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Effect of Adding Lemongrass (*Cymbopogon citratus*) Extract on Quality Characteristics of Chicken Burger during Frozen Storage

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HIGHLIGHTS

- Addition of lemongrass extract had significant effects on quality characteristics of chicken burger during frozen storage.
- Chicken burger formulated with lemongrass extract exhibited improvement in color stability during frozen storage.
- Using lemongrass extract in the formulation chicken burger resulted in delayed the lipid oxidation.
- Addition of lemongrass extract reduced the bacterial count during frozen storage.

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Acronyms and abbreviations
TBA=Thiobarbituric Acid
DPPH=2,2-Diphenyl-1-Picrylhydrazyl

ABSTRACT

Background: Lemongrass (*Cymbopogon citratus*) is an aromatic herb; rich source of citric, vitamin C, and phenolic compounds used as natural antioxidant and antibacterial agents in food processing. This study aimed to evaluate the effect of lemongrass extract on the quality properties of chicken burger during frozen storage.
Methods: Lemongrass extract was prepared with three levels (0.5, 1.0, and 1.5%) in the formulation of chicken burger and its effect was studied on some chemical, physical, and microbiological quality characteristics during frozen storage at -20 °C for 90 days. Data were analyzed using statistical analysis system (SAS, 2000).
Results: Chicken burger treated with different levels of lemongrass extract exhibited the lowest pH values than control one. L* values (the lightness) of treated chicken burger showed a gradually decrease as the level of lemongrass increased. Significant increase ($p<0.05$) was found in a* value (the redness) of chicken burger formulated with 1.5% lemongrass after 30 days of storage and remained constant during frozen storage period 90 days. Significant differences ($p<0.05$) were found in b* value (the yellowness) during frozen storage of chicken burger treated with different levels of lemongrass extract. Chicken burger formulated with 1.5% lemongrass extract exhibited a significant decreased ($p<0.05$) in Thiobarbituric Acid (TBA) value at the end of frozen storage period 90 days.
Conclusion: Using different levels of lemongrass extract in the formulation of chicken burger resulted in delaying the lipid oxidation, improved the color stability, and reduced the bacterial count during frozen storage.

Introduction

Lipid oxidation and microbial growth are the main factors which responsible for the deterioration in meat and meat products during storage. It is associated with quality degradation, reducing shelf life, and decreasing consumer

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acceptability (Al-Dalali et al., 2019). To avoid the effects of lipid oxidation and spoilage of meat and meat products, many synthetic preservatives are widely used as antioxidants and antibacterial agents during processing and storage (Manessis et al., 2020). Currently, consumers are aware about disadvantages of using synthetic preservatives and their harmful effects on human health, which increase the demand for using natural antioxidant and antimicrobial to extend the shelf life of meat and meat products (Kumari et al., 2019).

Lemongrass (*Cymbopogon citratus*), as an aromatic herb, belongs to the section of Andropogan called Cymbopogam of the *Gramineae* family and grows in almost tropical and subtropical countries, also it known in the North and West tropical Africa, Arabian Peninsula, and Egypt (Khadri et al., 2010; Khan et al., 2013). Lemongrass is a rich source of citric, vitamin C, and phenolic compounds, including flavonoids, phenolic acids, and monoterpene hydrocarbons. These compounds had high potential antioxidant activity because of their ability of scavenging free radical and showed antimicrobial activity against *Salmonella typhi*, *Bacillus cereus*, and also *Staphylococcus aureus* (Pezeshk et al., 2015).

Frozen storage induces many undesirable changes in the quality of meat and meat products such as color, protein denaturation, and lipid oxidation which can influence the microbiological quality of frozen chicken meat (Soyer et al., 2010). Therefore, this study aimed to evaluate the effect of addition lemongrass extract on the quality properties of chicken burger during frozen storage.

Materials and methods

Preparation of lemongrass extract

The present work was carried out at Desert Research Center (DRC), El Matarya. Cairo, Egypt. Fresh lemongrass was obtained from Siwa Experimental Station belonging DRC, Egypt (season 2018-2019, November and February). Lemongrass leaves were washed in clean water and dried. The plants were milled to a fine powder by using an electric mill (Moulinex, Type: DPA2 and Ref. DPA2,417/0 G-0,614-R., France).

Ten g of lemongrass powder were soaked in dichloromethane for 24 h to remove the chlorophyll, resinous, and waxy materials; and then extracted with 25 ml of 70% aqueous methanol (Piochem, Egypt) several times. The extract was then filtered and evaporated under reduced pressure until removal the entire methanol, and then the aqueous extract was evaporated till very small volume (Liu et al., 1989).

Antimicrobial activity screening

Antibacterial activity of lemongrass extract was determined according to Lewus and Montville (1991) by using well-diffusion method as follows. The nutrient glucose agar medium (Biolab, Hungary) was poured onto petri dishes. After complete solidification, 6 mm wells were punched, and 60 µl of the lemongrass extract (0.5, 1.0, and 1.5%) was placed in each well. The plates were incubated at 37 °C for 48 h. Antimicrobial activity against the indicator microorganisms were determined by formation of clear inhibition zone around the wells. Diameter of the clear zones was measured by using a ruler. This test was repeated three times. The tested microorganisms including *S. aureus* (MRSA PRO1), *Salmonella enterica* VII SARC15, and *Shigella flexneri* 5840 were obtained from Microbiology Department, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Determination of 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) radical scavenging activity

DPPH radical scavenging activity of lemongrass extract was determined according to the methods described by Burits and Bucar (2000). Fifty µl of different concentrations of lemongrass extract (200, 400, 600, 800, and 1,000 ppm) were added to 5 ml of the DPPH solution (Merck, Germany/0.004% methanol), and the mixtures were incubated for 30 min at room temperature. The absorbance was measured at 517 nm by using UV spectrophotometer (NICOLET evolution 300/Thermo, USA). The DPPH radical scavenging activity was calculated as percentage of inhibition according to the following equation:

$$\mathrm{I\%} = \frac{\mathrm{A\ blank} - \mathrm{A\ sample}}{\mathrm{A\ blank}} \times 100$$

Where A blank is the absorbance of the control and A sample is the absorbance of the test compound. The (IC_{50}) values were calculated from the plot of inhibition percentage against extract concentration using PHARM/ PCS-version 4. All tests were done in triplicate.

Preparation of chicken burger

Chicken meat of thigh and breast muscles were collected from local poultry market and ground through a 3 mm plat meat grinder (K-R-SU, Model: KMG1,700, China). The following ingredients: 7.5% onion, 1.5% salt, 0.5% black pepper, and 0.5% spices were added to chicken meat for burger processing as described by Mikhail et al. (2014). The minced meat was divided into four formulas. Control (without lemongrass extract) and the other formulas were prepared with 0.5, 1.0, and 1.5% of lemongrass extract (1,000 ppm). Each formula was mixed by hand and formed by using manual burger press machine (Metaltex No.25.17.25, PRC). Chicken burgers

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(1cm thickness, 10 cm diameter, and 70±2 g weight) were placed in plastic foam trays packed in polyethylene bags and frozen at -20 ºC±1until further analysis.

Analysis

-pH

Values of pH were measured in raw chicken burger by using a digital pH-meter (Jenway 3,320 conductivity and pH meter, England) as described by Khalil (2000).

-Color measurements

Color of raw chicken burger was measured by using Chroma meter (model CR 410, Konica Minolta, Japan) and calibrated with a white plate and light trap provided by the manufacturer (CIE, 1976). The color was expressed as (L*) values: lightness (dark to light), (a*) values: redness (reddish to greenish), and (b*) values: yellowness (yellowish to bluish). The average of three spectral readings was obtained at different locations for burgers of each formula.

-Thiobarbituric Acid (TBA) value

The extent of lipid oxidation in raw chicken burger was determined as described by AOCS (1998) for measurement of TBA values. Results were expressed as mg of Malondialdehyde per kg (mg MDA/kg).

-Microbiology analysis

Total bacterial counts determined in the various dilutions of chicken burger prepared in 0.1% peptone water, plated in duplicates on plate count agar (Biolab, Hungary) as described by APHA (1992). The plates were incubated for at 30 °C for 72 h.

Psychrophilic counts were determined in chicken burger samples during frozen storage by the technique described by APHA (1992) using plate count agar (Biolab, Hungary). The plates were incubated at 7 ºC±1 for 10 days.

Molds and yeasts in chicken burger were determined by using potato dextrose agar medium (Biolab, PH EUR-USP, Hungary) according to the method described by APHA (1992). The plates were incubated at 20-22 ºC for 72 h. Results were expressed as log of Colony Forming Unit (CFU)/g.

Statistical analysis

All data generated from each treatment were analyzed using statistical analysis system (SAS, 2000). Two-way ANOVA was applied for pH, TBA, and color measurements. In case of antibacterial activity and antioxidant activity one-way ANOVA was applied. The *p* value less than 0.05 was considered statistically significant.

Results

Antimicrobial activity of lemongrass extract

Results of antimicrobial activity of lemongrass extract by using well-diffusion method and measured as inhibition zone (mm) are shown in Table 1. Data cleared that the largest inhibition zone was found against *S. enterica* followed by *S. flexneri* and *S. aureus*. It can be noticed that antibacterial activity significantly increased ($p<0.05$) as the concentration of lemongrass extract increased.

Antioxidant activity of lemongrass extract

The effect of lemongrass extracts on (DPPH) radical scavenging activity was estimated in order to determine the antioxidant activity as illustrated in Figure 1. Lemongrass extracts exhibited high potential antioxidant. Also, it can be observed that increased the concentration of lemongrass extract resulted in increased the antioxidant activity.

Table 1: Antimicrobial activity of lemongrass extract based on inhibition zone (mm)

Strains of bacteria	**Lemongrass levels (%)**			
	0.5	1.0	1.5	Negative control
Staphylococcus aureus	6.00 ^{b}	9.66 ^{a}	10.33 ^{a}	-
Salmonella enterica	8.33 ^{c}	12.00 ^{b}	17.66 ^{a}	-
Shigella flexneri	5.66 ^{c}	9.00 ^{b}	13.00 ^{a}	-
SEM	0.707	0.707	0.707	-

$^{a-c}$ Means within the same row with different superscripts letters are different ($p<0.05$).
SEM=Standard Error of Means.

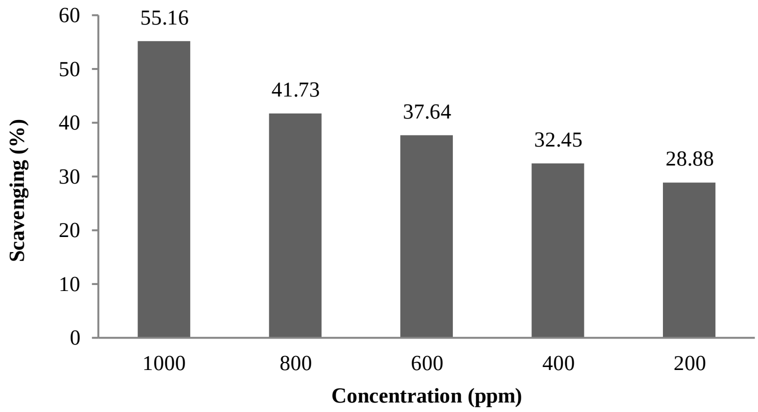

Figure 1: Antioxidant activity (scavenging percentage) of different concentrations of lemongrass extract

pH

Data of pH values of chicken burger formulated with different levels of lemongrass during frozen storage are showed in Table 2. Chicken burger treated with lemongrass extract exhibited the lowest pH values than control one. Regards to frozen storage, control group showed decrease in pH value after 30 days of storage and significantly increased (p<0.05) as the time of frozen storage increased. Chicken burger formulated with 0.5% lemongrass showed significant decreased (p<0.05) during 60 days of storage and surprisingly increased at the end of storage period 90 days. Contrarily, burger with 1.5% lemongrass showed significant increased (p<0.05) during 60 days of storage and surprisingly decreased at the end of storage period 90 days. However, no significant different (p>0.05) was found in pH value of burger formulated with 1% lemongrass during frozen storage period 90 days.

Color measurements

Color measurements of chicken burger formulated with different levels of lemongrass extract during frozen storage are shown in Table 3. Data illustrated that L* values of treated chicken burger with lemongrass extract showed a gradually decrease as the level of lemongrass increased. Regards to frozen storage, L* values exhibited a gradually increase after 30 days of storage till the end frozen storage period, except for burger treated with 1% lemongrass showed slight decreased after 90 days of frozen storage. Significant increase (p<0.05) was in a* values (redness) of burger formulated with different levels of lemongrass extract. Burger formulated with 0.5% lemongrass exhibited slight decreased after 30 days of storage then gradually increased after 60 and 90 days of storage. Burger formulated with 1.0% lemongrass showed slight decreasing in a* values during 30 and 60 days of storage and significantly increased (p<0.05) after 90 days of frozen storage. Significant increase (p<0.05) was found in a* value of chicken burger formulated with 1.5% lemongrass after 30 days of storage and remained constant during frozen storage period 90 days.

Significant differences (p<0.05) were found in b* values (yellowness) during frozen storage of chicken burger treated with different levels of lemongrass extract. Control samples showed significant decreased (p<0.05) after 30 days of storage then increased after 60 days and decreased again at the end of storage time. Burger formulated with lemongrass extract showed a significant increase in b* values during frozen storage for 90 days, expect for burger formulated with 1% showed slight decreased were found in b* value at 60 days of frozen storage.

TBA value

TBA values in burger treated with lemongrass extract showed the lowest value of TBA during frozen storage period (Table 4). Regards to frozen storage, TBA values of all burger samples significantly increased (p<0.05) as the time of frozen storage increased. Chicken burger formulated with 1.5% lemongrass extract exhibited a significant decreased (p<0.05) in TBA value at the end of frozen storage period 90 days.

Microbiological quality

Data in Table 5 showed the changes in total bacterial count, mold, yeast, and psychrophilic of chicken burger during frozen storage at -20 °C for 90 days. Control sample exhibited significant increase (*p*<0.05) after 30 days of storage and no significant changes were found in total count during storage period 90 days. Regards to levels of lemongrass extract, data showed that burger treated with 0.5% and 1.0% lemongrass extract showed significant increase (*p*<0.05) in total count after 30 days of storage. No significant changes were found during 60 and 90 days. Contrarily, burgers treated with 1.5% showed significant increase after 30 days of storage and significant decrease (*p*<0.05) were found after 60 days of storage and slightly increase was found at the end of storage time. Data of mold and yeasts showed that control group exhibited significant decrease (*p*<0.05) after 30 days of storage and no significant changes were found in mold and yeast counts during storage period 90 days. Meanwhile, burger of 1.0% lemongrass showed gradually decrease (*p*<0.05) in mold and yeast counts during frozen storage period. Slight increase in mold and yeast counts was found in burger formulated with 1.5% lemongrass after 30 days of storage and no significant differences were found during 60 and 90 days of storage (*p*>0.05).

Results of psychrophilic bacteria counts of chicken burger samples during frozen storage showed that burger of control, 0.5%, and 1.0% lemongrass extract had increase (*p*<0.05) in psychrophilic bacteria counts after 30 days of frozen storage. Conversely, burger formulated with 1.5% lemongrass exhibited slight insignificant decreased (*p*>0.05) after 30 days of storage. Burger treated with 1% lemongrass showed significant decreased in psychrophilic bacteria counts during 60 and 90 days of storage. Despite of burger formulated with 1.5% lemongrass exhibited significant increased (*p*<0.05) during 60 and 90 days of storage but, it had the lowest count of psychrophilic bacteria till the end of storage period.

Table 2: pH values of chicken burger during frozen storage at -20 °C for 90 days

	Storage periods (days)			
Treatments	0	30	60	90
T1	5.92 ^{Aab}	5.60 ^{Ac}	5.83 ^{Ab}	6.04 ^{Aa}
T2	5.80 ^{ABa}	5.73 ^{Ab}	5.72 ^{Ab}	5.89 ^{Aa}
T3	5.71 ^{Ba}	5.73 ^{Aa}	5.82 ^{Aa}	5.83 ^{ABa}
T4	5.67 ^{Bb}	5.71 ^{Aab}	5.85 ^{Aa}	5.68 ^{Bb}
SEM	0.039	0.039	0.039	0.039

$^{a\text{-}b}$ Means within the same row with different superscripts letters are different (*p*<0.05).
$^{A\text{-}B}$ Means within the same column with different superscripts letters are different (*p*<0.05).
T1: control; T2: contains 0.5% lemongrass; T3: contains 1.0% lemongrass; and T4: contains 1.5% lemongrass.
SEM=Standard Error of Means.

Table 3: Color parameters of chicken burger during frozen storage at -20 °C for 90 days

	Storage periods (days)				
Treatments	**0**	**30**	**60**	**90**	**SEM**
*L**					
T1	53.06 ^{Ab}	53.03 ^{Ab}	52.76 ^{Bb}	58.55 ^{Aa}	0.479
T2	54.62 ^{Aa}	53.88 ^{Aa}	55.50 ^{Aa}	56.63 ^{Aa}	0.479
T3	53.64 ^{Aa}	53.18 ^{Aa}	55.86 ^{Aa}	54.59 ^{Ba}	0.479
T4	52.59 ^{Ab}	53.34 ^{Ab}	56.47 ^{Aa}	57.53 ^{Aa}	0.479
*a**					
T1	2.95 ^{Bb}	3.17 ^{Aab}	3.61 ^{Aa}	3.50 ^{Aa}	0.098
T2	3.57 ^{Aa}	3.08 ^{Bb}	3.28 ^{Aab}	3.38 ^{Aa}	0.098
T3	3.51 ^{Aab}	3.44 ^{Aab}	3.13 ^{Ab}	3.80 ^{Aa}	0.098
T4	2.95 ^{Bb}	3.50 ^{Aa}	3.55 ^{Aa}	3.58 ^{Aa}	0.098
*b**					
T1	14.30 ^{Aab}	13.38 ^{Bb}	16.02 ^{Aa}	14.48 ^{Bab}	0.354
T2	12.59 ^{Bb}	14.83 ^{Ab}	16.31 ^{Aab}	17.43 ^{Aa}	0.354
T3	12.91 ^{Bc}	15.28 ^{Ab}	14.56 ^{Bbc}	17.77 ^{Aa}	0.354
T4	14.84 ^{Ab}	15.74 ^{Ab}	15.96 ^{ABb}	19.02 ^{Aa}	0.354

$^{a\text{-}c}$ Means within the same row with different superscripts letters are different (*p*<0.05).
$^{A\text{-}B}$ Means within the same column with different superscripts letters are different (*p*<0.05).
T1: control; T2: contains 0.5% lemongrass; T3: contains 1.0% lemongrass; and T4: contains 1.5% lemongrass.
SEM: Standard Error of Means; L*= Lightness; a*=Redness; b*=Yellowness.

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Table 4: Thiobarbituric Acid (TBA) value (mg MDA/kg) of chicken burger during frozen storage at -20 °C for 90 days

Treatments	Storage periods (days)			
	0	30	60	90
T1	0.099 ^{Ab}	0.103 ^{Ab}	0.796 ^{Aa}	0.617 ^{Aa}
T2	0.101 ^{Ab}	0.178 ^{Ab}	0.260 ^{Bb}	0.629 ^{Aa}
T3	0.086 ^{Ab}	0.087 ^{Ab}	0.669 ^{Aa}	0.803 ^{Aa}
T4	0.088 ^{Ab}	0.132 ^{Ab}	0.676 ^{Aa}	0.154 ^{Bb}
SEM	64.56	64.56	64.56	64.56

$^{a-b}$ Means within the same row with different superscripts letters are different (p<0.05).
$^{A-B}$ Means within the same column with different superscripts letters are different (p<0.05).
T1: control; T2: contains 0.5% lemongrass; T3: contains 1.0% lemongrass; and T4: contains 1.5% lemongrass.
SEM=Standard Error of Means; MDA=Malondialdehyde

Table 5: Total bacterial count, mold, yeast, and psychrophilic of chicken burger during frozen storage at -20 °C for 90 days

Treatments	Storage periods (days)				
	0	30	60	90	SEM
Total bacterial count (log CFU/g)					
T1	6.56 ^{Ab}	7.01 ^{Ba}	7.02 ^{Ba}	7.02 ^{Ba}	0.033
T2	6.44 ^{Ab}	6.94 ^{Ba}	6.96 ^{Ba}	7.00 ^{Ba}	0.033
T3	6.46 ^{Ab}	7.20 ^{Aa}	7.27 ^{Aa}	7.18 ^{Aa}	0.033
T4	6.40 ^{Ac}	7.11 ^{ABa}	6.86 ^{Bb}	7.01 ^{Bab}	0.033
Mold and yeast (log CFU/g)					
T1	4.12 ^{Aa}	3.94 ^{Aa}	3.95 ^{Aa}	3.88 ^{Aa}	0.085
T2	4.00 ^{Aa}	4.00 ^{Aa}	3.94 ^{Aa}	3.96 ^{Aa}	0.085
T3	4.43 ^{Aa}	4.36 ^{Aa}	3.90 ^{Ab}	3.90 ^{Ab}	0.085
T4	4.04 ^{Aa}	4.13 ^{Aa}	3.96 ^{Aa}	3.98 ^{Aa}	0.085
Psychrophilic (log CFU/g)					
T1	6.42 ^{Ac}	7.47 ^{Aa}	7.22 ^{ABb}	7.20 ^{Ab}	0.023
T2	5.97 ^{Cb}	7.32 ^{Ba}	7.30 ^{Aa}	7.28 ^{Aa}	0.023
T3	6.27 ^{Bc}	7.34 ^{Ba}	7.14 ^{Bb}	7.14 ^{Bb}	0.023
T4	6.08 ^{Cb}	6.07 ^{Cb}	6.41 ^{Ca}	6.44 ^{Ca}	0.023

$^{a-c}$ Means within the same row with different superscripts letters are different (p<0.05).
$^{A-C}$ Means within the same column with different superscripts letters are different (p<0.05).
T1: control; T2: contains 0.5% lemongrass; T3: contains 1.0% lemongrass; and T4: contains 1.5% lemongrass.
SEM=Standard Error of Means; CFU=Colony Forming Unit.

Discussion

Results of antimicrobial activity of lemongrass extract showed that the antibacterial activity increased as the level of lemongrass extract increased. These results are close to that obtained by Jafari et al. (2012) that studied the antibacterial activity of lemongrass methanolic extracts (20, 30, 50, and 400 mg/ml) against *S. aureus*, *B. cereus*, and *Escherichia coli* by using well diffusion method and found that the inhibitory effect elevated with increasing concentrations of lemongrass extract. On the same line, Ibrahim and Abu Salem (2013) investigated the effect of addition lemongrass and lime peel extracts (fresh and oil) to chicken patties and its effect on antibacterial activity against *B. cereus*, *S. typhimurium*, and *S. aureus*. They demonstrated that the oil extracts showed higher potential antibacterial activity than fresh extract and their antibacterial effect elevated with increasing the concentration. However, inhibition effect of lemongrass extract may be due to its active compounds such as saponin, citral, phenolic compounds, and flavonoids (Hindumathy, 2011).

Results of antioxidant activity showed that lemongrass extracts exhibited high potential antioxidant. These results are confirmed by Ibrahim and Abu Salem (2013) that investigated the antioxidant activity of lemongrass extracts to set up the optimum concentrations which can be added to chicken patties. They found that methanolic extract of lemongrass showed significant high antioxidant activity equivalent to gallic acid and Butylated Hydroxyanisole (BHA). View of the current study, it can be concluded that antioxidant activity elevated as the level of lemongrass extract increased. These results are consistency with findings obtained by Eldeeb and

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Mosilhey (2018). These researchers examined the effect of addition different levels of lemongrass extract (0.5, 1.0, 1.5, and 2%) on the antioxidant activity of chicken burgers during cold storage. They indicated that chicken burger formulated with 2% lemongrass leaves showed the highest antioxidant activity. Also, they indicated that the higher antioxidant activity was associated with the higher concentrations of lemongrass. However, the high antioxidant activity of lemongrass may be attributed to the high content of bioactive compounds, including tannins, flavonoids, and phenols and their ability to scavenge free radicals (Hasim et al., 2015).

Addition of lemongrass significantly decreased the pH values of chicken burgers than control sample. These results are consistent with data obtained by Lee et al. (2014). They found that patties formulated with different levels of lemon balm powder (0.1, 0.5, and 1%) showed significant decreased in pH values than control samples. On the same line, Morshdy et al. (2021) found that addition of lemongrass oil with concentrations (0.5, 0.75, and 1%) slightly decreased the pH value of rabbit meat than control group. However, the decreasing in pH values of treated samples with different levels of lemongrass extract could be related to the active compounds in lemongrass extract. This finding came in accordance with the results of Lara et al. (2011) that indicated the pH values of pork patties formulated with lemon balm were lower than control group and this decreasing could be attributed to the fact the active compound in lemon balm extract is rosmaric acid. During frozen storage, chicken burger samples exhibit decreasing and increasing in pH values during storage period except for burger formulated with 1% lemongrass which was stable during storage time 90 days. Data of pH values in current study are consistent with data of Utami et al. (2018). They found slight increase and decrease in pH values of beef sausages treated with different levels of kaffir lime leaf essential oil (0.2 and 1.4%) during frozen storage at -18 °C. Also, they found that pH value of beef sausages treated with 0.2% kaffir lime leaf essential oil was stable during storage period (four months). Generally, the decrease and increase in pH values during frozen storage is related to the growth and activity of bacteria. The decrease in pH values of chicken burger during frozen storage may be due to the psychrophilic bacteria activity which deteriorates the carbohydrate producing lactic acid. While, the increasing in pH values may be due to break down of protein by microorganisms and enzymes which resulting in protein deamination and producing alkali compound such as ammonia, dimethyl amine, and trimethyl amine (Leygonie et al., 2012).

Results of L* values in the current study are consistency with the results of Awad (2019) who found that L* values showed a significant decreased in beef burger formulated with different levels of lemongrass powder (1, 3, and 5%). Also, they found that L* values were increased as the time of frozen storage at -20 °C increased for three months. On the same line, Utami et al. (2018) found that L* values slightly decrease in beef sausages formulated with kaffir lime leaf essential oil (0.2 and 1.4%) than control group. Also, they found L* values increased after three and four months of frozen storage at -18 °C. However, the increasing in L* values during frozen storage may be due to the changes of frozen storage on protein composition including denaturation and decomposition which lead to increase of light scattering (Soyer et al., 2010).

Data of a* values are consistent with the results of Utami et al. (2018). They found that a* values were stable in treated beef sausages with kaffir lime leaf essential oil (0.2 and 1.4%) during frozen storage at -18 °C for four months. On the other hand, results of a* values in the current study contradict with the results of a* values obtained by Awad (2019) who found a decreasing trend in a* value in beef burger formulated with different levels of lemongrass powder (1, 3, and 5%) during frozen storage at -20 °C for three months. This may be due to the effect of using lemongrass extract (which increase the antioxidant activity) compared with lemongrass powder.

However, the stability of a* values (redness) of chicken burger formulated with lemongrass extract is related to the high potential antioxidant of lemongrass extract especially in high level (1.5%) leading to improve the red color (a* values) during frozen storage. Ibrahim and Abu Salem (2013) found that methanolic extract of lemongrass showed significant high antioxidant activity equivalent to gallic acid and to BHA. Data of b* values are in same line with data of Awad (2019) who found that b* values increased in beef burger formulated with different levels of lemongrass powder (1, 3, and 5%) during frozen storage at -20 °C for three months. The increase in b* values of treated burger may be attributed to the natural color (yellowish) of lemongrass which affecting on treated burger color. Also, Utami et al. (2018) found b* values were increased as the time of frozen storage increased in beef sausages formulated with kaffir lime leaf essential oil (0.2 and 1.4%) during frozen storage at -18 °C for four months. This increase in b* values during frozen storage may be due to the decrease in myoglobin content and increase in metmyoglobin formation resulting in the pale brown color of meat (Utami et al., 2018).

Addition of lemongrass extract significantly affected on TBA values of chicken burger. These results are close to that obtained by Hussein et al. (2015) that found control beef burger recorded the higher TBA value followed by formula, which contained (0.5%) of lemongrass while, the lowest TBA value was found in formula contained

2% lemongrass. Also, Awad (2019) found that addition of different levels (1.0, 3.0, and 5.0%) of lemongrass powder significantly decreased the TBA values of beef burger than control sample. Results in the current study indicated that frozen storage significantly increased the TBA values of all chicken burger samples and the inhibition effect of lipid oxidation during frozen storage was observed in the burger treated with the highest level (1.5%) of lemongrass extract. These results are consonance with Awad (2019) who found that during frozen storage, TBA values were significantly increased in control sample while, the increase in TBA values of beef burger treated with the highest concentrations (3 and 5%) of lemongrass leaves powder was slow and remained lower up to the end of frozen storage at -20 °C for three months. On the same basis, Abd El-Wahab (2018) found that TBA values of beef burger formulated with (0.5, 1.0, 1.5, and 2.0%) lemongrass extract were lower than control group. Also, they found that TBA values increased in all beef burger, but treated burger with lemongrass extract exhibited lower TBA values during storage time at -4 °C for three months.

The changes in the microbiological quality of chicken burger were affected by addition of lemongrass extract during frozen storage. Total bacterial count of chicken burgers treated with different levels of lemongrass extract showed the lowest bacterial count. These results came in accordance with the results of Awad (2019) who indicated that total bacterial count of beef burger formulated with different levels of lemongrass leaves powder (1, 3, and 5%) was lower than control burger. The results of the current study are close to that obtained by Abd El-Wahab (2018) found that total bacterial count of beef burger formulated with lemongrass (0.5, 1.0, 1.5, and 2.0%) was lower than control samples during frozen storage at -4 °C for three months. The changes in mold and yeasts counts during storage came in accordance with the results of Ibrahim and Abu Salem (2013) that found addition of lemongrass extract (0.25%) to chicken patties significantly decreases the counts of mold and yeast. Significant differences were found in psychrophilic bacteria counts of chicken burger samples during frozen storage. Addition of lemongrass significantly decreased the psychrophilic bacteria counts during storage time. These results are close to that obtained by Kamona and Alzobaay (2021) that found the psychrophilic bacteria count significantly decrease in fish balls treated with 5 and 10 µg/ml lemongrass oil under cold storage.

Conclusion

Addition of lemongrass extract had significant effects on some chemical, physical, and microbiological quality characteristics of chicken burger during frozen storage at -20 °C for three months. Using different levels of lemongrass extract in the formulation chicken burger resulted in delaying the lipid oxidation, improved the color stability, and reduced the bacterial count. Therefore, it can be concluded that lemongrass extract could be used as a natural antioxidant and antimicrobial in chicken burger during frozen storage.

Author contributions

Not applicable.

Conflicts of interest

The author declared no conflict of interest.

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