivation of food-related pathogens, J. Food Prot. 63 (1) (2000) 19–24.

Loretz, M.; Stephan, R. and Zweifel, C. (2010): Antibacterial activity of decontamination treatments for cattle hides and beef carcasses. Food Control 22: 347–359.

Mensah, P.; Yeboah-Manu, D.; Owusu-Darku, K. and Ablordey, A. (2002): Street Food in Accra, how safe Bull. Ghana: Are they? W.H.O. 80: 546-556.

Moghassem Hamidi, R.; Shekarforoush, S.S.; Hosseinzadeh, S. and Basiri, S. (2021): Evaluation of the effect of neutral electrolyzed water and peroxyacetic acid alone and in combination on microbiological, chemical, and sensory characteristics of poul-try meat during refrigeration storage, Food Sci. Technol. Int. 27 (6) (2021) 499– 507.

OECD Publishing (2016): OECD-FAO Agricultural Outlook 2016-2025. Paris: OECD Publishing.

Patricia, J.R.; Héctor E.R.; Juan C.R.; Patricia S. and José A.C. (2023): Neutral Electrolyzed Water in Chicken Breast—A Preservative Option in Poultry Industry. Foods 2023, 12, 1970.

Rahman, S.M.E.; Park, J.; Bin Song, K.; Al-Harbi, N.A. and Oh, D.-H. (2011): Effects of Slightly Acidic Low Concentration Electrolyzed Water on Microbiological, Physicochemical, and Sensory Quality of Fresh Chicken Breast Meat. J. Food Sci. 2011, 77, M35–M41.

Rahman, S.M.E.; Khan, I. and Oh, D.H. (2016): Electrolyzed water as a novel sanitizer in the food industry: current trends and future perspectives, Compr. Rev. Food Sci. Food Saf. 15 (3) (2016) 471–490.

Ramos, B.; Miller, F.A.; Brandão, T.R.S.; Teixeira, P. and Silva, C.L.M. (2013): Fresh fruits and vegetables—An overview on applied methodologies to improve its quality and safety. Innov. Food Sci. Emerg. Technol. 2013, 20, 1–15.

Rasooli, I. (2007): Food preservation-A biopreservative approach. Global Science Books, Food, 1: 111-136.

Rivera-Garcia, A.; Santos-Ferro, L.; Ramirez-Orejel, J.C.; Agredano-Moreno, L.T.; Jimenez-Garcia, L.F.; Paez-Esquiliano, D.; Andrade-Esquivel, E. and Cano-Buendia, J.A. (2019): The effect of neutral electrolyzed water as a disinfectant of eggshells artificially contaminated with Listeria monocytogenes.Food Sci. Nutr. 2019, 7, 2252–2260.

Saengkrajang, W.; Samaae, P.; Paewkrasin, K. and Matan, N. (2011): Electrolyzed water as an antibacterial agent for washing fresh chicken meat, Asian J. Food Agro-Ind. 4 (5) (2011) 342–348.

Shirahata, S.; Hamasaki, T. and Teruya, K. (2012): Advanced research on the health benefit of reduced water, Trends Food Sci. Technol. 23 (2) (2012) 124–131,

Veasey, S. and Muriana, P.M. (2016): Evaluation of electrolytically-generated hypochlorous acid ('electrolyzed water') for sanitation of meat and meat-contact surfaces, Foods 5 (2) (2016) 42.

WHO (World Health Organization). (2000): Chemistry of Disinfectants and Disinfectant By-Products. Geneva, Environmental Health Criteria Number 216, Disinfectants and disinfectant by-products. p. 39.

Yashoda, K.P.; Sachiondra, N.M.; Sakhare, P.Z. and Rao, D.N. (2001): Microbiological quality of broiler chicken carcasses processed hygienically in small scale poultry processing quality of broiler chicken carcasses processed hygienically in small scale poultry processing unit. Journal of Food Quality 24: 249-259.

Zahran, D.A. (2004): Using gamma irradiation as an option for controlling bacteria contaminating some foods of animal origin. Ph. D. Thesis (Meat Hygiene), Fac. Vet. Med., Zagazig Univ. (Banha Branch), Egypt.

تأثير الماء المتأين علي فترة صلاحية لحوم الدجاج المبردة

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هدف هذه الدراسة هو تقييم فاعلية الماء المتعادل كهربائيا (NEW) بتركيزات (٥٠، ١٠٠ و ٢٠٠ جزء في المليون) على الصفات الحسية والجودة الكيميائية والميكروبيولوجية للحم صدور الدجاج الطازجة المخزنة عند درجة حرارة ٤ ± ١ درجة مئوية لمدة ٦ أيام. . أظهرت النتائج أن غمس عينات لحم صدور الدجاج في الماء المتعادل كهربائيا (NEW) بثلاثة تركيزات (٥٠، ١٠٠، ٢٠٠ جزء في المليون) يمكن أن يحسن استقرار التخزين ويقلل التجمعات الميكروبية في جميع مجموعات المعاملات حيث أظهرت النتائج في اليوم السادس من التخزين أن قيمة الرقم الهيدروجيني ٠٣±٦,٤١، ٠٢±٦,٣٤ و٠٢±٦,٣٢ على التوالي. في حين أن قيمة حمض الثيوباربتيورك هي ٠,٧٩ ± ٠,٠٢ و ٠,٦٨ ± ٠,٠٥ و ٠,٥٠ ± ٠,٠٢ على التوالي. في حين أن العد الكلي للميكروبات الهوائية، و العد الكلي لميكروب الإشريكية القولونية و العد الكلي لميكروب المكور العنقودي الذهبي في المجموعات المعاملة بالماء المتعادل كهربائيا بتركيزات (٥٠ و١٠٠ و٢٠٠ جزء في المليون) كان ٥,٥٨ ± ٠,٢٣، ٤,٥٤ ± ٠,٢٩، ٣,٩٢ ± ٠,٠٦ و ١,٨٢ ± ٠,١٥، ١,٦٥ ± ٠,٠٤، ١,٣٨ ± ٠,١٢ و١,٦٢ ± ٠,٠٧، ١,٥٠ ± ٠,٠١، ١,٣٢ ± ٠,٠٢ CFU / g ، على التوالي والتى كانت أقل من المجموعة الضابطة (P <0.05) في جميع المعالجات في اليوم ٦. في حين كانت الصفات الحسية للمجموعات المعاملة بالغمس بالماء المتعادل كهربائيا افضل مقارنة بالمجموعة الضابطة السلبية كما زادت قيم الرقم الهيدروجيني و حمض الثيوباربتيورك لعينات لحوم الدواجن مع زيادة مدة التخزين خلال ٦ أيام من التخزين في جميع المجموعات المعالجة. كما خلصت هذه الدراسة إلى أن استخدام الماء المتعادل كهربائيا بتركيز ٢٠٠ جزء في المليون أكثر فاعلية مقارنة بتركيزات ٥٠ و ١٠٠ جزء في المليون. لذلك، يمكن أن تكون طريقة واعدة لإطالة العمر الافتراضي للحوم الدجاج بدون أي بقايا ضارة في لحم صدور الدجاج ويوصى باستخدامها في تطهير لحم صدور الدجاج كمواد حافظة مضادة للميكروبات للحوم الدجاج المبرد المحفوظ في درجة حرارة الثلاجة.