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Improvement of the Chemical and Microbial Quality of Marketed Chicken Meat Using Organic Acids

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Abstract

This study aimed to determine the impact of organic acids (acetic acid, lactic acid, and lemon juice) at concentrations 1% and 2% to enhance sensory parameters and chicken meat's chemical and microbiological quality. Seventy chicken meat samples were collected from Damanhur city market , Egypt. The samples were divided into seven groups control, where collected chicken samples were represented by control, acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2%, lemon juice 1% and lemon juice 2% treated groups after dipping for 5 minutes (35 samples, 5 for each group) also, after 10 minutes the protocol repeated. The results indicated that sensory evaluation of all treated samples was improved, especially in the acetic acid 2% and lactic acid 2% treated groups. The pH significantly decreased in all treatments, especially lactic and acetic 2% at 10 minutes of dipping. The TVN and TBA mean values were reduced in all treated groups, especially under the effect of acetic acid 2% for 10 minutes. The APC, the TEC and the TCC mean values were reduced in all treated groups, especially under the acetic acid 2% effect after 5 and 10 minutes. The *S. aureus* count and the total pseudomonas count mean values were reduced under acetic acid 2%, respectively. It was concluded that acetic acid 2% in dipping water for 10 minutes is highly effective in decontaminating chicken meat and improving the sensory character, reducing chemical changes.

Keywords: Chicken meat; Organic acids; Chemical; Microbial quality

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1. Introduction

Poultry meat is exposed to microbial contamination from various sources during slaughtering, preparation, and processing. The rapid onset of lipid oxidation and high microbial load of poultry meat are responsible for low sensory scores and short storage periods for products manufactured with poultry meat. The chicken industry's major goal is to lengthen the shelf life by employing a lot of synthetic preservatives, but consumers want nutritious meals (free of traditional chemical preservatives). Hence natural decontaminants have been suggested. Antioxidants are substances that can slow down, stop, or prevent the oxidation of lipids **(Shahidi et al., 1992)**. The microbiological quality of chicken meat relies on several factors, such as the quality of the raw materials, other materials used or added during processing operations to the products, or sanitation during processing and packaging **(Ahmed and Ismail, 2010)**. Food handlers and equipment are the principal sources of microbial contamination of the foods during processing and preparation **(Cordoba et al, 1998)**.

Because of their antibacterial properties, organic acids (acetic, lactic, and lemon juice) are commonly used as food preservatives. Organic acids are classified by the FDA as generally recognized as safe substances (GRAS) and have been accepted as food additives by the European Commission **(Surekha and Reddy, 2000)**. The action of organic acids in intracellular pH decreases and membrane function alteration could be liable for the microbial inactivation **(Hirschfield et al., 2003)**. Lactic acid can be used in beef carcasses to inhibit infections and reduce microbial burdens **(Ramirez et al., 2001)**. Acetic acid has been studied as a potential antimicrobial agent for poultry meat to extend shelf life and suppress pathogen growth, such as Salmonellae **(Jiménez et al., 2007)**. Citric acid shows good antimicrobial activity to preserve feed against bacterial spoilage, reduces the levels of undesirable bacteria in the gastrointestinal tract and can improve growth rate **(Deepa et al., 2011).** Thus, this study aimed to assess the effect of organic acids (acetic acid, lactic acid, and lemon juice) on poultry meat sensory, microbiological, and chemical parameters.

2. Material and Methods

2.1. Sampling

Seventy chicken carcasses were collected from Damanhour city market before and after the application of organic acids (acetic acid, lactic acid, and lemon juice) at different concentrations (1% and 2%) and different dipping times (5 and 10 minutes). The collected chicken samples were represented by control, 1% acetic acid, 2% acetic acid, 1% lactic acid, 2% lactic acid, 1% lemon juice, and 2% lemon juice treated groups for 5 minutes (35 samples, 5 for each group). Typically, the other samples were taken from the chicken carcasses either control or dipped in such organic acids for 10 minutes (35 swabs, 5 for each group). As a control, the first group was dipped in distilled water. The other six groups were dipped for 5 or 10 minutes in 1 percent acetic acid, 2 percent acetic acid, 1 percent lactic acid, 2 percent lactic acid, 1 percent lemon juice, and 2 percent lemon juice, respectively. The samples were dipped and then allowed to drain for 10 minutes. 5 samples from each group were placed in polystyrene trays and kept at 2°C for 6 hours. The studied samples were put through a series of bacteriological, chemical, and sensory tests to see how these organic acids affected the bacterial load on chicken surfaces while increasing their quality.

2.2. Sensory evaluation

Chicken meats were examined final sensory evaluation according to **World's Poultry Science Association (1987)**. In brief, five trained panellists give grades ranging from 1 to 3. The analyzed sensorial attributes were visual look (skin and meat color), meat consistency and elasticity, and odor evaluation.

2.3. Chemical parameters

The pH of chicken meat was determined according to **Pearson (2006)**. In a blender, approximately 10 g of the sample was blended in 10 mL of neutralized distilled water, after which the pH value was measured using a digital pH meter **(Bye model 6020, USA)**. To determine the total Volatile Nitrogen (TVN), ten grams were mixed with 100 mL of distilled water. They rinsed into a distillation flask holding 100 mL of distilled water, followed by adding 2 g of magnesium oxide and an antifoaming agent. To dissolve the combination, micro-Kjeldahl distillation equipment was utilized. Twenty-five minutes of distillation were conducted in 25 mL of boric acid (4%), including five drops of Tashiro indicator. The solution was titrated with 0.1MHCl to determine the TVN in the sample in terms of mg TVN/100 g **(EOS: 63-9/2006)**. The sample (10 g) was combined with 25 mL of 20% trichloroacetic acid (w/v) and homogenized for 30 seconds in a blender for the thiobarbituric acid (TBA) assay. After filtering, the filtrate (2 mL) was mixed with 2 mL of 0.02 M aqueous TBA in a test tube. For 20 hours, the test tubes were incubated at room temperature in the dark. A UV-vis spectrophotometer set at 532 nm was used to measure the absorption. **(Schmedes and Holmers, 1989**).

2.4. Bacteriological examination

2.4.1. preparation of samples

25 grammes of the sample were weighed and put into a sterile homogenizer flask containing 225 mL of sterile peptone water under complete aseptic conditions (0.1 percent). One ml of the homogenate was transferred to

a separate tube containing 9 ml of sterile peptone water (0.1 percent), from which tenfold serial dilutions were made. The number of aerobic platelets was calculated. according to **ISO :4833-1 (2013)**.

2.4.2. isolation and identification of bacteria

The total APC = number of colonies x dilution factor. The count was presented as a colony-forming unit (CFU/cm^2). For Enterobacteriaceae count, 100 microliters of the suspension were inoculated by spreading it on duplicate plates on violet-red bile glucose agar and incubating it aerobically at 37°C for 24 hours. Plates containing typical Enterobacteriaceae colonies (pink or red, 0.5 mm or more in diameter, and with or without precipitation) were counted after incubation. **(ISO: 4832/2006)**. The same previous technique was used to count total coliforms using violet-red bile agar media. The plates were incubated for 24 hours at 37°C. The average number of colonies on the plates was calculated by counting all dark red colonies measuring 0.5 mm in diameter. **(ISO:4832/2006)**. For Pseudomonas count, 0.1 mL of the original mixture was evenly spread over a dry plate of pseudomonas agar base (CM 559; Oxoid) supplemented with cetrimide, fucidin, and cephaloridine supplements (SR 103; Oxoid, Basingstoke, Hampshire, United Kingdom). Using sterile bent glass spreader. After thorough spreading, the inoculated and control plates were incubated at 25ºC for 48 hours. The suspected colonies of Pseudomonas species were enumerated, and the average count per gram was recorded **(FDA, 2013)**. For *S. aureus* count, 0.1 mL from each of the previously prepared serial dilutions was spread over Baird Parker agar **(BP, Hi-Media, M043-500G, Mumbai India)** supplemented with egg yolk tellurite emulsion and incubated at 37ºC for 48 hours. The developed shiny black colonies surrounded by a halo zone were enumerated as presumptive *S. aureus* count/g according to **ISO 6888-1:(1999)**.

2.5. Statistical Analysis

Data were statistically assessed using the two-way student ANOVA and mean values presented ± standard error.

3. Results and Discussion

In this study, the effect of acetic acid, lactic acid, and lemon juice on chicken meat quality was evaluated as a critical control point in the HACCP system in Damanhur city market.

3.1. Sensory evaluation

Consumers' perceptions of quality are influenced by appearance, which substantially impacts purchasing decisions. Appearance, texture, and flavor are the three sensory aspects that customers use to determine meat quality **(Liu et al., 1995)**.

The final score obtained from the average of (color, appearance, texture, and aroma recorded in **Table 1** declared that the final score in the control group was 8 versus 11,12, 10, 12, 9 and 11 for acetic acid (1%), acetic acid (2%), lactic acid (1%), lactic acid (2%), lemon juice (1%), and lemon juice (2%), respectively after dipping for 5 minutes. The control group considered as very low-quality sensory properties, while low quality or suspicious properties for lactic acid 1% and lemon juice 1%, and still within the acceptable range and considered good for acetic acid (2%), lactic acid (2%), acetic acid (1%), and lemon juice (2%).

The data in **Table 2** revealed that the final score for the control group was 5. On the other hand, the final score was 12,13, 10, 13, 10, and 12 in acetic acid (1%), acetic acid (2%), lactic acid (1%), lactic acid (2%), lemon juice (1%) and lemon juice (2%), respectively after dipping for 10 minutes. The control group considered as very low-quality sensory properties, while low quality or suspicious properties for lactic acid 1% and lemon juice 1%, and still within the acceptable range and considered good for acetic acid (2%), lactic acid (2%), acetic acid 1% and lemon juice 2%. Nearly similar results were reported on the decontamination of poultry carcasses with acetic acid **(Dickens and Whittemore, 1994)** and lactic acid **(Hussein et al., 2018)**.

In this study, no alteration of organoleptic characters of treated groups is consistent with **Alaa (2008)**. Contact time of the organic acids may be determining factor in the appearance changes of the carcasses **(Dickens and Whittemore, 1997)**. The enhancement of organoleptic score in organic acid-treated groups is attributed to the reduction level of microbial growth that was similar to **Smaoui et al (2011)** and **Hussein et al (2018)**.

3.2. Chemical parameters

3.2.1. pH value

Because the ultimate pH of meat is critical for its resistance to deterioration, the pH value is a key indicator of meat quality **(Walker and Betts, 2000)**. Meat should not have a pH value greater than 6.4 in any condition or be regarded unfit for human consumption **(Gracey and Collins, 1992).**

The results in Table 3 revealed that the mean pH value at control treatment was 5.84 ± 0.1 and 5.84 ± 0.1 at 5- and 10-minutes dipping of chicken meat samples.

On the 5minutes of dipping the pH decreased in all treatments and mean values became 5.68± 0.1, 5.60 ± 0.8, 5.75 ± 0.1, 5.63± 0.1, 5.77 ± 0.1 and 5.71 ± 0.1, while the reduction percentage (R%) values were 2.7, 4.1, 1.5, 3.5, 1.2, and 2.2 in acetic acid 1%, acetic acid 2%, lactic acid 1% and lactic acid 2 %, lemon juice 1% and lemon juice 2 %, respectively.

On the 10 minutes of dipping the pH decreased in all treatments and mean values became 5.64 ± 0.1, 5.57 ± 0.8, 5.72 ± 0.1, 5.59 ± 0.1, 5.73 ± 0.1, and 5.76 ± 0.1 while the reduction percentage (R%) values were 3.4, 4.6, 2.1, 4.3, 1.9, and 2.9 in acetic acid 1%, acetic acid 2%, lactic acid 1%, and lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

All treated groups were in the range of permissible level reported by **EOS: 4178 / 2005**, limiting the pH to be less than 5.9. Meanwhile, the control group exceeded the allowable limit. Nearly similar results were obtained from 5.7 to 6.1 **(Shedeed, 1999)**, 5.9 to 6.4 **(Afifi, 2000)** and from 5.6 to 6.2 **(Fathy, 2012)** While, whereas higher results (6.57 ± 0.03 and 6.67 ± 0.05) were obtained by **Hassanin and Hassan (2003)**.

The pH in the control group increased dramatically, possibly due to bacteria's use of amino acids, which resulted in the accumulation of ammonia as a byproduct of amino acid degradation, increasing pH **(Valencia et al. 2008)**.

3.2.2. Total volatile basic nitrogen

Table 1. Sensory characteristics of the examined samples of chicken meat dipped in organic acids for 5 minutes.

	External aspect (3)	Odor (3)	Color of skin (3)	Color of meat (3)	Meat elasticity (3)	Overall Score (15)	Sensorial Quality
Control	2	1	2	2	1	8	**Acceptable**
1% Acetic acid	3	2	2	2	2	11	**Acceptable**
2% Acetic acid	3	2	2	2	3	12	**Excellent**
1% Lactic acid	2	1	2	2	3	10	**Acceptable**
2% Lactic acid	2	2	3	3	2	12	**Excellent**
1% Lemon juice	2	2	2	1	2	9	**Acceptable**
2% Lemon juice	**2**	**3**	**2**	**2**	**2**	**11**	**Acceptable**

***** 12-15= Excellent, 8-11= Acceptable

Table 2. Sensory characteristics of the examined samples of chicken meat dipped in organic acids for 10 minutes.

	External aspect (3)	Odor (3)	Color of skin (3)	Color of meat (3)	Meat elasticity (3)	Overall Score (15)	Sensorial Quality
Control	2	1	2	2	1	8	**Acceptable**
1% Acetic acid	3	2	2	3	2	12	**Excellent**
2% Acetic acid	3	2	3	3	2	13	**Excellent**
1% Lactic acid	2	2	2	2	2	10	**Acceptable**
2% Lactic acid	2	2	3	3	3	13	**Excellent**
1% Lemon juice	2	3	2	1	2	10	**Acceptable**
2% Lemon juice	**3**	**3**	**2**	**2**	**2**	**12**	**Excellent**

***** 12-15= Excellent, 8-11= Acceptable

The total volatile basic nitrogen (TVBN mg/100g) is used as an index of raw meat quality. **Egyptian standard (3602/2013)** stated that the permissible limit of TVN contents in chilled chicken should not exceed 20mg /100g. The results in **Table 4** revealed that the mean value of total volatile basic nitrogen (TVB-N) at control treatment was 7.56 ± 0.41 and 7.71 ± 0.38 at 5 and 10 minutes dipping of chicken meat samples.On the 5 minutes of dipping the TVB-N decreased in all treatments and mean values became 4.89 ± 0.32, 3.61 ± 0.19, 5.95± 0.28 , 4.51 ± 0.26 , 6.29 ± 0.37 and 5.67 ± 0.23 while the reduction percentage (R%) values were 35.3, 52.3, 21.3, 40.4, 16.8, and 25 in acetic acid 1%, acetic acid 2%, lactic acid 1%, and lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

Meanwhile, 10 minutes of dipping the TVB-N decreased in all treatments and mean values became 3.73 ± 0.1, 2.49 ± 0.8, 5.07 ± 0.1, 3.39 ± 0.1, 5.47 ± 0.1, and 4.70 ± 0.1, while the reduction percentage (R%) values were 51.6, 67.7, 34.3, 56, 29.1, and 39.1 in acetic acid 1%, acetic acid 2%, lactic acid 1%, and lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

All treated groups were in the range of permissible level reported by **EOS: 4178 / 2005**, limiting the content of TVB-N to be less than 20 mg /100g. Meanwhile, the control group exceeded the permissible limit.

The control group significantly had a higher level of TVB-N, suggesting that the organic acids inhibited the microbial activity in chicken meat samples in treated groups. Moreover, higher, and rapid bacterial growth and multiplication in control groups led to protein degradation and free amines formation. Nearly similar results were obtained by **Fathy (2012)**, who detected 6.57 ± 0.19 mg %. Higher results were obtained by **Afifi (2000)**, who noticed 12.57 ± 0.222 mg % and **Hassanin and Hassan (2003),** who detected 30.76 ± 1.07 mg %.

3.2.3. Thiobarbituric acid

The TBARS assay is one of the most extensively used methods for assessing secondary oxidation products, primarily Malondialdehyde (MDA), which are known to produce oxidative rancidity and may contribute to off-flavor and oxidized fat **(Zhang et al., 2016).**

The obtained data in **Table 5** showed that thiobarbituric acid (TBA) mean value was 0.33 ± 0.01 and 0.35 ± 0.01 mg/kg for control treatment when after dipping for 5 minutes and 10 minutes. After 5 minutes of dipping the TBA gradually decreased in all treatments and mean values became 0.14 ± 0.01, 0.06 ± 0.01, 0.22 ± 0.01, 0.09 ± 0.01, 0.24 ± 0.01, and 0.19 ± 0.01 mg/kg, while the reduction percentage (R%) values were 57.6, 81.8, 33.3, 72.7, 27.3, and 42.4 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. Furthermore, TBA mean values was 0.08 ± 0.01, 0.03 ± 0.01, 0.11 ± 0.01, 0.05 ± 0.01, 0.14 ± 0.01, and 0.11 ± 0.01 mg/kg, while the reduction percentage (R%) values were 77.2, 91.4, 68.6, 85.7, 60, and 68.6 acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively after 10 minutes of dipping. The accumulation of malonaldehyde in chicken samples could be due to the hydrolytic and oxidative processes in the lipid fraction **(Brake and Fennema, 1999)**, as well as to the increase in free iron ions **(Kanner et al., 1991)**.

All treated groups were in the range of permissible levels reported by **EOS: 4178/2005.** This limited the value of TBA to be not more than 0.9 mg of MDA/kg for chicken meat. The TBARS values of all samples decreased significantly with the dipping of chicken meat in organic acids. The TBARS values of all treated samples were significantly lower ($P < 0.05$) than those of the control group for each sampling during treatments, showing the effects of organic acids against lipid oxidation in chicken. The inhibitory effect of organic acids was stronger ($P < 0.05$) in acetic acid 2 % than in other organic acids after the dipping periods (5 minutes and 10 minutes). Analysis of variance showed that the TBARS values were significantly affected ($P < 0.05$) by organic acid dipping (acetic acid, lactic acid, and lemon juice). These results suggest that these organic acids delayed lipid oxidation during storage.

3.3. Bacteriological parameters

3.3.1. Aerobic plate count

Aerobic plate count is a general indicator of the total degree of microbial contamination of meat and is used to determine the microbiological state of chicken meat **(Shaltout et al., 2016)**.

The data in **Table 6** showed that the mean values of APC after 5 and 10 minutes in control groups were $3.6\times10^5\pm 0.2\times10^5$ and $3.9\times10^5\pm 0.2\times10^5$ CFU/g, respectively. Similar finding 5.1 $\log_{10}$ CFU/g were obtained by **Balamatsia et al (2006)**, 5.13 CFU/g by **Morshdy and Sallam (2009)** and 5.41 $\log_{10}$ CFU/g by **Zhang et al (2016)**. **Bailey et al (2000)** detected Lower APC 4.6 $\log_{10}$ CFU/g.

The mean values after dipping for 5 minutes was $1.4\times10^5 \pm 0.1\times10^5$, $7.9\times10^4 \pm 0.8\times10^4$, $2.0\times10^5 \pm 0.1\times10^5$, $1.3\times10^5 \pm 0.1\times10^5$, $2.4\times10^5 \pm 0.2\times10^5$, and $1.9\times10^5\pm 0.1\times10^5$ CFU/g while the reduction percentage (R%) values were 61.1 , 78, 44.5, 63.9, 33.3, and 47.2 in in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. Comparatively the mean values after dipping for 10 minutes was $1 \times10^5 \pm 0.1\times10^5$, $3.8\times10^4 \pm 0.2\times10^4$, $1.5 \times10^5 \pm 0.1\times10^5$, $8.9\times10^4 \pm 1.4 \times10^4$, $2 \times10^5 \pm 0.1 \times10^5$, and $1.6 \times10^5 \pm 0.1\times10^5$ CFU/g, while the reduction percentage (R%) values were 74.4, 90.2, 61.5, 77.2, 48.7, and 58.9 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. Lower results obtained by **Hassanien et al (2013)** who found APC $2.12\times10^6 \pm 0.35\times10^6$, $8.92\times10^4 \pm 1.73\times10^4$ for control and acetic acid 1% treated surface of chicken carcass, respectively.

3.3.2. Total Enterobacteriaceae count

Because some members of the Enterobacteriaceae family are pathogenic and can cause serious illnesses and food poisoning, they are of epidemiological interest and concern. Furthermore, in the absence of Coliform, the overall Enterobacteriaceae count can predict probable enteric contamination **(El-Ansary, 1997)**.

The data in **Table 7** showed that the mean values of TEC after 5 and 10 minutes in control groups were $8.4 \times10^4 \pm 1.3\times10^4$ and $8.5 \times10^4 \pm 1.4\times10^4$ CFU/g.The mean values after dipping for 5 minutes was $3.5 \times 10^4 \pm 0.2\times10^4$, $2.2\times10^4 \pm 0.1\times10^4$, $4.9 \times10^4 \pm 0.4\times10^4$, $3.4\times10^4 \pm 0.2\times10^4$, $5.7\times10^4 \pm 0.6\times10^4$ and $4.6\times10^4 \pm 0.1\times10^4$ CFU/g while the reduction percentage (R%) values were 58.3, 73.8, 41.6, 59.5, 32.1, and 45.2 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

Table 3. Statistical analysis of pH values in control and treated chicken meat samples

Treatments	Dipping time			
	5 min	**R %**	**10 min**	**R %***
Control	5.84± 0.1 ^{aA}	------	5.84± 0.1 ^{aA}	------
1% Acetic acid	5.68± 0.1 ^{abA}	2.7	5.64± 0.1 ^{abA}	3.4
2% Acetic acid	5.60 ± 0.8 ^{bA}	4.1	5.57 ± 0.8 ^{bA}	4.6
1% Lactic acid	5.75 ± 0.1 ^{aA}	1.5	5.72 ± 0.1 ^{aA}	2.1
2% Lactic acid	5.63± 0.1 ^{bA}	3.5	5.59± 0.1 ^{bA}	4.3
1% Lemon juice	5.77± 0.1 ^{aA}	1.2	5.73± 0.1 ^{aA}	1.9
2% Lemon juice	5.71± 0.1 ^{abA}	2.2	5.67± 0.1 ^{abA}	2.9

Table 4. Statistical analysis of TVN values (mg %) in the control and treated chicken meat samples.

Treatments	Dipping time			
	5 min	**R %**	**10 min**	**R %***
Control	7.56± 0.41 ^{aA}	------	7.71± 0.38 ^{aA}	------
1% Acetic acid	4.89± 0.32 ^{cA}	35.3	3.73± 0.1 ^{cB}	51.6
2% Acetic acid	3.61± 0.19 ^{dA}	52.24	2.49± 0.8 ^{dB}	67.7
1% Lactic acid	5.95± 0.28 ^{bA}	21.3	5.07± 0.1 ^{bB}	34.24
2% Lactic acid	4.51± 0.26 ^{cA}	40.34	3.39± 0.1 ^{cB}	56
1% Lemon juice	6.29± 0.37 ^{bA}	16.8	5.47± 0.1 ^{bB}	29.1
2% Lemon juice	5.67± 0.23 ^{bA}	25	4.70± 0.1 ^{bB}	39.1

Table 5. Statistical analysis of thiobarbituric acid values (TBA) (mg/Kg) in control and treated chicken meat samples.

Treatments	Dipping time			
	5 min	R %	10 min	R %*
Control	0.33± 0.01 aA	------	0.35± 0.01 aA	------
1% Acetic acid	0.14± 0.01 back	57.6	0.08± 0.01 back	77.2
2% Acetic acid	0.06± 0.01 cA	81.8	0.03± 0.01 cA	91.4
1% Lactic acid	0.22± 0.01 bA	33.3	0.11± 0.01 bB	68.6
2% Lactic acid	0.09± 0.01 cA	72.7	0.05± 0.01 cA	85.7
1% Lemon juice	0.24± 0.01 bA	27.3	0.14± 0.01 bB	60
2% Lemon juice	0.19 ± 0.01bA	42.4	0.11 ± 0.01bA	68.6

Table 6. Antibacterial activity of organic acids on Total aerobic plate count (APC) (CFU/g) in the chicken meat samples.

Treatments	Dipping time			
	5 min	R %	10 min	R %*
Control	$3.6\times10^5\pm 0.2\times10^5$ aA	------	$3.9\times10^5\pm 0.2\times10^5$ aA	------
1% Acetic acid	$1.4\times10^5\pm 0.1\times10^5$ dA	61.1	$1.0\times10^5\pm 0.1\times10^5$ dB	74.4
2% Acetic acid	$7.9\times10^4\pm 0.8\times10^4$ eA	78.0	$3.8\times10^4\pm 0.2\times10^4$ eB	90.2
1% Lactic acid	$2.0\times10^5\pm 0.1\times10^5$ cA	44.5	$1.5\times10^5\pm 0.1\times10^5$ cB	61.5
2% Lactic acid	$1.3\times10^5\pm 0.1\times10^5$ dA	63.9	$8.9\times10^4\pm 1.4\times10^4$ dB	77.2
1% Lemon juice	$2.4\times10^5\pm 0.2\times10^5$ bA	33.3	$2.0\times10^5\pm 0.1\times10^5$ bB	48.7
2% Lemon juice	$1.9\times10^5\pm 0.1\times10^5$ cA	47.2	$1.6\times10^5\pm 0.1\times10^5$ cB	58.9

Table 7. Antibacterial activity of organic acids on *Enterobacteriaceae* count (CFU/g) in the chicken meat samples.

Treatments	Dipping time			
	5 min	R %	10 min	R %*
Control	$8.4\times10^4\pm 1.3\times10^4$ aA	------	$8.5\times10^4\pm 1.4\times10^4$ aA	------
1% Acetic acid	$3.5\times10^4\pm 0.2\times10^4$ dA	58.3	$2.3\times10^4\pm 0.1\times10^4$ dB	72.9
2% Acetic acid	$2.2\times10^4\pm 0.1\times10^4$ eA	73.8	$1.2\times10^4\pm 0.1\times10^4$ eB	85.9
1% Lactic acid	$4.9\times10^4\pm 0.4\times10^4$ cA	41.6	$3.6\times10^4\pm 0.2\times10^4$ cB	57.6
2% Lactic acid	$3.4\times10^4\pm 0.2\times10^4$ dA	59.5	$2.2\times10^4\pm 0.1\times10^4$ dB	74.1
1% Lemon juice	$5.7\times10^4\pm 0.6\times10^4$ bA	32.1	$4.6\times10^4\pm 0.3\times10^4$ bB	45.8
2% Lemon juice	$4.6\times10^4\pm 0.1\times10^4$ cA	45.2	$3.7\times10^4\pm 0.2\times10^5$ cB	56.4

On the other hand, the mean values after dipping for 10 minutes was $2.3\times10^4 \pm 0.1\times10^4$, $1.2\times10^4 \pm 0.1\times10^4$, $3.6\times10^4 \pm 0.2\times10^4$, $2.2\times10^4 \pm 0.1\times10^4$, $4.6\times10^4 \pm 0.3\times10^4$ and $3.7\times10^4 \pm 0.2\times10^5$CFU/g while the reduction percentage (R%) values were 72.9, 85.9, 57.6, 74.1, 45.8, and 56.4 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. Lower results were obtained by **Hassanien et al (2013),** who recorded TEC $7.46\times10^4 \pm 1.83\times10^4$ and $2.28\times10^3 \pm 0.65\times10^3$ CFU/g for control and acetic acid 1% treated surface of chicken carcass, respectively.

3.3.3. Total coliforms count

Coliform bacteria are universally distributed on hands, bodies, and clothes, in the air and the soil, on utensils and equipment and in sewage and contaminated water. The animals used for food are equally contaminated, and man and animals are the primary sources of the pathogenic microorganism that contaminate the food we eat and cause food-borne illnesses **(Youssef et al., 2016)**. *E. coli* in food of animal origin is considered an indicator of faults during preparation, handling, storage, or service **(Tebbutt, 1993)**. It is also considered an indicator of fecal contamination, besides it may induce severe diarrhea in infants and young children, as well as food poisoning and gastroenteritis among adults **(Synge, 2000)**.

The data in **Table 8** showed that mean values of TCC after 5 and 10 minutes in control groups were $5.1\times10^4\pm 0.8\times10^4$ and $5.3\times10^4 \pm 0.7\times10^4$ CFU/g. Nearly similar finding 5.1 $\log_{10}$ CFU/g were obtained by **Balamatsia et al (2006)**, 5.13 CFU/g **Morshdy and Sallam (2009)** and (5.41 $\log_{10}$ CFU/g) **Zhang et al (2016)**. A lower TCC count was detected by **Bailey et al (2000),** who noticed 4.6 $\log_{10}$ CFU/g.

The mean values after dipping for 5 minutes was $1.4\times10^5 \pm 0.1\times10^5$, $7.9\times10^4 \pm 0.8\times10^4$, $2.0\times10^5\pm 0.1\times10^5$, $1.3\times10^5 \pm 0.1\times10^5$, $2.4\times10^5\pm 0.2\times10^5$ and $1.9\times10^5 \pm 0.1\times10^5$ CFU/g while the reduction percentage (R%) values were 54.9, 72.5, 39.2, 58.8, 31.3, and 43.1 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

While mean, The mean values in the dipping for 10 minutes was $1.5\times10^4 \pm 0.1\times10^4$, $8\times10^3 \pm 1.3\times10^3$, $2.4\times10^5 \pm 0.2\times10^5$, $1.4\times10^4 \pm 0.1\times10^4$, $3\times10^4 \pm 0.2\times10^4$ and $2.5\times10^4 \pm 0.1\times10^5$ CFU/g while the reduction percentage (R%) values were 71.7, 84.9, 54.7, 73.6, 43.3, and 52.8 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. The obtained results were parallel to the finding of **Alaa (2008)**, **Morshdy and Sallam (2009)**, **Hassanien et al (2013)**, and **Hussein et al (2018).** They found that organic acid had a significant effect on TCC.

3.3.4. Total Pseudomonas count

The data in Table 9 showed that the mean values of TPC after 5 and 10 minutes in control groups were $9.5\times10^3 \pm 1.6\times10^3$ and $9.6\times10^3 \pm 1.7\times10^3$ CFU/g. The mean values after dipping for 5 minutes was $4.8\times10^3 \pm 0.5\times10^3$, $3\times10^3 \pm 0.1\times10^3$, $6.1\times10^3 \pm 1\times10^3$, $4.2\times10^3 \pm 0.1\times10^3$, $6.7\times10^3 \pm 0.9\times10^3$, and $5.6\times10^3 \pm 0.7\times10^3$ CFU/g while the reduction percentage (R%) values were 49.5, 68.4, 35.8, 55.7, 29.4, and 41 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively. While mean , The mean values in the dipping for 10 minutes was $3.1\times10^3 \pm 0.2\times10^3$, $1.6\times10^3 \pm 0.1\times10^3$, $4.6\times10^3 \pm 0.5\times10^3$, $2.8\times10^3 \pm 0.2\times10^3$, $5.5\times10^3 \pm 0.6\times10^3$, and $4.8\times10^3 \pm 0.4\times10^5$ CFU/g with the reduction percentage (R%) values were 67.7, 83.3, 52.1, 70.8, 42.7, and 50 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, and lemon juice 2 %, respectively.

3.3.5. Staphylococcus aureus count

Staphylococci strains are commonly carried by live chicken and enter the processing plant in the liver, skin, and nasal cavity of many birds, where they can be discovered in low concentrations. Staphylococci cannot develop in healthy poultry tissues for lengthy periods but can survive in injured tissues **(Cohen et al., 2007)**.

The data in **Table 10** showed that the mean values of *S. aureus* after 5 and 10 minutes in control groups were $2\times10^3 \pm 0.1\times10^3$ and $2\times10^3 \pm 0.1\times10^3$ $\log_{10}$ CFU/g. The mean values after dipping for 5 minutes were $1.1\times10^3 \pm 0.1\times10^3$, $6.7\times10^2 \pm 0.8\times10^2$, $1.3\times10^3 \pm 0.1\times10^3$, $9.6\times10^2 \pm 1.5\times10^2$, $1.5\times10^5\pm 0.1\times10^5$, and $1.2\times10^3 \pm 0.1\times10^3$ CFU/g, while the reduction percentage (R%) values were 45, 66.5, 35.1, 51.9, 25, and 39.8 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1% and lemon juice 2 %, respectively. Comparatively, the mean values after dipping for 10 minutes were $6.9\times10^2 \pm 0.7\times10^2$, $3.7\times10^2 \pm 0.4\times10^2$, $9.4\times10^2 \pm 1.3\times10^2$, $6.5\times10^2 \pm 0.6\times10^2$, $1.2\times10^3 \pm 0.1\times10^3$, and $9.8\times10^2 \pm 1.7\times10^5$ CFU/g, while the reduction percentage (R%) values were 65.4, 81.5, 53, 67.6, 39.8, and 51.1 in acetic acid 1%, acetic acid 2%, lactic acid 1%, lactic acid 2 %, lemon juice 1%, lemon juice 2 %, respectively. The obtained results for lactic acid were nearly similar to **Sudershan et al (2011),** who studied the effect of lactic acid on *S. aureus* in chicken meat. A higher reduction percentage was achieved by **(Aksoy, 2003),** who decreased *S. aureus* count on chicken meat from 74×10^5 to 93×10^2 CFU/g by dipping inoculated samples in 2 % lactic acid solution. Also, **Saad et al (2015)** reported that *S. aureus* count was decreased from 67×10^5 CFU/g to $69\times10^4 \pm 0.26\times10^4$, $46\times10^4 \pm 0.34\times10^4$, and $09\times10^4 \pm 0.43\times10^4$ CFU/g, respectively, Where the reduction percentages achieved in the experiment were 17.28 % and 21.34 %, while for the three concentrations of lactic acid used (0.75% 1.25% and 2% solution), respectively.

Table 8. Antibacterial activity of organic acids on Total *coliform* count (CFU/g) in the chicken meat samples

	Dipping time			
	5 min	**R %**	**10 min**	**R %***
Control	$5.1\times10^4\pm 0.8\times10^{4\,aA}$	------	$5.3\times10^4\pm 0.7\times10^{4\,aA}$	------
1% Acetic acid	$2.3\times10^4\pm 0.1\times10^{4\,dA}$	54.9	$1.5\times10^4\pm 0.1\times10^{4\,dB}$	71.7
2% Acetic acid	$1.4\times10^4\pm 0.1\times10^{4\,eA}$	72.5	$8.0\times10^3\pm 1.3\times10^{3\,eB}$	84.9
1% Lactic acid	$3.1\times10^4\pm 0.2\times10^{4\,cA}$	39.2	$2.4\times10^4\pm 0.2\times10^{4\,cB}$	54.7
2% Lactic acid	$2.1\times10^4\pm 0.1\times10^{4\,dA}$	58.8	$1.4\times10^4\pm 0.1\times10^{4\,dB}$	73.6
1% Lemon juice	$3.5\times10^4\pm 0.3\times10^{4\,bA}$	31.3	$3.0\times10^4\pm 0.2\times10^{4\,bB}$	43.3
2% Lemon juice	$2.9\times10^4\pm 0.2\times10^{4\,cA}$	43.1	$2.5\times10^4\pm 0.1\times10^{5\,cB}$	52.8

Table 9. Antibacterial activity of organic acids on Total *Pseudomonas* count (CFU/g) in the chicken meat samples.

	Dripping time			
	5 min	**R %**	**10 min**	**R %***
Control	$9.5\times10^3\pm 1.7\times10^{3\,aA}$	------	$9.6\times10^3\pm 1.6\times10^{3\,aA}$	------
1% Acetic acid	$4.8\times10^3\pm 0.5\times10^{3\,dA}$	49.5	$3.1\times10^3\pm 0.2\times10^{3\,dB}$	67.7
2% Acetic acid	$3.0\times10^3\pm 0.1\times10^{3\,fA}$	68.4	$1.6\times10^3\pm 0.1\times10^{3\,fB}$	83.3
1% Lactic acid	$6.1\times10^3\pm 1.0\times10^{3\,cA}$	35.8	$4.6\times10^3\pm 0.5\times10^{3\,cB}$	52.1
2% Lactic acid	$4.2\times10^3\pm 0.1\times10^{3\,eA}$	55.7	$2.8\times10^3\pm 0.2\times10^{3\,eB}$	70.8
1% Lemon juice	$6.7\times10^3\pm 0.9\times10^{3\,bA}$	29.4	$5.5\times10^3\pm 0.6\times10^{3\,bB}$	42.7
2% Lemon juice	$5.6\times10^3\pm 0.7\times10^{3\,cA}$	41.0	$4.8\times10^3\pm 0.4\times10^{5\,cB}$	50.0

Table 10. Antibacterial activity of organic acids on *Staphylococcus* aureus count (CFU/g) in the chicken meat samples

	Dipping time			
	5 min	**R %**	**10 min**	**R %***
Control	$2.0\times10^3\pm 0.1\times10^{3\,aA}$	------	$2.0\times10^3\pm 0.1\times10^{3\,aA}$	------
1% Acetic acid	$1.1\times10^3\pm 0.1\times10^{3\,cA}$	45.0	$6.9\times10^2\pm 0.7\times10^{2\,dB}$	65.4
2% Acetic acid	$6.7\times10^2\pm 0.8\times10^{2\,eA}$	66.5	$3.7\times10^2\pm 0.4\times10^{2\,fB}$	81.5
1% Lactic acid	$1.3\times10^3\pm 0.1\times10^{3\,cA}$	35.1	$9.4\times10^2\pm 1.3\times10^{2\,cB}$	53.0
2% Lactic acid	$9.6\times10^2\pm 1.5\times10^{2\,dA}$	51.9	$6.5\times10^2\pm 0.6\times10^{2\,eB}$	67.6
1% Lemon juice	$1.5\times10^3\pm 0.1\times10^{3\,bA}$	25.0	$1.2\times10^3\pm 0.1\times10^{3\,bB}$	39.8
2% Lemon juice	$1.2\times10^3\pm 0.1\times10^{3\,cA}$	39.8	$9.8\times10^2\pm 1.7\times10^{5\,cB}$	51.1

Lower results were obtained by **Hassanien et al (2013)**, that mentioned $4.37 \times 10^4 \pm 0.81 \times 10^4$ and $2.03 \times10^3 \pm 0.49 \times10^3$ for control and acetic acid 1% treated surface of chicken carcass, respectively. Non-dissociated organic acids, in general, can passively diffuse through the bacterial cell wall and dissociate into the cell cytoplasm's neutral pH, dissociate into anions and protons, which have an inhibitory impact on bacteria **(Ricke, 2003)**.

4. Conclusion

Finally, using organic acids such as (lactic acid, acetic acid, and lemon juice) as a dipping solution for 5 or 10 minutes in chicken meat will not eliminate the pathogen and total aerobic count. Still, it will reduce the number of most harmful pathogens and microbial loads on chicken meat carcasses, which will increase the shelf life and meat quality by improving sensory, chemical, and microbiological quality. These methods for carcass decontamination must be considered as complementary measures for the meat's hygiene quality assurance in the raising and slaughtering units.

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