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Research Article

Preservation of chicken breast meat by ginger extract and ginger essential oil

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Abstract

The study aims to extend the shelf-life of chicken breast meat by different treatments, including: (i) ratio of ginger: water = 60:40, 70:30 and 80:20; (ii) ginger essential oil 6%, 10% and 14%; (iii) edible coatings formula (sodium alginate combined with ginger extract or ginger essential oil). The research evaluated the effect of these treatments on the physicochemical parameters (pH, color, shear force, drip loss) and microbiological indicators (*E. coli* and aerobic plate count) of chicken breast meat during the cooling storage. The results showed that the physicochemical parameters of chicken breast meat were not affected by different treatments, these parameters were well maintained during cooling storage (4 ± 1°C). Moreover, the ginger extract 70%, ginger essential oil 10% and the combination of ginger with an edible coating positively inhibit the growth of microorganisms. The total aerobic and *E. coli* plate count of samples, which were treated by these treatments, decreased within 7-10 days of cooling storage. Moreover, the chicken breast meat was treated with sodium alginate-ginger essential oil 10% had *E. coli* and the aerobic microbial plate count was within Vietnamese National Standards (TCVN 12429-3:2021) during ten days of cooling storage.

***Keywords**: chicken meat, ginger, essential oil, sodium alginate, meat quality.*

1. INTRODUCTION

Poultry is the most frequent form of livestock owned by rural households and the second-largest contributor of meat to the country [1]. Poultry meat has become more prevalent in recent decades due to its low production costs compared to other meat products [2]. However, poultry meat contains high moisture and protein content, leading to becoming

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a sensitive material to the growth of spoilage and pathogenic bacteria [3]. Therefore, a challenge for manufacturers is finding methods to preserve fresh meat post-mortem and control the growth of microorganisms.

Applying natural ingredients in food preservation is trending in popularity nowadays. The essential oils were extracted from plants and used for many purposes, such as complementary medicines and food preservatives [4]. Especially, essential oils have been investigated to replace chemical compounds in food preservation[5]. Ginger (*Zingiber officinale* Rosc.) is a commonly cultivated plant consumed as a spice in meals and used as a traditional remedy. Ginger contains a small quantity of steam-volatile oil, fatty oil, pungent compounds, resin, proteins, cellulose, pentosans, starch, and mineral components. The volatile oil content of commercially dried ginger has been shown to be 0.5-4.4%, but the range is usually 1-3% for the major types [6]. Additionally, both ginger and ginger essential oil (GEO) have been reported to possess antioxidant activity (due to compounds including gingerols, shogarols, gingerdiols, dehydrogingerdiones) [7], antimicrobial activity (from the sesquiterpenoids, zingiberene, β-sesquiphellandrene, β-bisabolene, α-farnesene compounds) [8], and numerous compounds have benefits for the health. Therefore, ginger (extracted or essential oil type) has a variety of applications in medicine, food, cosmetics, …

The edible coating can be defined generically as thin layers of material that people can consume as part of the overall food product. The most advantageous features of edible coating films are their edibility and biodegradability. The edible coating films prevent the food products from physical damage that was caused by mechanical forces [9]. It can enhance the nutritional value of fresh, frozen, and processed products (meat, poultry, and seafood) by reducing moisture loss, as well as decreasing lipid oxidation and discoloration. Moreover, the edible coating films can improve the product appearance in the packages by controlling the dripping and sealing of volatile flavors. Moreover, the films play a role as the carrier of food additives, such as antimicrobial and antioxidant agents [10]. This study was carried out to investigate the ability to prolong the shelf-life of chicken breast meat by using ginger based on its antioxidant and antibacterial properties.

2. MATERIALS AND METHODS

2.1. Materials

Chicken breast meat and fresh ginger were used in the experiment, which was purchased at the markets in Ninh Kieu District, Can Tho City, Viet Nam. The commercial ginger essential oil used in the study was sourced from India and distributed by Heber Vietnam Co., LTD. The bacterial cultural mediums used in the study: Nutrient Agar (NA) - India, Tryptone Bile Glucuronic (TBX) Agar - India.

2.1.1. Ginger extract (GE) and ginger essential oil (GEO) preparation

Ginger extract preparation: ginger was purchased at the market and brought to the laboratory of Can Tho University, where it was cleaned with water and drained for 2 min. Ginger was mixed with cleaned water at the ratio of ginger: water, such as 60:40, 70:30, and 80:20, then the mixture was filtered and collected clear of liquid ginger extract.

Ginger essential oil preparation: Emulsifier Tween 80 (Polysorbate 80) (10% mass fraction of mixture) was dissolved in distilled water, heated to 50°C, stirred continuously for 5 min to obtain a homogeneous solution, and cooled down. Thereafter, the essential oil with different concentrations, such as 6%, 10%, and 14% (v/v), was slowly added to the solution and stirred for 10 min.

2.1.2. The process of treating chicken breasts with ginger extract and ginger essential oil

The chicken breast meat was bought at the market and brought to the lab to be pretreated with cleaned water and drained; thereafter, the meat was sliced into small pieces which had the same weight (100 g/piece). The chicken breast will be immersed in ginger extract or ginger essential oil (prepared) for 60 seconds for each sample. The samples were placed in PA packages, vacuumed, and sealed. Then, the sample was kept at 4 ± 1°C for seven days and tested for microorganism and physicochemical properties on days 0, 2, 4, and 7.

2.1.3. Coating solution preparation

Sodium alginate solution of 2% (w/v) fixed, proceed to weigh 20 g of sodium alginate completely dissolved in 1 L of water (mixed in a temperature bath of 70°C and stirred), cooling down to ambient temperature. Ginger extract and ginger essential oil (with concentrations selected from experiments 1 and 2) were added to the solution. Then, the mixture was homogenized to obtain a homogeneous coating solution. There were three types of coating solutions, including sodium alginate (SA), sodium alginate and ginger extract (SA-GE), sodium alginate and ginger essential oil (SA-GEO).

2.1.4 Process of treating chicken breast with sodium alginate edible coating

The chicken breast meat was bought at the market and brought to the lab to be pretreated with water and drained, thereafter the meat was sliced into small pieces which had the same weight (100 g/piece). Then, immerse each sample in a coating mixture solution for 60 seconds. The samples were stored in PA packages, vacuumed and sealed, and kept at 4 ± 1°C for ten days and tested for microorganism and physicochemical properties on days 0, 3, 6, and 10.

2.2. Methods

2.2.1. Color assessment

The colors were measured using a colorimeter Fru (WR10, China). Determine the values of L*, a*, and b*. The color deviation (ΔE) of meat after n days is calculated according to the formula (1) [11].

$$\Delta E = [(L^*{}_0 - L^*{}_n)^2 + (a^*{}_0 - a^*{}_n)^2 + (b^*{}_0 - b^*{}_n)^2]^{1/2} \quad (1)$$

2.2.2. pH assessment

Using the Sinotester pH meter (pH-618, China) to determine the pH value at different intervals. Mince 5 g chicken breast meat finely to ensure that both the inside and the outside are sampled, placed in a beaker and pour 50 mL of distilled water. Then measure the pH and record the value.

2.2.3. Shear force assessment

According to Young's Modulus formula (2) [12].

$$E = \frac{P}{\Delta L / L} \text{ (Pa)} \qquad (2)$$

2.2.4. Drip loss assessment

Determination of drip loss rate (%) by weighing samples before and after the period of storage. Weigh meat samples and PA packaging before storage (m_1). After storage, pour out all the water, then reweigh the meat sample and PA package (m_2). According to the formula (3).

$$\text{Drip loss} = \frac{m_1 - m_2}{m_1} \times 100\ (\%) \qquad (3)$$

2.2.5. Aerobic plate count assessment

According to TCVN 4884-1: 2015 (ISO 4833-1: 2013) [13].

2.2.6. E. coli plate count assessment

According to TCVN 7924-2: 2008 (ISO 16649-2: 2001) [14].

2.3. Data analysis

The results of the experiments were collected and processed using the statistical software Statgraphics Centurion 19 and Microsoft Excel 2019. Analysis of variance (ANOVA) and LSD test were used to conclude the difference between the mean value of the treatments. The difference at the significance level of the survey treatments at the 95% confidence level.

3. RESULTS AND DISCUSSION

3.1. Effect of ginger extract (GE) on the quality of chicken breast meat during storage

3.1.1. Effect of ginger extract (GE) on the physicochemical parameters of chicken breast meat during storage

During the preservation process, it is important and necessary to monitor the changes in the physicochemical parameters of chicken breast meat. Indicators such as color, pH, texture (shear force), and drip loss directly affect the quality. Tables 1 and 2 showed that the concentration of ginger extract treatment on the chicken breast meat was increased, as well as the prolonged storage time; all treated samples with the ginger extract had significantly higher L* values (lightness value) than the control sample ($p < 0.05$), leading to these samples became brighter. Moreover, these samples also had significantly lower shear force values, as well as higher drip loss, indicating that the treated chicken breast meat with GE became more tender. Tenderization occurred as a result of ginger's powerful proteolytic enzyme, which was able to tenderize tough meat. Ginger protease had a relatively stronger proteolytic influence on collagen than actomyosin, and simultaneous proteolysis of both muscle proteins resulted in meat tenderness [15-16]. Moreover, dissolved collagen derived from connective tissue following ginger treatment has a good water-binding capability and can improve meat tenderness [17-18].

***Table 1**. Effect of ratio of ginger:water on physicochemical properties of chicken breast meat*

Ginger: water ratio	L*	ΔE	pH	Shear force (kPa)	Drip loss (%)
0	59.86^{c}	1.70^{b}	6.193^{ns}	14.18^{a}	3.86^{b}
60:40	63.22^{b}	2.32^{ab}	6.178^{ns}	13.57^{ab}	5.73^{a}
70:30	65.15^{a}	2.53^{a}	6.177^{ns}	12.98^{bc}	5.88^{a}
80:20	65.69^{a}	2.57^{a}	6.182^{ns}	12.66^{c}	5.98^{a}

Different letters of mean value in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

The results in Table 1 and Table 2 showed that the pH values of chicken breast meat were not affected by the ratio of ginger to water. During the cooling storage period, the pH values decreased significantly ($p < 0.05$).

***Table 2.** Effect of storage period on physicochemical properties of the treated chicken breast meat by ginger extract*

Days	L*	ΔE	pH	Shear force (kPa)	Drip loss (%)
0	62.80^{b}	0^{c}	6.21^{a}	16.27^{a}	$0±^{d}$
2	63.55^{ab}	1.92^{b}	6.20^{ab}	13.16^{b}	5.69^{c}
4	63.31^{a}	2.53^{b}	6.16^{bc}	12.84^{b}	6.82^{b}
7	64.26^{a}	4.67^{a}	6.16^{c}	11.12^{c}	8.93^{a}

Different letters of mean value in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

3.1.2. Effect of ginger extract (GE) on the antimicrobial activity in chicken breast meat during storage

In Table 3 and Table 4, the results showed the antibacterial activity of the ginger extract, the ratio of ginger: water on the chicken breast meat was increased, as well as the prolonged storage time, all treated samples with the ginger extract had significantly lower the aerobic plate count and *E. coli* plate count. Moreover, the sample was treated by the ratio of ginger: water 70:30 had the best antibacterial activity, and the *E. coli* count and aerobic plate count were the lowest. Ginger contains a variety of phenolic compounds, including eugenol, shogaols, zingerone, gingerdiols, gingerols, etc, which are primarily responsible for antimicrobial activity observed in ginger extract, ginger essential oil and oleoresins [19-20]. The reduction of the *E. coli* bacteria occurred due to the methanol extract of zinger, which had antibacterial activity against *E. coli* [21]. Furthermore, vacuum storage conditions with PA packaging can prevent the growth and spread of microorganisms found in chicken breast meat [22].

Table 3. *The effect of the ratio of ginger: water on the aerobic plate count in chicken breast meat during the storage period*

Ginger: water ratio	**Total aerobic plate count (×10^5 cfu/g)**				
	Day 0	**Day 2**	**Day 4**	**Day 7**	**Average**
0	191.4	174.6	173.0	173.2	178.2^a
60:40	173.0	158.2	140.6	129.0	150.2^b
70:30	130.8	90.3	87.6	52.0	90.8^c
80:20	104.6	96.8	92.6	82.8	94.5^c
Average	**149.4^a**	**129.9^b**	**123.1^b**	**109.2^c**	

Different letters in the same column or the same row indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

Table 4. *The effect of ratio of ginger: water on the E. coli plate count in chicken breast meat during storage period*

Ginger: water ratio	***E. coli* plate count (× 10^3 CFU/g)**				
	Day 0	**Day 2**	**Day 4**	**Day 7**	**Average**
0	202.5	270.5	280.0	269.5	225.6^a
60:40	186.5	174.0	169.0	143.5	168.2^b
70:30	109.5	86.0	40.5	35.0	67.7^c
80:20	96.5	80.0	78.5	61.0	79.1^c
Average	**148.6^{ab}**	**152.7^a**	**142.1^{ab}**	**127.2^b**	

Different letters in the same column or the same row indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

The results in Table 3 and Table 4 showed that both the E. coli and the aerobic plate count were higher than the standard of TCVN 12429-3:2021 throughout 7 days of cooling storage, indicating the antibacterial activity of the ginger extract was less effective in the growth of microorganisms. It might due to the concentrations of antimicrobial compounds in the ginger extract was not high enough to control the the growth of microorganisms.

3.2. Effect of ginger essential oil (GEO) on the quality of chicken breast meat during storage

3.2.1. Effect of ginger essential oil (GEO) on the physicochemical parameters of chicken breast meat during storage

The results in Table 5 showed that the lightness and pH values of treated chicken breast meats were significantly increased ($p < 0.05$) compared with the control sample. Otherwise, these treated samples had a decrease in shear force values ($p < 0.05$). The results in Table 6 showed that the physicochemical properties of treated chicken breast meat had many changes during storage. The lightness (L*) and drip loss increased significantly ($p < 0.05$), but the pH and shear force values tended to decrease within 7 days of cooling storage. The results proved that ginger essential oil has the impact of maintaining the color of the chicken breast due to the antioxidant properties of ginger essential oil. Samples treated with essential oils can decrease the oxidation of myoglobin to oxymyoglobin and metmyoglobin [18], hence stabilizing color during the storage. Similar to the previous experiment, the texture of the meat was changed significantly after 7 days.

Table 5. *Effect of GEO concentrations on the physicochemical properties of chicken breast meat*

Concentration of GEO (%)	L*	ΔE	pH	Shear force (kPa)	Drip loss (%)
0	59.78[b]	1.84[ns]	6.00[b]	14.84[a]	3.59[a]
6	59.93[b]	1.01[ns]	6.13[a]	14.00[ab]	4.08[a]
10	60.85[a]	1.35[ns]	6.10[a]	13.19[bc]	4.08[a]
14	61.06[a]	1.54[ns]	6.12[a]	12.95[c]	4.20[b]

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

Table 6. *Effect of storage period on physicochemical properties of the treated chicken breast meat by ginger essential oil*

Days	L*	ΔE	pH	Shear force (kPa)	Drip loss (%)
0	60.03[b]	0±[b]	6.18[a]	15.43[a]	0[d]
2	60.16[b]	1.81[a]	6.09[b]	14.18[b]	3.77[c]
4	60.39[ab]	2.18[a]	6.07[b]	12.52[c]	4.84[b]
7	61.04[a]	1.75[a]	6.00[c]	12.84[c]	7.35[a]

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

3.2.2. Effect of ginger essential oil (GEO) on the antimicrobial activity in chicken breast meat during storage

The results in Table 7 showed that the concentrations of ginger essential oil treatment were increased, and the aerobic microbial count tended to decrease. The number of aerobic microbial in the treated chicken breast meats reduced significantly compared with the control sample, as well as decreased after 7 days of cooling storage ($p < 0.05$). Moreover, the sample was treated with ginger essential oil, which had the aerobic plate count within the standard of TCVN 12429-3:2021, throughout seven days of cooling storage.

Table 7. *The effect of concentrations of GEO on the aerobic plate count in chicken breast meat during the storage period*

Concentration of GEO (%)	Total aerobic plate count (x 10^5 CFU/g)				
	Day 0	Day 2	Day 4	Day 7	Average
0	180.5	113.5	130.0	120.5	136.8[a]
6	111.0	43.0	38.5	12.0	51.1[b]
10	90.0	23.5	27.0	4.0	36.2[c]
14	73.0	39.0	31.5	11.5	38.8[c]
Average	**113.3[a]**	**54.7[b]**	**56.7[b]**	**37.2[c]**	

Different letters in the same column or the same row indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

The results in Table 8 showed that the *E. coli* plate count in chicken breast meat also decreased statistically when samples were treated with ginger essential oil. Moreover, the *E. coli* bacteria in chicken breast meat changed significantly during the 7 days of the experiment, with samples treated with ginger essential oil showing a distinct and fast reduction. Antibacterial compounds in ginger essential oil considerably inhibit the development of aerobic microorganisms in chicken breast meat. The presence of phenolic compounds (eugenol, shogarols, zingerone, gingerdiols, gingerols, etc.) in ginger essential oil has a resonance correlation with compounds such as β-sesquiphellandrene, cis-caryophillene, zingiberene, α-farnesene, α- and β-bisabolene, which are mainly responsible for antibacterial activity [8]. Moreover, meat preservation by PA packaging combined with vacuum conditions can limit the development of many aerobic bacteria in chicken breast meat [23]. It should be recognized that cold storage conditions helped to prevent the growth and development of microorganisms [24]. Besides that, GEO exerted its effects on the cell membrane of *E. coli* bacteria, ruining the structure of the cell membrane before increasing the permeability of the cell membrane, causing the organism to lose its principal structural function and eventually causing bacterial cell death [25]. However, the samples were treated with ginger essential oil, which had the *E. coli* plate counts higher than the standard of TCVN 12429-3:2021 throughout seven days of cooling storage.

Table 8. *The effect of concentrations of GEO on the E. coli plate count in chicken breast meat during storage period*

Concentration of GEO (%)	***E. coli* plate count (×10^3 CFU/g)**				
	Day 0	**Day 2**	**Day 4**	**Day 7**	**Average**
0	184.5	180.6	172.5	183.5	180.6^a
6	97.0	71.5	53.0	11.0	58.0^b
10	70.0	60.5	38.5	8.0	44.5^c
14	86.0	67.0	49.0	8.5	52.6^{bc}
Average	**109.8^a**	**94.3^b**	**78.2^c**	**52.2^d**	

Different letters in the same column or the same row indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

3.3. Effect of sodium alginate edible coating incorporated with ginger extract and ginger essential oil on the quality of chicken breast meat during storage

3.3.1. Effect of sodium alginate edible coating incorporated with ginger extract (GE) and ginger essential oil (GEO) on the physicochemical parameters

The results in Table 9 and Table 10 showed that the color of chicken breast meat treated with sodium alginate (SA) coating had significant differences with others, and the color of samples changed during ten days of cooling storage ($p < 0.05$). The reason was that ginger contains antioxidant components that interact and combine with the SA coating to generate an effective barrier, preventing oxidation and maintaining the color of the chicken breast meat [26, 27]. By adding GEO/GE to the SA solution, the emulsion was formed and caused a high turbidity blocking effect and an increase of opacity that caused the change in color. However, by fabricating an emulsion, the GEO was dispersed more homogeneously, and the size of the droplet was reduced, which increased the light transmittance and resulted in the slowing down of the discoloration process [28].

The pH of chicken breasts tend to fall when GE and GEO were used along with SA coating. Because of their antibacterial and antioxidant properties, the incorporation of GE/GEO and SA caused a progressive fall in pH [29, 30]. During storage, the pH value of samples had a significant increase ($p < 0.05$) due to the result of ammonia and trimethylamine produced when protein is broken down by both microbial enzymes and endogenous meat enzymes such as protease and lipase during storage [31, 32] as well as bacterial metabolites from the growth of bacterial populations [33].

Also, there was a significant decrease in shear force values ($p < 0.05$) when GE and GEO were added to the coating composition, illustrating that the application of SA assists in maintaining the tenderness of chicken breast meat and enhances the sensory. The difference observed was due to the presence of a powerful proteolytic enzyme in ginger and GEO, which has a tenderizing effect on the meat. In addition, the reduction in shear force could be due to the coating's water-holding capacity characteristics, which retained water in the structure of the meat and made it more flexible. Water is closely attached to proteins in muscle tissue, and it also occurs in the spaces between myofibrils, giving the meat its tenderness and elastic structure [34].

The difference in drip loss between treatments was considerable ($p < 0.05$), which could be due to the effect of compounds in GE/GEO and the edible coating properties affecting the protein structure in chicken meat, causing less leakage of water. The coating played a role as a barrier [35], keeping water in the system and thus reducing exudation. The formation of a gelatinous from the edible coating around the meat can reduce water loss [36]. When the drip loss in this experiment was compared to two previous experiments, the values in the previous experiments were higher. Furthermore, drip loss increased gradually throughout ten days of storage, and this result was significant ($p < 0.05$), but this value was still lower than the drip loss value of chicken meat treated with GE/GEO at day 7.

Table 9*. Effect of edible coating incorporated with ginger on physicochemical properties of chicken breast meat*

Treatment	**L***	**ΔE**	**pH**	**Shear force (kPa)**	**Drip loss (%)**
SA	58.49^{b}	2.01^{ns}	6.42^{a}	14.92^{a}	3.12^{c}
SA+GE	63.21^{a}	2.22^{ns}	6.01^{b}	14.00^{b}	4.51^{a}
SA+GEO	64.04^{a}	2.40^{ns}	5.98^{b}	13.65^{b}	3.66^{b}

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

***Table 10**. Effect of storage period on the physicochemical properties of chicken breast meat coating by alginate*

Days	L*	ΔE	pH	Shear force (kPa)	Drip loss (%)
0	59.76^{c}	0^{b}	6.03^{c}	16.50^{a}	0^{a}
3	62.21^{b}	2.76^{a}	6.16^{ab}	14.17^{b}	3.93^{b}
6	61.79^{b}	2.28^{a}	6.25^{a}	13.39^{c}	5.10^{c}
10	63.88^{a}	3.81^{a}	6.11^{bc}	12.69^{c}	6.02^{d}

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

3.3.2. Effect of edible coating incorporated with ginger on the antimicrobial activity in chicken breast meat during storage

There was a significant variation ($p < 0.05$) in the total aerobic and *E. coli* plate count in the samples when treated with different coating compositions from the results in Table 11 and Table 12. Furthermore, the quantity of total aerobic and *E. coli* plate count of chicken breast meat changed ($p < 0.05$) after ten days of cooling storage. These results indicated that the alginate edible coating had a greater antibacterial activity when combined with GE/GEO [37], and the aerobic plate count of all samples were within the allowable range of TCVN 12429-3:2021.

***Table 11.** Effect of edible coating formulas on the aerobic plate count of chicken breast meat*

Treatment	Total aerobic plate count (×10^{5} CFU/g)				
	Day 0	Day 3	Day 6	Day 10	Average
SA	130.2	99.1	67.1	43.0	113.89^{a}
SA+GE	51.6	39.7	34.4	14.6	46.11^{b}
SA+GEO	19.4	5.9	5.8	4.7	11.95^{c}
Average	**67.83^{a}**	**48.0^{b}**	**35.7^{c}**	**20.2^{d}**	

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level.

The *E. coli* plate count showed a significant difference ($p < 0.05$) between the composition used for coating chicken breast meat. In addition, during the 10 days of preservation, the value of *E. coli* plate count continuously decreased compared with the beginning of the cooling storage period. Antibacterial properties from components in GE and GEO such as eugenol, shogaols, zingerone, gingerdiols, gingerols, … [20] along with well-forming coating, permeability, and barrier functions [38] of the emulsion system made up of SA combining with GE or GEO, which could maintain the growth inhibitory capabilities in *E. coli* bacteria in the chicken breast meat. This result is similar to the results of Fernández-Pan *et al.* [38], the author found that the edible coatings have antibacterial effects on *Enterobacteriaceae*, all edible coatings exerted a similar antimicrobial effect during the sample storage. In particular, the chicken breast meat coated with SA-GEO had the lowest *E. coli* and aerobic plate count ($p < 0.05$) during ten days of storage, as well as remained relatively constant throughout the storage time and still belongs to the standard of TCVN 12429-3:2021.

Table 12. *Effect of edible coating formulas on the E. coli plate count of chicken breast meat*

Treatment	***E. coli* plate count (×10^3 CFU/g)**				
	Day 0	**Day 3**	**Day 6**	**Day 10**	**Average**
SA	21.2	17.4	7.7	7.4	17.9^a
SA+GE	15.6	12.3	8.9	8.6	15.2^b
SA+GEO	10.3	4.6	4.2	3.9	5.7^c
Average	**15.7^a**	**11.4^b**	**6.9^c**	**6.6^c**	

Different letters in the same column indicate the significant difference of the survey treatments according to the LSD test at the 95% confidence level

4. CONCLUSION

Ginger extract and ginger essential oil had a great effect on the color, shear force, and drip loss values of chicken breast, as well as the pH values of the treated samples still remained stable during cooling storage. In the antimicrobial aspect, the chicken breast meat was treated with 70% ginger extract, 10% ginger essential oil, or alginate-ginger essential oil, which effectively reduced the density of microorganisms than other treatments. In particular, chicken breast meat treated with ginger essential oil had the aerobic plate count within the standard of TCVN 12429-3:2021 until seven days of cooling storage, while the chicken breast meat treated with sodium alginate-ginger essential oil had the *E. coli* and the aerobic plate count within Vietnamese national standards of TCVN 12429-3:2021 until ten days of cooling storage.

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