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Biochemical Characteristics of Refrigerated Smoked Chicken Luncheon as Affected by Liquid Smoke

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THE main goal of this study was to prolongate the shelf life of refrigerated chicken luncheon and improving product flavor using various concentrations of liquid smoke. Chicken luncheon treatments were control, 1, 2 and 3% liquid smoke. Liquid smoke showed a high content of phenolic compounds and aldehydes in liquid smoke, which were characterized by their high antioxidant activity, as inhibition concentration 50(IC_{50}) value reached 9.09 µL compared to 8.38µg/ mL for vitamin C. It also showed its anti-bacterial effect on some strains such as *Bacillus cereus*, *Listeria monocytogens* and *Salmonella typhimrium*. From the same results, it could be noticed that 1% and 2% treatments had high score of sensory characteristics compared with control sample. The tabulated data obtained showed that increasing liquid smoke concentration led to decrease pH values of luncheon treatments. Also, the TVN, TBA values and total bacterial count were in the acceptable limits which were 20 mg N/100g sample, 0.9 mg MDA/Kg sample and 10^4 CFU, respectively. Expected values of total volatile nitrogen showed that 2% and 3% liquid smoke treatments will be spoilage at 24 days, but control and 1% liquid smoke treatments will spoil at only 21 days from refrigerated storage period. Finally, this research recommends using liquid smoke at 2% concentration in smoked chicken products, as it improves the ability to be preserved refrigerated and increases the quality of its sensory characteristics.

Keywords: Chicken luncheon, Color measurement, Liquid smoke, Physiochemical, Sensory evaluation.

Introduction

One of the most popular sources of animal protein now extensively available worldwide is poultry meat and their products. Compared to beef and other red meats, chicken and turkey meat is richer in protein and lower in fat. Chicken and turkey meat products including tenderloins, breast, cutlets, and ground turkey have become more popular in the market (Sorour et al., 2021). Chickens and turkeys account for the majority of poultry meat sources (90 and 5% of total poultry production, respectively) (FAO, 2020). Agarwal et al. (2015) illustrated that lunch meat is a type of filling pressed minced meat that became more popular during World War II. The military's supply of lunch meat was in show. Lunch meat, either pre-cooked or cured, continues to be a very popular canned food today. Generally, canned lunch meat is made from raw pork, beef, or chicken. For the majority of consumers, including adults and children, luncheon meat is a common and beloved food item, and it is regarded as a significant industrial product. According to EL-Hadidie et al. (2017), it is a comminuted product that has been processed with curing salts and beef lipids and may or may not contain non-meat binding agents.

Luncheon is one of the most consumed meat products in Egypt. The majority of Egyptians commonly eat it as quick food. It is made of

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ground meat and animal fat, with or without grains, and is heatedly processed to cure the meat with nitrite and salt. There are two varieties of this product in Egypt. The first is a semi-dry luncheon, and the second is canned luncheon. These lunches are prepared and ready to eat, so cooking is not necessary (Ali et al., 2017).

Proteinaceous food products can be smoked. In addition, the aromatic chemical in smoke may provide food more flavor and color, and it may also have antioxidant and bacteriostatic properties that can increase the shelf life (Soares et al., 2016). Liquid smoke is compounds that evaporate simultaneously from the heated reactor through the pyrolysis (heat decomposition) and condense in the cooling system. Phenolic compounds can also act as antioxidants by stabilizing free radicals. Liquid smoke provides a specific aroma and better color quality to smoked products (Indiarto et al., 2020).

Chemical substances of liquid smoke can act as flavoring agents (aroma), colorants, antibacterial agents, and antioxidants. The antibacterial and antioxidant characteristics of liquid smoke can be employed as a preservative. *Pseudomonas fluorescence*, *Bacillus subtilis, Escherichia coli*, and *Staphylococcus aureus* are among the bacteria that can be inhibited by phenolic chemicals and acetic acid found in liquid smoke. Phenol molecules can also act as antioxidants by preventing free radicals from oxidizing. On smoked products, liquid smoke gives out a distinct aroma and improves color quality (Ayudiarti & Sari, 2010 and Asri, 2016). Saloko et al. (2014) illustrated that due to a residual PAH (Polycyclic Aromatic Hydrocarbon) molecule may be reduced through purification using re-distillation, using liquid smoke is safer than using traditional smoking techniques

The presence of acid, phenol, and carbonyl compounds in liquid smoke has the potential to be used in the food industry. The content of phenol and acetic acid compounds in liquid smoke can inhibit the growth of bacteria such as *Pseudomonas fluorescence*, *Bacillus subtilis*, *Escherichia coli*, and *Staphylococcus aureus* (Soares et al., 2016). The use of liquid smoke is easy, safe and effective; it can be used to preserve fish, meatballs and other food products when applied at a specific level (Maryam, 2015). This study's major goal was to clarify how liquid smoke affected on the shelf life of refrigerated chicken luncheon. This objective was accomplished through the evaluation of the studied chicken luncheon treatments on a physiochemical attributes, total bacterial count and sensory characteristics for assessing the quality of processed chicken meat luncheon.

Materials and Methods

Materials

Chicken were purchased from local market, Damietta Governorate, Egypt during May, 2023. Then, cleaned, gutted and washed in iced conditions. Minced breast chicken meat was kept under freezing conditions until the luncheon blenders were processed. Liquid smoke was purchased from Agricultural Research Center, Giza, Egypt.

Bacterial strains

Five bacterial strains were used namely; *Staphylococcus aureus* (ATCC 6538), *Bacillus cereus* (B-210) and *Escherichia coli* (B-211) were supplied from Assiut University Mycological Center (AUMC) as well as *Listeria monocytogens* and *Salmonella typhimrium* were supplied from Agricultural Microbiology Department, Faculty of Agriculture, Damietta University. Microbiological media were bought from El-Gomhoria for Trading Chemicals and Drugs as: Soya bean Casein Digest Medium (Tryptone soya Broth) for strains activation and Nutrient agar medium for detecting the inhibition zone of studied strains and to determine total bacterial count (TBC) of smoked luncheon treatments at storage period (Oxoid, 2006).

Chemicals

All analytical grade chemicals were purchased from El-Gomhoria Company for Trading Chemicals and Drugs as TBA (Techno. Pharmchem., India), DPPH (Sigma-Aldrich), Boric acid, NaOH, Bromo cresol green and methyl red (Loba-Chem., India), and Glacial acetic acid (Euromedox, France).

Methods

Gas chromatography mass spectrometry (GC-MS) of liquid smoke components

Thermo Scientific, Austin, TX, USA) TRACE GC 1310- TSQ 9000 mass spectrometer with a direct capillary column TG-5MS 30 m × 0.25 mm×0.25 µm film thickness was used to analyze the active compounds of the liquid smoke. (There were gathered spectra) Spectra were collected, the components were identified by comparing their mass specrea and retention times to those of WILEY 09 and NIST 14 mass spectral database (Abd El-Kareem et al., 2016). This analysis was

conducted at Damietta University's Center for Excellence in Research of Advanced Agricultural Sciences (CERAAS).

Radical scavenging activities of Liquid smoke

The antioxidant activity of liquid smoke was performed by 2,2- Diphenyl-1-picrylhdrazyl (DPPH) radical scavenging capacity (Marinova and Batchvarov, 2011). Liquid smoke was diluted with DMSO (Dimethyl Sulfoxide) to 1, 2 and 3% concentrations. Ascorbic acid was used as reference standard. Then, various concentrations of liquid smoke were mixed with 2.0 mL of 100 µM DPPH, were shaken vigorously and allowed to reach a steady at room temperature for 30 min in dark place. De- colorization of purple DPPH was measured at 517 nm with spectrophotometer.

$$\% \text{ scavenging activity} = (A_0 - A_1/A_0) \text{ X } 100$$

A_0: Absorbance without liquid smoke or standard
A_1: Absorbance in the presence of liquid smoke or standard

Antibacterial activity of liquid smoke

According to Boyanova et al. (2005), the antibacterial activity of liquid smoke was evaluated using the well agar diffusion method. The tested bacterial strains were inoculated with a 24 hr culture in petri plates containing 15-20 mL of nutrient agar medium. Using a sterile cork borer, wells with a diameter of 6 mm were drilled into the agar. The wells were carefully filled with liquid smoke using sterilized dropping pipettes. Pour plates were filled with sequential concentrations of liquid smoke (v/v), as follows: Using a micropipette with sanitized tips, the wells were filled with 0, 1, 2, and 3%, respectively. As a control, Di methyl sulfoxide (DMSO) was employed. Liquid smoke and control plates were then incubated at 35°C following the inoculation methods. After 24 hr of incubation, the plates were examined to see whether or not each bacterial species was visible growing on the agar plate. Zone inhibition, which refers to the lack of colonies on test plates, was measured and expressed as (millimeter).

Preparation of breast chicken meat luncheon

The minced breast chicken has been added in proportion 75%, salt 2%, (ground garlic, onion, sugar) 0.5% for each, spices 1.7%, corn starch 5%, sodium tri-polyphosphate 0.3% and chilled water 14.5%. The mixture was divided into four parts, the 1st part was control, the 2nd part was treated with 1% liquid smoke, the 3rd part was treated with 2% liquid smoke and the 4th part was treated with 3% liquid smoke. All ingredients were mixed by hand and ground twice through a 4 mm plate. The emulsion was filled in stretch roll as 4 Cm diameter and 10 Cm in height to a weight of 100 g. The rolls were steamed for 60 min at 95°C.The luncheon rolls were cooled by water and stored at low temperature (2±1ºC) for storage period (15 days) and were analyzed every 3 days.

Microbiological examination of luncheon treatments during storage period

Luncheon meat samples preparation

Treatments for smoked luncheon meat were weighted aseptically in a sterilized conditions.. For the preparation of a 1:10 dilution, transferring 5 g of the sample to 45 mLof sterile water and the suspension was manually shaken for 5 min. As required, further dilutions were made and plated in triplicate.

Total viable bacterial count (TVBC) determination

After preparing serial dilutions of luncheon treatments, they were aseptically put into each of three sterile glass Petri dishes using the "poured plate" approach. Each plate received fifteen milliliters of nutrient agar medium that had been properly mixed and cool to 45 to 50ºC. The plates were incubated for 24 hr at 30 °C. Developed colonies on each plate were counted after the incubation time. Following an inventory of the colonies on triplicate plates with the same dilution, the total colonies count per gram of sample was computed as follows:
Total bacterial count = (average number of identical-dilution triplicate plates x reciprocal of the dilution) as colony forming unit (CFU)/g sample.

Physiochemical analysis of luncheon treatments

Determination of thiobarbituric acid (TBA)

According to the procedure by EOS (2006a), the thiobarbituric acid (TBA) of smoked luncheon treatments was determined every three days using a spectrophotometer at 538 nm. Malondialdehyde (MDA) mg/kg of sample was used to express the TBA values.

Determination of total volatile nitrogen (TVN)

The EOS (2006b) method was used to determine the (TVN) mg Nitrogen/100 g sample of chicken meat luncheon every three days.

Measurement of pH value

To determine the pH value of chicken meat luncheon samples, 5 g of the sample was homogenized with 50 mLof distilled water at 25ºC for 30 min. According to EOS (2020), pH value was measured using a pH meter (Model JENWAY pH/mv meter Model 3510 instruction Manual).

Color measurements

The color profile system of lightness L* (whiteness or brightness/ darkness), a* (redness/ greenness), and b* (yellowness/blueness) was utilized to examine the internal surface color of chicken meat luncheon samples exclusively at zero time using the spectrophotometer CM-3600A, KONICA MINOLTA, Osaka, Japan.

Sensory evaluation

At Food Science Department of the Faculty of Agriculture at Damietta University in Egypt, fifteen trained panelists who were representatives of graduate students and staff evaluated the sensory quality of smoked chicken meat luncheon treatments in comparison to the control sample. Randomly coded samples were given to each panelist individually (Ali et al., 2017). A nine-point hedonic scale was used to rate the acceptability of taste, odor, color, texture and overall acceptability. The scale had nine points, 9 for extremely like, 8 for very much like, 7 for moderately like, 6 for slightly like, 5 for neither like nor dislike, 4 for slightly dislike, 3 for moderately dislike, 2 for very much dislike and 1 for extremely dislike.

Statistical analysis

The obtained results were statistically analyzed using one way analysis of variance (ANOVA) in the SPSS (2008) version 17 program for windows and comparisons were done using Duncan's test at $P<0.05$ level of significance.

Results and Discussion

Phytochemical components of studied liquid smoke

GC-MS analysis is performed in order to determined compounds containing phenol, carbonyl, and acid groups in Liquid smoke. Simultaneously all these compounds can act as an antioxidant and antibacterial and has positive effects to the color and distinctive flavor of smoked food products. The mixture of components that are passed to gas chromatography will be separated into individual components as peaks area obtained in Table 1. The tabulated data showed that the liquid smoke contains several active groups such as phenolic compounds and aldehydes representing the major portion of these groups which were 27.08 and 25.70%, respectively as area peak%. On the other hand, alcohols, ketones, and acids were represented 8.64, 8.25, 6.75, and 5.82%, respectively.

Antioxidant activity of Liquid smoke

Based on presented data in Fig. 1, liquid smoke achieved a high level of antioxidant activity for DPPH scavenging. All liquid smoke doses achieved a high level of DPPH inhibition (IC_{50}) 9.09 µL comparing with V.C (8.38 µg/mL) as standard. The phenolic compounds in liquid smoke may be the cause of the previous data; as aldehydes (25.70%), phenols (27.08%), ketones (6.75%), alcohols (8.64%) and acids (5.82%) in Table 1. These results concur with those of Zuraida et al. (2011), who illustrated that liquid smoke contained bioactive substances such carbonyls, phenols and organic acids that may enhancing the shelf life of proteinaceous food products which may be attributed to the high boiling of these compounds, which can give hydrogen ions to the free radicals and inhibit the active chain reaction (Maryam, 2015).

Antibacterial activity of studiedliquid smoke

Table 2 provides an illustration of the antibacterial activity of liquid smoke at various concentrations against several foodborne bacterial strains. According to showed data, liquid smoke has strong antibacterial properties against *Salmonella typhimrium*, *Listeria monocytogens* and *Bacillus cereus* at all doses. As concentrations increased, the antibacterial impact grew stronger. This could be as a result of the antibacterial action of high content aldehydes, ketones and phenolic compounds of liquid smoke such as phenol and their derivatives, furfural and several components in Table 1. These results were in agreement with Milly (2003) who reported thatthe smoke fraction with the highest carbonyl content and the lowest pH appear to have broad spectrum antimicrobial activity against Gram positive bacteria, Gram negative bacteria, as well as against pathogens *Salmonella*, *Listeria*. On the other hand, the same results showed that liquid smoke had no effect against *Staphylococcus* and *Escherichia coli*. These results are consistent with what Fellows (2017) explained, as he obtained that the preservative effect of liquid smoke is due to its high content of phenolic compounds such as Syringol, guiacol, and phenol . From the same results, it was noticed that by increasing liquid smoke concentration above 2%, no inhibition of *Bacillus cereus* was observed.

TABLE 1. Phytochemical components of studied liquid smoke.

NO	Liquid Smoke component	Molecular Formula	Peak Area %
	Acids		
1	Propionic acid	$C_3H_6O_2$	2.31
2	Acetic acid, sec-octyl ester	$C_{10}H_{20}O_2$	0.91
3	9-Hexadecenoic acid	$C_{16}H_{30}O_2$	0.70
4	Dodecanoic acid, 3-hydroxy-	$C_{12}H_{24}O_3$	0.41
5	2,4- Octadienoic acid- 7 hydroxy 6-methyl	$C_9H_{14}O_3$	1.49
	Total Acids		**5.82**
	Alcohols		
1	Glycerol	C3H8O3	0.65
2	1,2-Propanediol diformate	$C_5H_8O_4$	1.25
3	2 Furan ethanol- à methoxy	$C_7H_{10}O_3$	0.54
4	1,2-Benzendiol	$C_6H_6O_2$	1.73
5	Maltol	$C_6H_6O_3$	1.90
6	Cyclohexanol- 5 methyl-2-(1-methyl ethyl)-	$C_{10}H_{20}O$	0.40
7	Dodecanol 3,7,11- trimethyl	$C_{15}H_{32}O$	2.17
	Total Alcohols		**8.64**
	Aldehydes		
1	Furfural	$C_5H_4O_2$	17.70
2	Butanal 2-ethyl-	$C_6H_{12}O$	0.64
3	Butanal 2-methyl-	C_5H_8O	2.31
4	Pentenal, 2-methyl	$C_6H_{10}O$	0.75
5	6-Octenal 3,7-dimethyl	$C_{10}H_{18}O$	0.35
6	2-Furan carboxaldehyde, 5-methyl-	$C_6H_6O_2$	2.12
7	2-Furan carboxaldehyde, 5-hydroxymethyl-	$C_6H_6O_3$	1.83
	Total Aldehydes		**25.70**
	Ketones		
1	1,2 –Cyclopentanedione, 3- methyl	$C_6H_8O_2$	4.78
2	1-Hydroxy 2-butanone	$C_4H_8O_2$	1.97
	Total Ketones		**6.75**
	Phenols		
1	Phenol	C_6H_6O	0.47
2	Phenol, 2- methoxy	$C_7H_8O_2$	10.65
3	Phenol, 2- methoxy- 4- methyl	$C_8H_{10}O_2$	7.08
4	Phenol, 4 ethyl 2- methoxy	$C_9H_{12}O_2$	3.30
5	Phenol, 2- methoxy- 4- propyl	$C_{10}H_{14}O_2$	0.29
6	Phenol 2,6 di methoxy	$C_8H_{10}O_3$	2.61
7	Phenol, 2- methoxy- 5-(1- Propenyl)-	$C_{10}H_{12}O_2$	0.60
8	Phenol, 4- methoxy- 3(methoxy methyl)	$C_9H_{12}O_3$	0.37
9	Vanillin	$C_8H_8O_3$	1.71
	Total Phenols		**27.08**
	Hydrocarbons		
1	Furan, 2-ethyl-5-methyl	$C_7H_{10}O$	1.20
2	Furan-2-butyl tetra-hydro-	$C_8H_{16}O$	4.81
3	2- cyclopenten- 1-one, 2- methyl	C_6H_8O	1.03
4	2- Cyclopenten-1one, 3ethyl-2hydroxy	$C_7H_{10}O_2$	1.21
	Total Hydrocarbones		**8.25**
	Total		**80.27**

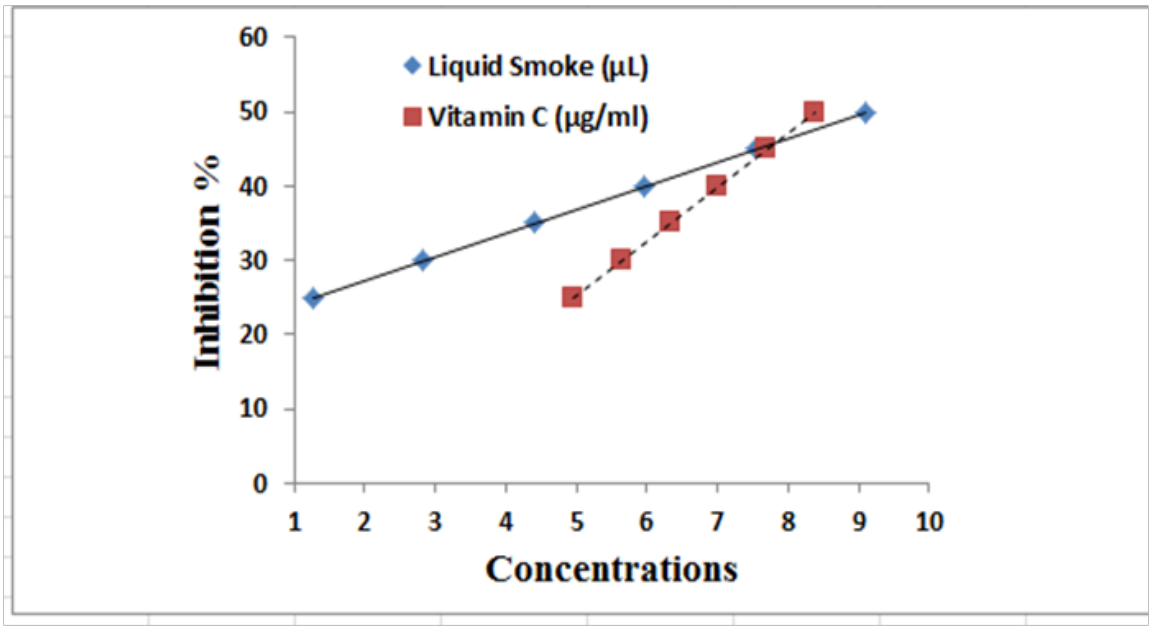

Fig. 1. Changes in DPPH radical scavenging activities of Liquid smoke comparing with ascorbic acid.

TABLE 2. Clear zones diameter (mm) of liquid smoke against some pathogenic bacteria strains.

Bacteria strains	Clear zones diameter (mm)			
	0.5%	1%	2%	3%
Bacillus cereus	20.3	22.6	29	27.3
Listeria monocytogens	12.3	14.6	16.6	18.6
Salmonella typhimrium	13.3	16.6	17	22.3

Physiochemical analysis of luncheon treatments

pH value, total volatile nitrogen (TVN), and thiobarbituric acid (TBA) value are the most three crucial physiochemical characteristics of meat products. Table 4 showed a decrease in pH values of all smoked chicken luncheon treatments with increasing of liquid smoke concentration. The predicted pH value at initial storage shows a decrease, along with the increased concentration of liquid smoke added. This is due to acidic liquid smoke which can be used as a preservative because it has a degree of acidity (pH) with a value of 2.8 to 3.1 so as to inhibit the growth of pathogenic bacteria (Maryam, 2015).

Furthermore the results shown in Table 3, the addition of liquid smoke resulted in a significant decrease in pH, which recorded 6.39, 6.15, 6.11 and 6.01 at zero time of control, 1, 2 and 3% liquid smoke treatments, respectively at $P< 0.05$; Which showed a slight change during cold storage period and reached to 6.42, 6.41, 6.15 and 6.04 of control, 1, 2 and 3% liquid smoke treatments, respectively at the end of storage period. These results are agreement with Indiarto et al.(2020) and Sorour et al. (2021) who found that the addition of liquid smoke resulted in decrease in pH value of chicken and turkey chilled meatballs.

As a result of Table 1, the liquid smoke contains acidic components 5.82% like propionic acid, acetic acid, and 2,4-Octadienoic acid-7-hydroxy-6-methyl and the oxidation process can cause decrease pH of meat during storage, according to Amaral et al. (2018). As a trial to predict the maximum shelf life of studied smoked chicken luncheon treatments, regression equations and fitting of TVN curves were carried out and expected TVN values were calculated.

TABLE 3. pH values of smoked chicken luncheon during refrigerated storage (2±1ºC for 15 days).

Treatments	Storage Period (days)					
	Zero	3	6	9	12	15
Control	6.36^{d}±0.006	6.41^{d}±0.012	6.35^{d}±0.006	6.43^{d}±0.006	6.43^{d}±0.006	6.42^{c}±0.006
1% Liquid smoke	6.15^{c}±0.009	6.23^{c}±0.009	6.26^{c}±0.009	6.35^{c}±0.012	6.37^{c}±0.006	6.41^{c}±0.009
2% Liquid smoke	6.11^{b}±0.009	6.13^{b}±0.009	6.23^{b}±0.006	6.24^{b}±0.009	6.26^{b}±0.006	6.15^{b}±0.006
3% Liquid smoke	6.01^{a}±0.009	6.09^{a}±0.009	6.07^{a}±0.006	6.13^{a}±0.006	6.11^{a}±0.006	6.04^{a}±0.006
Significance	0.000	0.000	0.000	0.000	0.000	0.000

Mean values ± standard error (n=3). Mean values in the same column with the same letter are not significantly different at $P< 0.05$.

Total volatile nitrogen reflects quality change in meat protein. From the results of Table 4, it could be observed that TVN values of all smoked chicken luncheon treatments gradually increased with increasing of refrigerated storage period, nonetheless the increasing rate was slightly increase for control and smoked treatments, tabulated data showed that total volatile nitrogen values ranged from 14.47 to 14.73 mg N/100g sample for all treatments at zero time. The same results had no significant differences between all treatments during storage period, except at the end of storage (15 days) had significant differences. Such results of TVN indicated the effect of liquid smoke as antimicrobial. According to EOS (2006c), this reported that the TVN of frozen poultry meat should not exceed 20 mg N /100 g sample. From the same results in Table 4, it could be noticed that all chicken luncheon treatments were still acceptable after cold storage for 15 days.

Figure 2 and Table 5 obtained the expected values of total volatile nitrogen during a month of refrigeated storage, which showed that control, and 1% liquid smoke treatments will be spoiled at 21 days, but 2 and 3% liquid smoke treatments will be spoiled at 24 days from refrigerated storage period.

These expected TVN values were calculated using the obtained equations resulted from TVN curves fitting and according to the maximum value of TVN in processed meat (30 mg N/100 g sample).

TBA value illustrates lipid oxidation. It has been extensively employed to gauge the production of lipid oxidation's secondary products, particularly aldehydes. The data in Table 6 showed values of TBA in all smoked chicken luncheon treatments, which ranged from 0.202 to 0.281 mg MDA kg-1 sample at zero time to 0.288 - 0.408 mg MDA kg-1 sample at 15 days of refrigerated storage period. These values indicate that there were significant differences between all luncheon treatments. For poultry meat products, the EOS (2006c) required that the value of TBA must be less than 0.9 mg MDA kg-1 meat. As can be seen, all samples were in accordance with this specification.

TABLE 4. Total volatile nitrogen (mg N/100 g sample)of smoked chicken luncheon during refrigerated storage (2±1ºC) for 15 days.

Treatments	Storage period (days)					
	Zero	3	6	9	12	15
Control	14.47^{a}±0.013	14.99^{a}±0.280	15.26^{a}±0.455	15.26^{a}±0.442	15.55^{a}±0.260	19.00^{b}±0.252
1% Liquid smoke	14.73^{a}±0.258	15.02^{a}±0.273	15.18^{a}±0.465	15.24^{a}±0.458	14.73^{a}±0.280	16.87^{a}±0.464
2% Liquid smoke	14.73^{a}±0.250	14.98^{a}±0.268	15.01^{a}±0.266	14.98^{a}±0.246	15.27^{a}±0.009	17.43^{a}±0.533
3% Liquid smoke	14.69^{a}±0.260	14.72^{a}±0.263	14.71^{a}±0.252	14.74^{a}±0.276	15.23^{a}±0.497	16.86^{a}±0.444
Significance	0.807	0.852	0.743	0.733	0.380	0.026

Mean values ± standard error (n=3). Mean values in the same column with the same letter are not significantly different at $P< 0.05$.

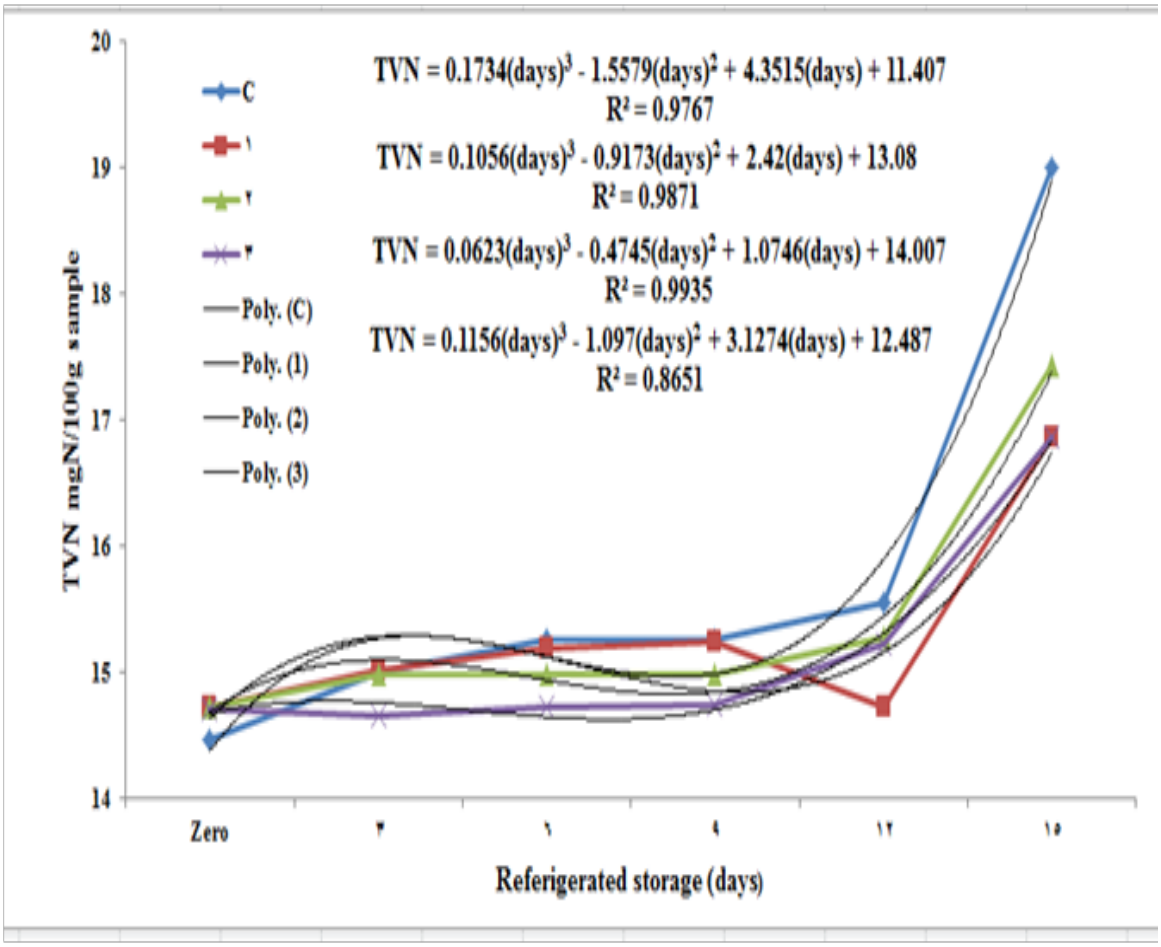

Fig. 2. Expected values of TVN for smoked chicken luncheon treatments during refrigerated storage at (2±1°C).

TABLE 5. Expected values of total volatile nitrogen as (mg N/100 g sample) of smoked chicken luncheon during refrigerated storage (2±1°C) for 30 days.

Storage Period (days)	Treatments			
	Control	1% Liquid smoke	2% Liquid smoke	3% Liquid smoke
Zero	11.41	13.08	14.01	12.49
3	14.37	14.68	14.67	14.63
6	15.26	15.09	14.76	15.28
9	15.12	14.94	14.64	15.12
12	14.98	14.84	17.70	14.84
15	15.89	15.45	15.31	15.15
18	18.88	17.39	16.83	16.73
21	**25.01**	**21.29**	19.65	20.28
24	35.29	27.80	**24.13**	**26.49**
27	50.79	37.54	30.66	36.05
30	72.53	51.15	39.60	49.66

TABLE 6. TBA value (mg MDA/kg sample) of smoked chicken luncheon during refrigerated storage (2±1ºC for 15 days)

Treatments	Storage period (days)					
	Zero	3	6	9	12	15
Control	0.239^{a}±0.007	0.236^{a}±0.002	0.304^{b}±0.005	0.327^{b}±0.005	0.478^{d}±0.007	0.512^{c}±0.011
1% Liquid smoke	0.202^{a}±0.005	0.205^{a}±0.016	0.294^{ab}±0.007	0.291^{a}±0.007	0.283^{a}±0.009	0.288^{a}±0.004
2% Liquid smoke	0.203^{a}±0.023	0.215^{a}±0.016	0.276^{a}±0.007	0.278^{a}±0.138	0.324^{b}±0.009	0.327^{a}±0.009
3% Liquid smoke	0.281^{b}±0.005	0.363^{b}±0.019	0.369^{c}±0.009	0.361^{c}±0.007	0.389^{c}±0.004	0.408^{b}±0.020
Significance	0.005	0.000	0.000	0.001	0.000	0.000

Mean values ± standard error (n=3). Mean values in the same column with the same letter are not significantly different at $P < 0.05$.

Color measurements for smoked chicken luncheon at zero time of storage

When consumers decide to purchase any products, color is the first factor theynotice to determine the product's quality because color grabs their attention. Results of color measurements of smoked chicken luncheon treatments as affected by different liquid smoke concentrations were obtained in Table 7. In the food products, color is a significant characteristic (parameter) defining consumer's choice and acceptability. Lightness (Whiteness) L^* is a material's ability to reflect light on its surface. From tabulated data, all smoked chicken luncheon samples had no significantly differences between all treatments of L^* value which showed a slight increase in the lightness (L^* value) with increasing liquid smoke concentration which they were 54.77, 55.63 and 55.14 in 1, 2 and 3% liquid smoke, respectively compared to 54.63 in control sample.

The same tabulated data revealed that the smoked chicken luncheon treatments' redness (a* value) results ranged from 2.84 to 4.58. All of smoked chicken treatments substantially differed from the control sample ($p<0.05$). However, there were significantly differences in the b* value, which reflects the yellow hue of the product, between the control and other treatments. This value ranged from 17.43 for the control luncheon treatment to 20.76, 21.69, and 21.55 for the 1, 2, and 3% liquid smoke luncheon treatments, respectively. The L* values, which previously averaged 54.6–55.63, and a* values, which ranged from 2.84–4.58, could be attributed to a decrease in myoglobin content in the breast chicken muscle. On the other hand, liquid smoke addition gives the smoked luncheon meat treatments their yellow color and raises the b* value over that of the control sample.

These results agreed with Hicks et al. (2018) who discovered that the golden-brown color of smoked meat product is a result of the carbonyl component in liquid smoke. The production of a golden-brown color and the Maillard reaction occur when amino groups and carbonyl molecules (generally glycolaldehyde and methylglyoxal) interact with amino groups in meat during the cooking process.

Sensory attributes of smoked chicken luncheon at zero time of storage

Sensory attributes of smoked chicken luncheon samples were obtained in Table 8 and Fig. 3. From obtained data, the treatments with 1% and 2% liquid smoke had the highest score of taste, color, odor, texture and overall acceptability. But the treatment with 3% liquid smoke had low values of sensory properties compare to other smoked treatments, these results may be due to that the increasing of liquid smoke concentration affected on the texture and gave the product an unacceptable sharp smoked taste. Also, control chicken luncheon had the lowest score of taste, color, odor, texture and overall acceptability, which were 7.07, 8.20, 6.27, 7.73 and 7.07, respectively. These results were in line with those of Purba et al. (2014) who reported that meatball samples treated with liquid smoke at a concentration of 1.5% received top marks for color, aroma, and texture. From the same tabulated results, it could be noticed that increasing of liquid smoke concentration to 3% led to a decrease in the sensory characteristics of the smoke luncheon meat samples which were 7.33, 8.53, 7.60, 7.80 and 7.73 for taste, color, odor, texture and overall acceptability, respectively compared to other smoked luncheon treatments.

TABLE 7. Color measurement of smoked chicken luncheon as affected by different liquid smoke concentrations at zero time

Treatments	Properties		
	L*	a*	b*
Control	54.63^{a}±0.348	2.84^{a}±0.312	17.43^{a}±1.138
1% Liquid smoke	54.77^{a}±0.244	3.93^{b}±0.143	20.76^{b}±0.477
2% Liquid smoke	55.63^{a}±0.520	4.31^{b}±0.097	21.69^{b}±0.646
3% Liquid smoke	55.14^{a}±1.256	4.58^{b}±0.355	21.55^{b}±1.182
Significance	0.763	0.006	0.035

Mean values ± standard error (n=3). Mean values in the same column with the same letter arenotsignificantly different at $P< 0.05$.

TABLE 8. Sensory characteristics of smoked chicken luncheon as affected by liquid smoke addition at zero time.

Treatments	Sensory characteristics		
	Taste (9)	Color (9)	Texture (9)
Control	7.07^{a}±0.371	8.20^{a}±0.354	7.73^{a}±0.316
1% Liquid smoke	7.80^{a}±0.312	8.47^{a}±0.274	8.07^{a}±0.316
2% Liquid smoke	8.13^{a}±0.322	8.53^{a}±0.236	8.27^{a}±0.284
3% Liquid smoke	7.33^{a}±0.398	8.53^{a}±0.215	7.80^{a}±0.355
Significance	0.154	0.802	0.618

Mean values ± standard error (n=10). Mean values in the same column with the same letter are not significantly different at 0.05 levels.

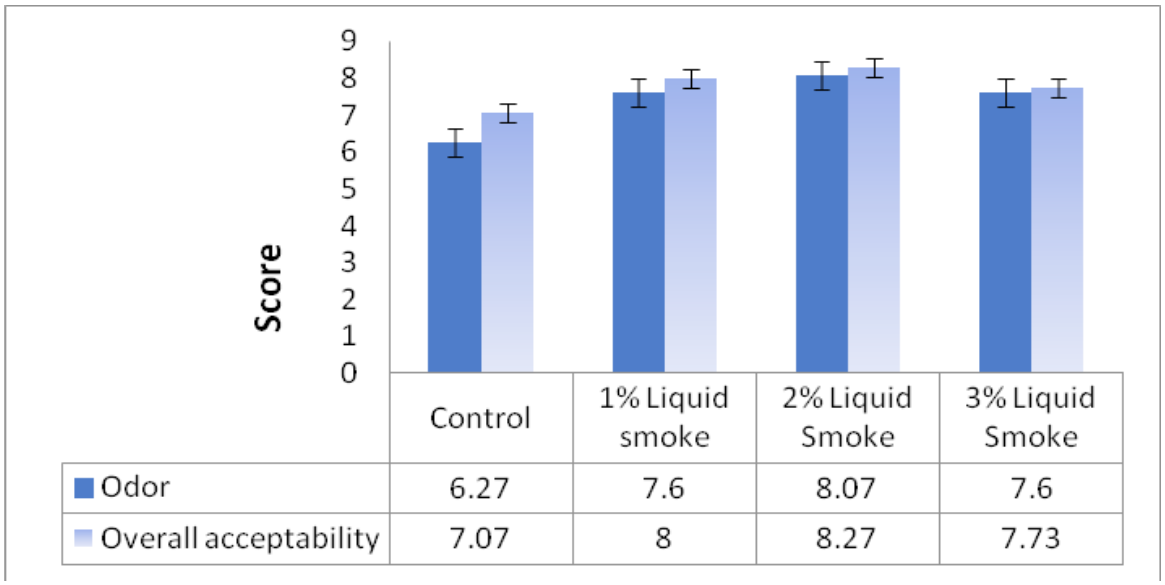

Fig. 3. Odor and overall acceptability of smoked chicken luncheon treatments as affected by different liquid smoke concentrations.

Total viable bacterial count (TVBC) of smoked luncheon

One of the parameters used to determine the quantity of bacteria in food products is total viable bacterial count by counting the grown bacterial colonies on agar media. The TVBC analysis was carried out in smoked chicken luncheon treatments by counting the quantity of grown bacteria on an agar medium at 30°C for 24 hrin order to assess the quality and shelf life of a food product. Data obtained and displayed in Table 9 reveal that lowering the total bacterial count of luncheon treatments occurred in smoked chicken by raising liquid smoke concentration to 2%. However, 3% liquid smoke addition had a comparable result to 2% liquid smoke addition. These results are a result of liquid smoke's high quantity of phenol and its derivatives, aldehydes, ketones, furfural and other phenolic compounds, which have an antibacterial effect. The previous results were in the same line of Keryanti et al. (2020) who illustrated that liquid smoke technique contained phenolic compounds, organic acids, and carbonyl groups that had the power to inhibit the growth of several bacteria and affect the flavor, pH and shelf life of food. These results are consistent with the results of Table 2, which shows the clear zones diameter (mm) of liquid smoke against some pathogenic bacteria strains as *Bacillus cereus*, *Listeria monocytogens* and *Salmonella typhimrium*.

Conclusion

Liquid smoke addition on breast chicken luncheon meat can greatly reduce the rate of deterioration, caused by microbes and other spoilage agents, compared with other used antioxidants. So that liquid smoke, a safe alternative to natural preservatives, can be utilized in chicken luncheon meat. But, consumers' interests must be taken in consideration whence flavor and smoked taste. From previous results, it could be recommended that utilizing the liquid smoke led to prolong the shelf life and improve the product flavor.

TABLE 9. Total viable bacterial count (CFU/g sample) of smoked chicken luncheon during refrigerated storage (2±1°C for 15 days)

Treatments	Total bacterial count (Log CFU) during Storage period (days)					
	Zero	3	6	9	12	15
Control	0.518	0.819	1	1	1.522	1.884
1% Liquid smoke	N.D	0.518	0.819	1	1.123	1.778
2% Liquid smoke	N.D	0.518	1	1.123	1.220	1.563
3% Liquid smoke	N.D	N.D	0.819	0.819	1.220	1.522

N.D: means Not Detected

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