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EFFECT OF COLD ATMOSPHERIC PLASMA TECHNOLOGY AND ROSEMARY OIL ON THE QUALITY OF POULTRY MEAT PRODUCTS

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ABSTRACT

This study aimed to evaluate the effectiveness of rosemary oil, cold atmospheric plasma (CAP), and a combination of both the shelf life parameters (sensory, chemical quality indices (pH, TVN, and TBA) and APC), in addition to evaluate the effectiveness on coliform count and the effect on *E. coli* and *S.aureus* artificially inoculated in thigh Fillet and Breast fillet samples. Concerning the shelf life of treated samples it was proved that the three treatment trials have a significant effect on related parameters including sensory criteria, chemical criteria, and APC especially that of samples treated by a combination of rosemary oil 1% with CAP technique (at 70 Kv for 3 minutes) with prolongation for about 7 days in thigh Fillet and 8 days in treated Breast Fillet. And for coliform, *E. coli* and *S.aureus* it was apparent that the three trials had considerable effect with respectable log reduction values especially CAP and the combination. According to the results it was fulfilled that CAP with the addition of rosemary oil should be considered a powerful technique that keeps the quality of poultry and meat products, prolongs their shelf-life and inactivates the pathogens.

Keywords: Chicken Fillet, Cold Atmospheric Plasma, Rosemary, Aerobic plate count

INTRODUCTION

Poultry meat is gaining popularity amongst the Egyptian population as it is considered a fast easily prepared meat meal and solves the problem of the shortage of red meat. Contamination of poultry meat products can usually occur in slaughtering processing plants during scalding, de-feathering, evisceration, cutting, packaging and storage until the product is sufficiently cooked and consumed, the most important contaminants were the food-borne pathogens such as *Escherichia coli* and *Staphylococcus aureus*. *E.coli* is a harmless commensal organism; however, pathogenic strains cause diarrhea and other serious gastrointestinal diseases (Hamilton *et al.*, 2010). *S. aureus* has been indicated as an important cause of food-borne infection that was mediated by

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Staphylococcal enterotoxins (SEs) worldwide (Soriano *et al.,* 2012). So the great industrial challenge in the poultry meat industry was how to produce safe food with no or low pathogen contamination, therefore efficient strategies are required to enhance the microbiological safety of chicken products besides shelf-life extension.

Non-thermal techniques conserve the sensory criteria and deactivate food-borne microbes without causing loss of quality, compared to heat treatment. One of these techniques is cold atmospheric plasma (Charoux *et al.,* 2021). This technology being a nonthermal technique can be used to inactivate food pathogens, delay fast physical and chemical deterioration and to extend the shelf life of poultry products (Yilmaz Ucar *et al.,* 2021)

It was considered the fourth condition of matter obtained via passing an electrical field to a working gas which is the atmospheric air in this study (Gaunt *et al.,* 2006). Plasma discharge includes many species such as ions, free electrons, reactive radical species and ozone (Laroussi and Leipold 2004, Fahmy *et al.* 2016a). Plasma gas contains species such as nitric oxide, Nitrogen Dioxide, nitrous oxide, carbon monoxide, carbon di-oxide and Hydrogen peroxide (Fahmy and Schönhals. 2016b, Fahmy *et al.,* 2015 and Fahmy *et al.,* 2013). This discharge acts at the ambient air temperature, suitable for processing fresh meat and meat products, milk and milk products preserving their quality (Coutinho *et al.,* 2018). The most important advantage of plasma technology besides microbial inactivation, it is environmentally safe, does not generate dangerous or poisonous substances, and does not produce toxic residues, and its process is sterile (Yang *et al.,* 2009).

Consequently, this study aimed to inspect the effect of rosemary oil 1%, CAP and their combination on the shelf life parameters (organoleptic criteria, keeping quality indices and APC) and microbial load of thigh and breast fillet as a raw material of chicken products.

MATERIALS AND METHODS

Plan of the work:

Four groups of samples were subjected to treatment with rosemary oil (Rosmarinus officinalis) 1%, cold atmospheric plasma, and a combination of both each group was divided into 4 subgroups (Control, rosemary oil 1%, CAP and combination of both rosemary 1% and CAP) in triplicate:

First group: For evaluation of the effectiveness of treatments on shelf-life parameters including sensory criteria, chemical quality indices (pH, TBA, TVN) and APC of the examined samples. analysis was done initially on the 2nd day then day after day until decomposition take occurs.

Second group: to detect the effect of treatment trials against coliform count of treated samples.

Third group: to detect the effect of treatments on E. *coli* artificially inoculated in the samples.

Fourth group: For evaluation of the effectiveness o*f S.aureus* in the artificially inoculated samples.

1- Samples preparation and pathogens inoculation:

Breast fillet and thigh fillet samples were collected from Zagazig, Egypt, then transported without delay to the bacteriology laboratory in the animal health research institute, Zagazig branch in a cooler box containing ice and kept at 4 °C for subsequent preparation. The samples were carefully shaped into 10 g square-shaped pieces (which can be inserted into the cold plasma device) under aseptic conditions.

Preparation of culture suspension:
The pure cultures of *Staphylococcus aureus* ATCC®6538™ and *E. coli* NCTC12241/ATCC®25922 were obtained from an Animal health research institute, cultivated in Brain heart infusion broth (BHI broth) at 37 °C for 24 h, re-cultured in BHI medium incubated for 24 hours. Then, cultured for 18-hour in a nutrient broth medium at 37 °C. The required concentration was obtained by adding the previous culture medium to normal saline at 0.85% and comparing its opacity to that of the standard half-McFarland tube which was equal to about 1.5×10^8 CFU/mL bacteria. In the next stage, 1 mL was added to 100 grams of the thigh and breast fillet, and thus, the count in every gram of meat reached about 10^6 CFU/g (Bagamboula *et al.*, 2004).

For the rosemary treatment trial**,** 495 g of breast fillet and thigh fillet were mixed with 5 g (1%) rosemary oil and control samples were prepared without rosemary oil.

Cold Atmospheric Plasma Treatment
A dielectric barrier discharge (DBD) cold plasma system was used to treat the samples with an input voltage intensity of 70 kV, and the treatment time was 3 min. The distance between the high voltage electrode and sample surface was set at 20 mm and atmospheric air was used as the working gas, the treatment of samples by cold plasma was achieved at room temperature (25 ± 2 °C). This step was done in the faculty of Science, at Al-Azhar University, Egypt.

2- Sensory evaluation:
The coded samples were organoleptically examined according to their color, odor, texture and overall acceptability by a panel consisting of members from the Animal Health Research Institute. And according to their decision, the samples are categorized as fit, borderline, or decomposed samples. Testing was done by the naked eye and by boiling and roasting tests (Gracy *et al.*, 1999).

3- Chemical quality parameters:
3.1- pH (Pearson, 2006)
Approximately 10 g of treated and control samples were blended in 10 ml of neutralized distilled water and left at room temperature for 10 minutes with continuous shaking. Then measuring the pH value by an electrical pH meter (Bye model 6020, USA).

3.2- Determination of Total Volatile Nitrogen (TVN)
According to **"FAO"** Food **and Agriculture Organization (1980):**

3.3- Determination of Thiobarbituric Acid Number (TBA): according toPikul *et al.,* (1989)

4- Bacteriological evaluation:
Preparation of samples:
From control and treated groups, 10 grams of each sample was aseptically transferred into a sterile polyethylene bag to which 90 ml of 0.1% sterile peptone water was to obtain a dilution 1/10. One ml from the first suspension (10^{-1}) was serially diluted in peptone water 0.1% (9 ml) to get a dilution of 10^{-2}, 10^{-3}, and so on until suitable countable dilution.

Bacteriological evaluation:
1- Aerobic plate count (APC): ISO 4833-1:2013 Amendment (2022):
1 ml of the initial suspension (10^{-1} dilution) was aseptically transferred to a pre-labeled plate. Pour about 15 ml of the plate count agar (PCA) 44 - 47 °C into the Petri dish, Carefully mix and let to harden, Invert the solidified plates and incubate at (30 ± 1) °C for (72 ± 3) h. The average count of the duplicate plates was enumerated, and APC/g was calculated.

2- Enumeration of coliform (BAM-FDA, Chapter 4: 2013 rev: 2020)
Transfer 1 ml of the prepared dilution into a prelabeled petri dish, Pour 10 mL violet red bile agar VRBA (48°C), mix and allow to harden. Cover with 5 mL VRBAagar. Invert solidified plates and incubate for 18-24 h at

35°C, Count purple-red colonies that are 0.5 mm or larger in diameter and surrounded by a zone of precipitated bile acids.

Confirmation: at least 10 typical colonies were picked then cultivated each colony to a tube of BGLB broth, incubated at 35°C and checked after 24/48 h for gas production.

3- Enumeration of artificially inoculated pathogens

0.1 ml from serial dilutions was uniformly cultivated into two plates containing L-EMB agar and Baird Parker media with Egg yolk-tellurite emulsion for *S.aureus*, *E.coli* respectively. then incubate at 37˚C for 48 hr-24 hrs respectively. The count of microorganisms was expressed as $\log_{10}$ CFU/g.

4- Statistical analysis

Comparative of means was performed according to Duncan, Multiple Range test for comparison of Means using SPSS ver. 14 (2006). All microbial counts were converted to the base – 10 logarithms of the number of colony-forming units per g of examined samples (log CFU/g). Results were recorded as mean ± standard errors (SE). The value of $P< 0.05$ was used to indicate statistical significance.

RESULTS

Table 1: The effect of treatments on sensory characteristics of chicken fillet samples.

Keeping quality	Control		Rosemary oil		CAP		Combination	
	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast
Fit for human consumption	0-3rd day	0- 4th day	0-7th day	0-7th day	0-9th day	0-11th day	0-10th day	0-12th day
Borderline	3th -4th day	4th-٥thday	7th -8th day	7th-8th day	9th -10th day	11th -12th day	10th-11th day	12th -13th day
Decomposed	٥th day	6th day	9th day	9th day	11th day	13th day	12th day	14th day

Table 2: The effect of different treatments on the pH values (Mean± SE) of chicken fillet samples.

Treated groups / Duration	Control		Rosemary oil		CAP		Combination	
	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast
2nd day	5.92±0.04	5.83±0.03	5.8±0.11	5.84±0.03	5.6±0.06	5.65±0.07	5.66±0.09	5.70±0.03
4th day	6.28±0.02	6.22±0.05	6.08±0.04	6.12±0.01	5.9±0.0	6.01±0.04	6.06±0.0	6.03±0.02
6th day	-	-	6.25±0.03	6.22±0.05	6.08±0.01	6.10±0.02	6.12±0.02	6.10±0.02
8th day	-	-	6.41±0.04	6.35±0.08	6.22±0.06	6.21±0.03	6.20±0.03	6.22±0.06
10th day	-	-	-	-	-	6.33±0.04	6.43±0.07	6.28±0.04
12th day	-	-	-	-	-	6.61±0.02	6.65±0.04	6.49±0.06

Table 3: The effect of different treatments on the TVN values (Mean± SE) mg % in treated and control samples.

Treated groups / Duration	Control		Rosemary oil		CAP		Combination	
	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast
2nd day	4.4±0.04	3.88±0.06	4.48±0.01	3.92±0.05	4.38±0.02	3.88±0.05	4.39±0.08	3.96±0.03
4th day	18.58±0.22	17.19±0.64	12.8±0.15	8.85±0.37	8.3±0.09	6.63±0.46	8.09±0.0	6.15±0.07
6th day	-	-	18.3±0.35	14.68±0.36	14.6±0.3	10.81±0.34	13.79±0.16	10.0±0.04
8th day	-	-	20.6±0.3	19.37±0.33	19.38±0.26	12.6±0.30	16.01±0.26	11.93±0.06
10th day	-	-	-	-	-	18.38±0.30	19.31±0.31	18.0±0.06
12th day	-	-	-	-	-	20±0.12	21.07±0.9	19.31±0.36

Table 4: The effect of different treatments on the TBA values (Mean ± SE) MDA/Kg in thigh and breast fillet samples.

Treated groups / Duration	Control		Samples treated with Rosemary oil		Samples treated CAP		Samples treated with a combination	
	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast
2nd day	٠,٠٩±0.٠٠٣	0.10±0.01	0.09±0.٠٠٥	0.09±0.004	٠,٣٨±0.٠١٢	0.29±0.04	٠,٢٤±0.0٣	0.22±0.02
4th day	0.77±0.014	0.71±0.05	٠,٣٨±0.0٣	0.40±0.02	0.8±0.008	0.75±0.05	0.49±0.003	0.52±0.03
6th day	-	-	0.88±0.02	0.78±0.02	0.97±0.02	0.89±0.01	0.77±0.017	0.80±0.02
8th day	-	-	1.0±0.008	0.92±0.01	1.05±0.02	0.99±0.01	0.89±0.01	0.85±0.03
10th day	-	-	-	-	-	1.05±0.02	1.00±0.03	1.0±0.01
12th day	-	-	-	-	-	1.11±0.10	1.09. ±0.2	1.31±0.06

Table 5: The effect of different treatments on APC (Mean ±SE)log_{10}cfu/g.

Treated groups / Duration	Control		Rosemary oil		CAP		Combination	
	Thigh Fillet	Breast Fillet	Thigh Fillet	Breast Fillet	Thigh Fillet	Breast Fillet	Thigh Fillet	Breast Fillet
2nd day	6.06±0.12	5.63±0.19	4.95±0.25	4.21±0.07	3.42±0.١٤	3.8±0.08	3.05±0.11	3.3±0.03
4th day	7.04±0.14	7.14±0.05	5.33±0.34	5.37±0.32	3.99±0.05	4.33±0.29	3.29±0.31	3.99±0.05
6th day	-	-	5.92±0.09	6.42±0.07	5.13±0.10	4.70 ±0.22	4.53±0.40	3.55±0.10
8th day	-	-	7.11±0.10	7.13±0.07	6.36±0.19	6.44±0.19	4.88±0.14	4.52±0.14
10th day	-	-	-	-	-	7.19±0.12	6.28±0.18	6.83±0.08
12th day	-	-	-	-	-	7.32±0.18	7.26±0.17	7.02±0.11

Table 6: The effect of different treatments on the mean counts ±S.E. (log_{10} CFU/g) of *coliform* (n = 3 for each group).

Treated groups / Sample	Control	Rosemary oil	CAP	Combination
Thigh Fillet (Log reduction)	3.91± 0.02[a]	3.04 ± 0.3 [b] (0.87)	2.27 ±0.12[c] (1.64)	2.12 ±0.13[c] (1.79)
Breast Fillet (Log reduction)	3.63± 0.17[a]	2.97± 0.03[b] (0.66)	2.30±0.09[c] (1.33)	2.20 ±0.13[c] (1.43)

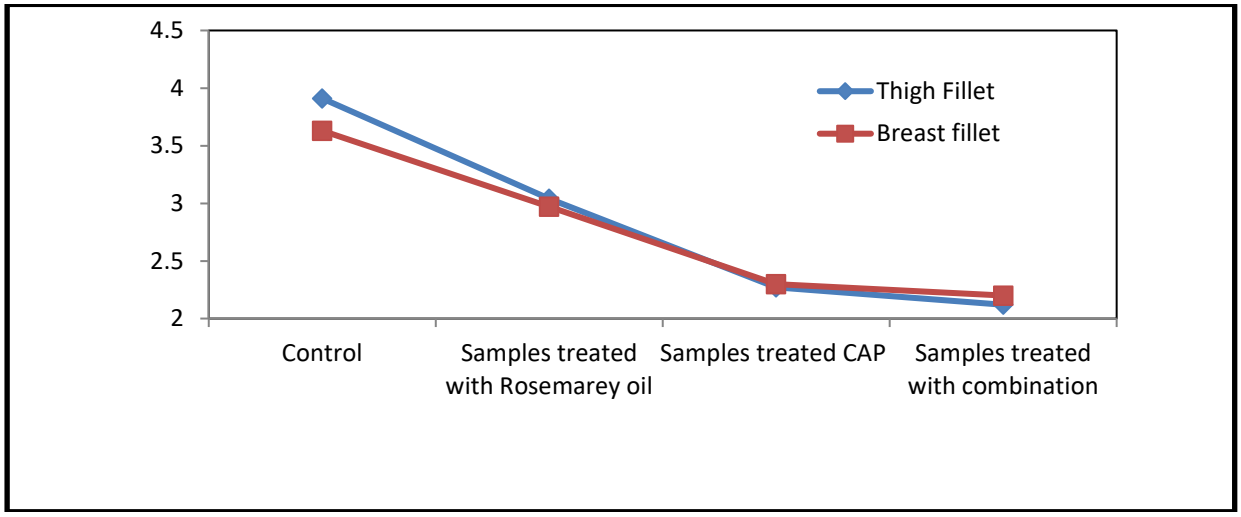

Figure 1: The mean counts ±S.E. (log_{10} CFU/g) of *coliform* in control untreated and treated samples (n = 3 for each group).

Table 7: The effect of different treatments on the mean counts ±S.E. (log_{10} CFU/g) of *E. coli* (n = 3 for each group).

Treated groups / Sample	Control	Rosemary oil	CAP	Combination
Thigh Fillet (Log reduction)	6.18± 0.06[a]	5.34 ± 0.12 [b] (0.84)	3.20 ±0.09[c] (2.98)	3.33±0.16[c] (2.85)
Breast Fillet (Log reduction)	6.25± 0.05[a]	5. 46 ± 0.12[b] (0.79)	3.27±0.02[c] (2.98)	3.30 ±0.18[c] (2.95)

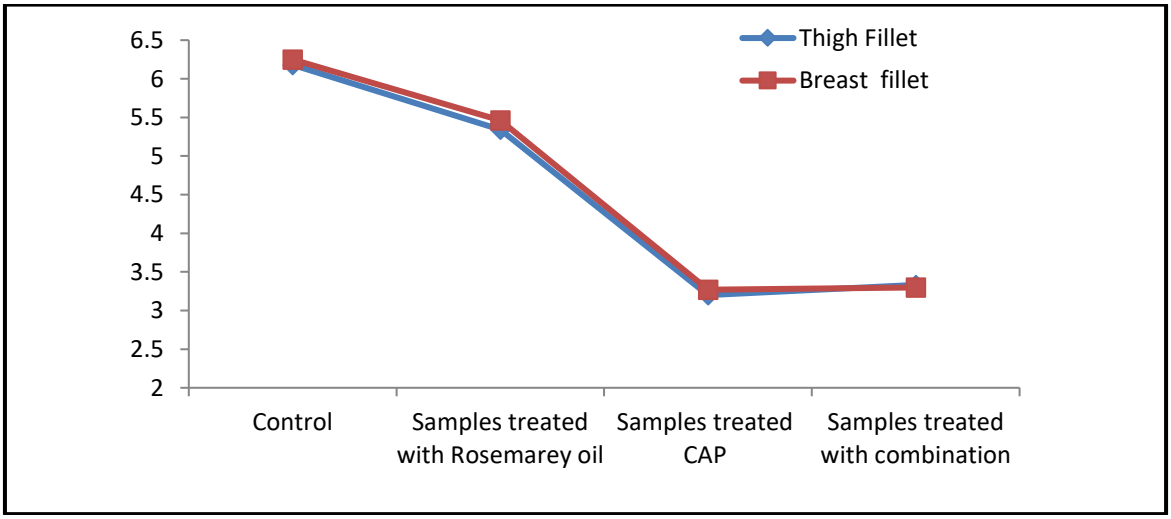

Figure 2: The mean counts ±S.E. (log_{10} CFU/g) of *E. coli* in control untreated and treated samples (n = 3 for each group).

Table 8: The effect of different treatments on the mean counts ±S.E. (log_{10} CFU/g) of *S. aureus* (n = 3 for each group).

Treated groups / Sample	Control	Rosemary oil	CAP	Combination
Thigh Fillet (Log reduction)	5.99± 0.05[a]	5.22 ± 0.11 [b] (0.77)	4.38 ±0.12[c] (1.61)	4.0±0.2[d] (1.99)
Breast Fillet (Log reduction)	6.04± 0.02[a]	5.35 ± 0.2[b] (0.69)	4.28±0.14[c] (1.76)	3.88 ±0.2[c] (2.16)

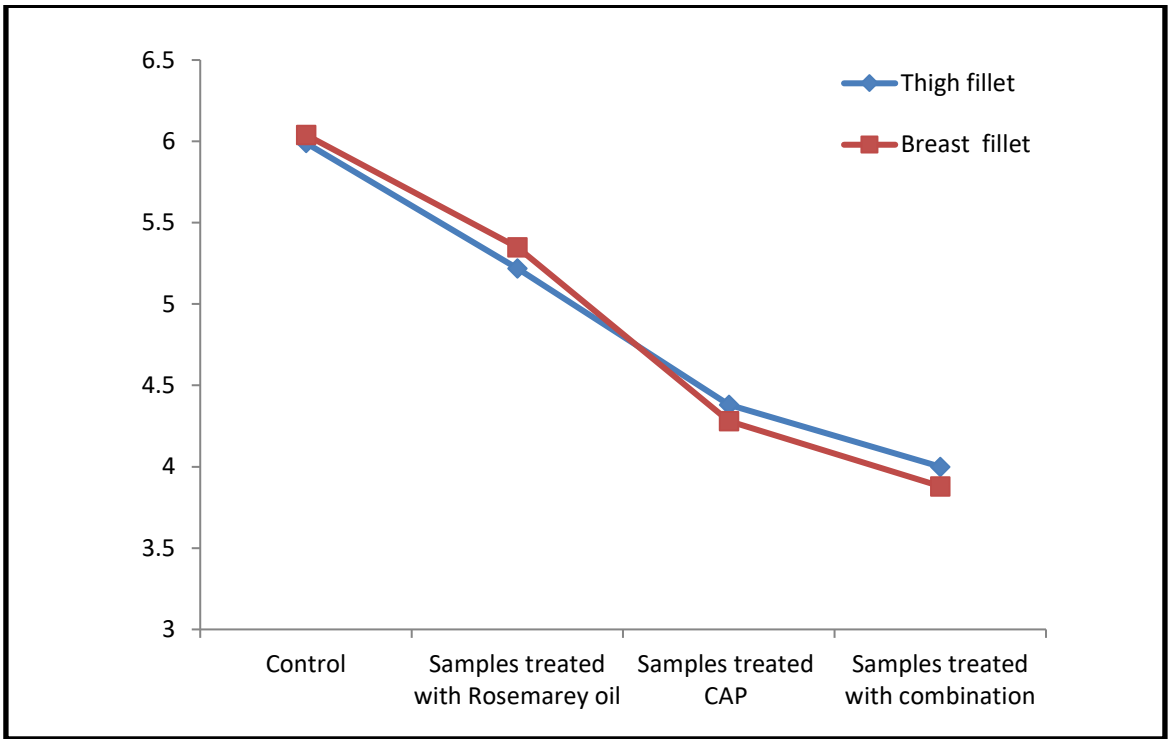

Figure 3: The mean counts ±S.E. (log_{10} CFU/g) of *S. aureus* in control untreated and treated samples (n = 3 for each group).

DISCUSSION

Shelf life is the period of time in which the product properties remain acceptable to the consumer according to sensory criteria and nutritive value (Singh and Singh 2005). This period depends on the level of microbial load of the products. Starting with a sensory evaluation of chicken parts such as thigh fillet and breast fillet along the time of chilled storage (4° C) in Table (1) in which it was clear that the samples treated with rosemary oil 1% in combination with cold atmospheric plasma technology have more acceptability extended 7 and 8 days more than control samples in thigh fillet and breast fillet, respectively, followed by CAP exposure, then treatment by rosemary oil which could improve the sensory attributes, this result agreed with (Ibrahim *et al.*, 2018). This prolongation in the shelf life is mainly attributed to the delayed proteolysis and lipolysis by the effect of different treatments on the total microbial load which will be discussed later, near results obtained by Moutiq *et al.*, (2020) in the treatment of breast Fillet and Wang *et al.* (2022) for Tilabia fish.

Concerning the effect of different treatments on the pH value in Table 2; it was obvious that the pH of CAP treated samples was considerably less than the untreated and rosemary treated ones. According to

(Pearson, 2006) who mentioned that the initial spoilage occurs at pH 6.2, cold atmospheric plasma and its combination have a great effect. this result agreed with (Moutiq *et al.,* 2020) who said that in all periods of exposure to plasma, a reduction of the pH value for chicken samples take occurred (Qian *et al.,* 2022) who stated that the pH value of plasma-treated beef patties was noticeably lower than the control one. Also rosemary oil 1% control pH value to some extent, this was due to their antimicrobial effect. In the control samples, while being stored at 4°C for some days, protein breaks down into alkaline substances (ammonia and trimethylamine) by the action of endogenous enzymes and bacteria, leading to elevation in the pH level (Sun *et al.,* 2015). These endogenous enzymes and contaminating bacteria were suppressed by the action of different treatments especially CAP lowering the changes in pH levels (Hatab *et al.,* 2021).

Total volatile nitrogen (TVN) is a useless compound produced as a result of proteolysis by bacterial or enzymatic action (Luan *et al.,* 2017). So, TVN is generally used as a valuable indicator of protein decomposition (Li *et al.,* 2018). It shouldn't go above 20 mg TVN/ 100 g according to (E.S.O. 2005). The obtained results in Table 3 declared that the TVN value remained within the acceptable limit until day 8 by rosemary treatment and day 12 by CAP and CAP- rosemary combination. CAP suppresses the replication of bacteria, leading to a reduction in the production of proteases by bacteria, decreasing the rate of deamination of amino acids and reduces nitrogenous products) Liu *et al.,* 2021).

Thiobarbituric acid (TBA) is an excellent marker for judging the meat quality and degree of lipid oxidation (Ndaw *et al.,* 2008). It has been proposed that a maximum TBA value indicating the good quality of thigh Fillets is 0.9mg MDA /Kg (ESO, 2005). In Table 4 it was shown that rosemary oil had a conservative role in MDA value compared to control samples and CAP treated samples in the first six days of storage. CAP discharges such as reactive oxygen species such as hydrogen peroxide, hydroxyl radicals, and superoxide anions not only play an effective role in the deactivation of microbes (Attri *et al.,* 2015) but also unfortunately can remove hydrogen ions from lipid molecules leading to lipid oxidation (Shahidi and Zhong, 2010). So, CAP-treated samples initially have higher TBA values than control and rosemary-treated ones and by days CAP CAP-treated samples show some stability certainly due to its antimicrobial effect. Rosemary oil 1% slows progress in TBA value compared to control one. Where the combination of rosemary oil 1% to CAP technology could improve this point, that's because rosemary can prevent lipid oxidation, chelate metals and scavenge superoxide radicals (Peschel *et al.,* 2007). Breast fillets are more stable against oxidation by plasma compared to thigh fillets this may be due to lower fat content (Gavahian *et al.,* 2018). Moutiq *et al.* (2020) found by TBA measurement that the difference in average value, between plasma treated and control samples, was found non-significant in all treatment periods.

Regarding to the effect of treatments on the total bacterial count of treated chicken meat samples as noticed in Table 5, it was significantly reduced by the three treatment trials especially combination of rosemary oil 1% and CAP technology, followed by CAP then rosemary 1%, the antimicrobial effect appear from the first analysis at the 2nd day compared to the control samples which decomposed at 5th and 6th day and no further bacteriological evaluation could be done. At the same time the three treatment groups exhibited a delayed growth in the term of APC. The antibacterial effect of Rosemary oil may be due to α-pinene which is reported as the major component of Rosemary essential oil, 1,8 – cineole, camphene, βmyrcene, camphor and borneol. Rosemary oil antimicrobial activity is achieved by

passing through the cell wall and cytoplasmic membranes and disrupting their structure as an atypical lipophilic substance (Stojanović-Radić *et al.,* 2010). CAP has various targets in the bacterial cell, such as the cell membrane, cell wall, DNA, and intracellular proteins. it can break peptidoglycan in the cell wall of Gram-positive bacteria and in Gram-negative ones cause lipid peroxidation leading to leakage of cell components, including potassium, nucleic acid, and proteins. Then plasma species can go through into the inner of the cell leading to more injury to DNA and other components (Liao *et al.,* 2021).

From the obtained results in Table 6, there was a reduction in the total coliform count of thigh fillet and breast fillet in the three trials with a log reduction of 0.87, 1.64 and 1.79 in thigh fillet, and 0.66, 1.33 and 1.43 in breast fillet treated samples for rosemary, CAP and their combination respectively. Table 7 showed that rosemary oil 1%, CAP and their combination has a comparable effect on the count of E.coli artificially inoculated in chicken fillet samples with a log reduction of 0.84, 2.98 and 2.85 in thigh fillet and 0.79, 2.89 and 2.95 in breast fillet. Choi1 *et al.* (2016) found that CAP achieved a higher rate of *E. coli* inactivation in fresh pork.

The effect of different trials on *S.aureus* artificially inoculated in chicken fillet samples as noticed in Table 8 that the three treatments had different log reductions ranging between moderate reduction by rosemary oil 0.77 and 0.69 log reduction in thigh fillet and strong reduction by rosemary-CAP combination 1.99 and 2.16 log reduction in thigh and breast fillet respectively. The antistaphylococcal effect of rosemary was proven in previous studies by Habashy *et al.* (2019), and so the effect of CAP was proven by Han *et al.* (2016).

The log reduction in the case of *E. coli* as a Gram-negative organism is larger than that in the case of *S. aureus* as a Gram-positive owing to the differences in their cell structure and composition. CAP produces discharges of microbial inhibiting properties that affect easily on the outer membranes of Gram-negative bacteria and kill them; nonetheless, these particles need to penetrate both the cell wall and cell membrane of Gram-positive bacteria before reaching intra-cellular components and killing the bacteria (Huang *et al.,* 2020).

CONCLUSION

The discussed data showed that combined treatment by rosemary 1% and CAP for 3 minutes reduced the microbial count on thigh and breast fillets, moreover, a combination of cold atmospheric plasma with rosemary oil could be used as a successful non-thermal method to preserve the sensory attributes of poultry meat and prolong their shelf-life.

REFERENCES

Attri, P.; Kim, Y.H.; Park, D.H.; Park, J.H.; Hong, Y.J.; Uhm, H.S. and Choi H.E. (2015): Generation mechanism of hydroxyl radical species and its lifetime prediction during the plasma-initiated ultraviolet (UV) photolysis. Scientific Reports, 5(1), 1–8. doi:10.9734/JSRR/2015/14076

Bagamboula, CF.; Uyttendaele M. and Debevere J. (2004): Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragole, linalool and p-cymene towards Shigella sonnei and S. flexneri. Food Microbiol.; 21(1): 33–42

BAM-FDA, Chapter 4 (2013): Rev., 2020: Bacteriological analytical manual, food and drug administration, Enumeration of Escherichia coli and the Coliform Bacteria BAM chapter 4

Charoux, C.M.G.; Patange, A.; Lamba, S.; O'Donnell, C.P.; Tiwari, B.K. and Scannell, A.G. M. (2021): Applications of nonthermal plasma technology on safety and quality of dried food ingredients. Journal of Applied Microbiology, 130(2), 325–340. https://doi.org/10.1111/jam.14823

Choi, Pradeep Puligundla and Chulkyoon Mok1 (2016): Corona discharge plasma jet for inactivation of Escherichia coli O157:H7 and Listeria monocytogenes on inoculated pork and its impact on meat quality attributes, Ann Microbiol (2016) 66: 685–694

Coutinho, N.; Silveira M.; Rocha, R.; Moraes, J.; Ferreira, M. and Pimente, l T. (2018): Cold plasma processing of milk and dairy products. Trends in Food Science & Technology. 74: 56–68

Egyptian Standards Organization (ESO) 2005/1651: For Egyptian chilled rabbit and poultry meat.

Fahmy, A.; Debarnot, D. and Friedrich, J. (2015): Influence of water addition on the structure of plasma-deposited allyl alcohol polymer films', J. of Adhesion Science and Technology, 29(10): 965–980.

Fahmy, A.; Friedrich, J.; Poncin-Epaillard, F. and Debarnot, D. (2016a): Plasma Polymerized Allyl Alcohol/O_2 Thin Films Embedded with Silver Nanoparticles, Thin Solid Films, 616: 339–347.

Fahmy, A. and Schönhals, A. (2016b): Reaction of CO_2 gas with (radicals in) plasma polymerized Acrylic Acid (and formation of COOH-rich polymer layers), Plasma Processes and Polymers 13: 499-508.

Fahmy, A.; Schönhals, A. and Friedrich, J. (2013): ´Reaction of water with (radicals in) plasma polymerized allyl alcohol (and formation of OH-rich polymer layers), J. Physical Chemistry B, 117: 10603−10611.

Food and Agriculture Organization "FAO"(1980): Manual of Food Quality Control. FAO, United Nations, Rome, Italy.

Gaunt, L.; Beggs, C. and Georghiou, G. (2006): Bactericidal Action of the Reactive Species Produced by Gas-Discharge Nonthermal Plasma at Atmospheric Pressure: A Review. IEEE Transactions on Plasma Science. 34(4):1257–69.

Gavahian, M.; Chu, Y.H.; Khaneghah, A.M.; Barba, F.J. and Misra, N.N. (2018): A critical analysis of the cold plasma induced lipid oxidation in foods. Trends in Food Science & Technology, 77, 32–41. doi:10.1016/j.tifs.2018.04.009

Gracey, J.F.; Collins, D.S. and Huey, R.J. (1999): Meat hygiene (10th ed.). London: W.B.Saunders Company LTD.p.55.

Habashy, Amina H.A.; El-Dien, W.S.; Hussein, M.A. and Darwish, W.S. (2019): Revalence Of Staphylococcus aureus And Salmonella Species In Retailed Chicken Meat With A Reduction Trial Using Nigella-Sativa And Rosemary Oil, Slov Vet Res 2021; 58 (Suppl 24): 299–305.

Hamilton, M.J.; Hadi, A.Z.; Griffith, J.F.; Ishii, S. and Sadowsky, M.J. (2010): Large scale analysis of virulence genes in Escherichia coli strains isolated from Avalon Bay, CA. Water Research, 44, 5463–5473.

Han, L.; DanaZiuzina, Caitlin Heslin, Daniela Boehm, Apurva Patange, David M. Sango, Vasilis P. Valdramidis, Patrick J. Cullen and Paula Bourke (2016): Controlling Microbial Safety Challenges of Meat Using High Voltage Atmospheric Cold Plasma, *ORIGINAL RESEARCH published: 22, 1-12.*

Hatab, S.; Koddy, J.K.; Miao, W.H.; Tang, L.L.; Xu, H.Q.; Deng, S.G. and Zheng, B. (2021): Atmospheric Cold Plasma: A New Approach to Modify Protein and Lipid Properties of MyofibrillarProtein Isolatefrom Hair-tail (Trichiuruslepturus) Fish. J. Sci. Food Agric., 102, 2041–2049. [CrossRef]

Huang, M.; Zhuang, H.; Zhao, J.; Wang, J.; Yan, W. and Zhang, J. (2020): Differences in cellular damage induced by dielectric barrier discharge plasma between Salmonella Typhimurium and

Staphylococcus aureus. Bioelectrochemistry, 132, 107445.

Ibrahim, H.M.; Hassan, M.A.A.; Amin, R.A.A.; Shawqy, N.A.B and Elkoly, R.L. (2018): Effect of Some Essential Oils on the Bacteriological Quality of Some Chicken Meat Products, BENHA VETERINARY MEDICAL JOURNAL, VOL. 35, NO. 1: 42-49.

International Standard Organization ISO (2022): 4833-1:2013 (E) Amendment 2022: Microbiology of food and animal feeding stuff — Horizontal methods for the detection and enumeration of microorganisms — Part 1: Colony-count at 30°C by pour plate technique

Laroussi M. and Leipold F. (2004): Evaluation of the roles of reactive species, heat, and UV radiation in the inactivation of bacterial cells by air plasmas at atmospheric pressure. International Journal of Mass Spectrometry. 2004; 233(1–3): 81–6. http://dx.doi.org/10.1016/j.ijms.200 3.11.016.

Li, Y.L.; Wang, W.J.; Long, Y.; Peng, Y.K.; Li, Y.Y.; Chao, K.L. and Tang, X.Y.A. (2018): feasibility study of rapid nondestructive detection of total volatile basic nitrogen (TVB-N) content in beef based on airflow and laser ranging technique. Meat Sci. 2018, 145, 367–374.

Liao, X.; Liu, D.; Chen, S.; Ye, X. and Ding, T. (2021): Degradation of antibiotic resistance contaminants in wastewater by atmospheric cold plasma: Kinetics and mechanisms. Environmental Technology, 42(1), 58–71. https://doi.org/10.1080/ 09593330. 2019.1620866

Liu, H.; Ji, Z.T.; Liu, X.L.; Shi, C. and Yang, X.T. (2020): Non-destructive determination of chemical and microbial spoilage indicators of beef for freshness evaluation using front-face synchronous fluorescence spectroscopy. Food Chem., 321, 126628. [CrossRef] [PubMed]

Luan, L.L.; Fu, S.L.; Yuan, C.H.; Ishimura, G.; Chen, S.G.; Chen, J.C. and Hu, Y.Q. (2017): Combined effect of superchilling and tea polyphenols on the preservation quality of hairtail (Trichiurushaumela). Int. J. Food Prop., 20, S992–S1001. [CrossRef]

Morfill, G.; Shimizu, T.; Steffes, B. and Schmidt, H. (2009): Nosocomial infections—a new approach towards preventive medicine using plasmas. New Journal of Physics; 11(11): 115019.

Moutiq, R.; Misra, N.N.; Mendonca, A. and Keener, K. (2020): In-package decontamination of the chicken breast using cold plasma technology: Microbial, quality and storage studies. Meat Science, 159, 1–9. doi:10.1016/j.meatsci.2019.107942

Ndaw, A.D.; Faid, M.; Bouseta, A. and Zinedine, A. (2008): Effect of controlled lactic acid bacteria fermentation on the microbiological and chemical quality of Morocans sardines (Sardina pilchardus). J.of Agric. and Biology, 10: 21-27.

Pearson, D. (2006): Chemical Analysis of Foods. 11th Ed, Publishing Co., Churchill Livingstone, Edinburgh, London, United Kingdom

Peschel, W.; Dieckmann, W.; Sonnenschein, M. and Plescher, A. (2007): High antioxidant potential of pressing residues from evening primrose in comparison to other oilseed cakes and plant antioxidants. Indust. Crops Prod. 25: 44

Pikul, J.; Leszezynski, D.E. and Kummerow, F. (1989): Evaluation of three modified TBA methods for measuring lipid oxidation in chicken meat. J. Agri. Food Chem., 37:1309.

Qian, J.; Zhao, Y.; Yan, L.; Luo, J.; Yan, W. and Zhang, J. (2022): Improving the lipid oxidation of beef patties by plasma-modified essential oil/protein edible composite films. LWT, 154, 112662. doi:10.1016/j.lwt.2021.112662

Shahidi, F. and Zhong, Y. (2010): Lipid oxidation and improving the oxidative stability. ChemicalSociety Reviews, 39(11), 4067–4079. doi:10.1039/ b922183m

Singh, R.K. and Singh, N. (2005): "3 Quality of packaged foods." Innovations in food packaging:24.

Soriano, J.M.; Mañes, J.; Soler, C. and Sospedra, I. (2012): Rapid whole protein quantitation of staphylococcal enterotoxins A and B by liquid chromatography/mass spectrometry. J. Chromatography A., 1238: 54–59.

Stojanović-Radić, Z.; Nešić1, M.; Ljiljana Čomić, L. and Radulović, N. (2010): Antimicrobial activity and cytotoxicity of commercial rosemary essential oil (Rosmarinus officinalis L.). Biologica. Nyssana., 1 (1-2): 83-88.

Sun, W.; Li, H.; Wang, H.; Xiao, S.; Wang, J.H. and Feng, L. (2015): Sensitivity enhancement of pH indicator and its application in the evaluation of fish freshness. Talanta, 143, 127–131. [CrossRef]

Wang, J.; Fu, T.; Sang, X. and Yafu Liu (2022): Effects of high voltage atmospheric cold plasma treatment on microbial diversity of tilapia (Oreochromis mossambicus) fillets treated during refrigeration, International Journal of Food Microbiology 375(4):109738, 1-13[PubMed] [CrossRef] [Google Scholar]

Yang, L.; Chen, J. and Gao, J. (2009): Low-temperature argon plasma sterilization effect on Pseudomonas aeruginosa and its mechanisms. Journal of Electrostatics, 67(4), 646–651. https://doi.org/10.1016/j.elstat.2009.01.060

Yilmaz Ucara; Zafer Ceylan; Mustafa Durmus; Oktay Tomar and Turgay Cetinkaya (2021): Application of cold plasma technology in the food industry and its combination with other emerging technologies, Trends in Food Science&Technology 114(2021)355–371

تأثير البلازما الجوية الباردة وزيت إكليل الجبل على جودة منتجات لحوم الدواجن

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تهدف هذه الدراسة إلى تقييم تأثير زيت إكليل الجبل وتكنولوجيا البلازما الباردة والاثنين معا على المعاييرالحسية والجودة الكيميائية والبكتيريولوجية لفيلية الدجاج كمادة خام لمصنعات لحوم الدواجن المختلفة، وأيضا دراسة تأثير المعالجات الثلاث على ميكروبى الإيشيريشياكولاى والمكور العنقودى الذهبي المحقونين فى العينات.

فيما يتعلق بفترة بقاء العينات صالحة فى درجة حرارة الثلاجة ٤ ° م، فقد خلصت الدراسة إلى أن المعالجات الثلاث لها تأثير كبير على العوامل ذات الصلة بما في ذلك المعايير الحسية والمعايير الكيميائية والعد الكلى للبكتيريا الهوائية وخاصة العينات المعالجة بزيت إكليل الجبل ١٪ مع تقنية البلازما الجوية الباردة عند ٧٠ كيلو فولت لمدة ٣ دقائق مع إطالة فترة الصلاحية لمدة سبع أو ثمان أيام تقريباً.

وبالنسبة لتأثير المعالجات المختلفة على مجموعة بكتيريا الكوليفورم وميكروبى الإيشريشيا كولاى والمكور العنقودى الذهبى كان من الواضح أن للمعالجات الثلاث تأثير معنوى وإن اختلف من معالجة لاخرى وكان أقواهم تأثيرا هو الجمع بين استخدام زيت اكليل الجبل ١% وتقنية البلازما الجوية الباردة.

ووفقا للنتائج تم التوصل إلى أنه يمكن استخدام تكنولوجيا البلازما الباردة والجمع بينها وبين استخدام بعض الزيوت الطيارة مثل زيت اكليل الجبل ١% كوسيلة غير حرارية فعالة للحفاظ على جودة منتجات الدواجن، وإطالة مدة صلاحيتها وتقليل مسببات الأمراض.