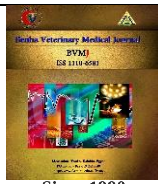
Official Journal Issued by Faculty of Veterinary Medicine

Benha Veterinary Medical Journal

Journal homepage: https://bvmj.journals.ekb.eg/



Since 1990

Original Paper

Effect of lavender oil, clove oil and frankincense extract on sensory and microbial properties of raw drumsticks in refrigerator

Soha T. Taha1, Fahim A. Shaltout1, Shimaa, N. Edris1, Mohamed, E. Nabil2*

[1]*Food Hygiene and Control Department., Faculty of Veterinary Medicine, Benha University, Egypt*
[2]*Food Hygiene Department., Animal Health Research Institute, ARC, Egypt.*

ARTICLE INFO

Keywords

Herbal byproducts
Poultry meat
Food safety

Received 14/11/2023
Accepted 04/01/2024
Available On-Line 01/04/2024

ABSTRACT

Prevention of microbial spoilage and extension of shelf life are usually the main goals of food additives. Therefore, this evaluation focused on the physical and antimicrobial effects of clove and lavender oils and frankincense extract (1.0%) on the shelf-life of raw, fresh chicken drumsticks after soaking for 24 hours in the refrigerator (4 ± 1 °C). Assessment of the used additives was conducted through sensory evaluation and microbiological quality through nine days of refrigeration. The treated chicken drumstick samples were much more acceptable overall than the control samples, which started to go bad after 6 days of storage. The treated groups with lavender and frankincense, on the other hand, were still acceptable after 9 days of storage. However, all of the additives that were tested were able to kill microbes. The frankincense aqueous extract was the most effective at stopping the growth of microbes, especially *Staphylococcus aureus* (*Staph. aureus*) and total fungal (mould and yeast) counts. Lavender and clove oils came in second and third, respectively. So, it can be concluded that the used herbal byproducts, either oils or aqueous extracts, gave a promising preservative effect on the treated samples with a significant enhancement of the sensory quality. Frankincense extract showed higher acceptability rates in comparison with the other examined additives; therefore, more research on its phytochemical structure, active principles, and side effects can be conducted.

1. INTRODUCTION

Poultry meat, especially chicken meat, is one of the most common foods preferred by consumers due to its health benefits with low-fat content, and high nutritional value due to its components of vitamins, minerals, and essential amino acids needed for body growth and immunity (Choi et al., 2023). On the other hand, it has been considered an ideal medium for spoilage and pathogenic microbial growth because it contains growth factors that represent minerals, nitrogenous complex, and high moisture (Katiyo et al., 2020).

Contamination of poultry meat and meat products may occur throughout handling, and processing stages till cold storage, whether due to personal faults and/or environmental and technical factors (Shaltout, 2020). So, using food additives with physical and antimicrobial functions became necessary to prevent the growth of microorganisms, prolong storage time, and increase overall quality and safety of the meat products.

Food additives can be either of chemical origin or natural origin such as herbal extracts and essential oils (Shaltout et al., 2017). Lavender (*Lavandula angustifolia*) and clove (Syzygium aromaticum) oils are food additives with significant preservation effects referring to their components of natural bioactive substances with antifungal, antibacterial, and antioxidant properties (Chouhan et al., 2017). Lavender has an ancient medicinal role due to its sedative, antibacterial and antifungal actions, therefore, it can be used in food preservation like meat, fish, dairy, fruits, and vegetables (Ez zoubi et al., 2020). On the other hand, clove oil has valuable effects on the immune and cardiovascular systems besides its effects as antiviral, antifungal, antibacterial, and antiprotozoal, which may be assigned to eugenol with humulene and caryophyllene (Haro-González et al., 2021).

Frankincense (*Boswellia sacra*) is a gum resin that has a strong, wide range of antimicrobial effects toward some foodborne pathogens like *S. aureus*, *E. coli*, and *Candida albicans* (Almutairi et al., 2022). Frankincense byproducts were used as early as the 11th century to treat microbial infections such as urinary infections, oral infections, arthritis, and asthma (Almeida-da-Silva et al., 2022).

This work was conducted to evaluate the improving effect of lavender, clove oils, and frankincense aqueous extract on the sensory and microbiological quality of raw drumsticks in refrigerated storage at 4 °C to obtain safe food for consumers without any public health hazard and enhance shelf life.

2. MATERIALS AND METHODS

2.1. Collection of chicken drumsticks

A sum of 3200 g of raw fresh chicken drumsticks (approximately 32 pieces) was collected from poultry butchers located in Benha City, Qalubiya Governorate, Egypt.

* Corresponding author: hadil.abbas@fvtm.bu.edu.eg

2.2. Preparation of the used additives

Commercially prepared ready-to-use clove and lavender (*Lavandula*) oils were extracted using a hydro-distillation technique and then were kept in dry-sealed amber glass containers in the refrigerator until use (Barros et al., 2022). On the other hand, frankincense aqueous extract was performed according to Riyad et al. (2020), where frankincense resin powder was mixed with boiled dist. water for one hour, followed by sieving and dryness in an electric oven, at 55 °C, overnight. Working solutions (1.0%) of the used oils and dried aqueous extracts were prepared by dissolving in tween-8- for oils and dist. water for the aqueous extract.

2.3. Experiment grouping

The drumstick samples were divided into four primary groups (8 drumsticks/each group, where each sample weighed about 100 g). Sensory and microbiological quality were investigated before treatment for each group. Each group was partitioned into four secondary groups as follows: (G1) untreated control group; and groups of G2 to G4 were treated with clove oil, lavender oil, and frankincense extract (1.0%), respectively.
Treated groups were treated by soaking in the tested additives for 24h, and stored in a refrigerator. Sensory and bacteriological examinations were started after 24h of soaking samples in the test additives (zero time), then repeated every 3 days (0, 3, 6, and 9) days of storage. Samples were subjected to the following examinations:

2.3.1. Microbiological examination

Samples were prepared according to ISO 6887-1 (2017), followed by counting of total bacterial count (TBC), *Staphylococcus aureus, Escherichia coli,* and total fungal counts according to ISO 4833-1 (2013), ISO 6888- 1 (2003), ISO 16649-2 (2018), and ISO 21527-1 (2008), respectively. Three readings were recorded by repeating the experiment three times for data confirmation.

2.3.2. Sensory evaluation of examined meat samples

The sensory quality (color, odor, texture, and taste) of the samples was graded on a scale of 1 to 5, with 5 denoting excellent and 1 denoting the worst sensory characteristics, following Mörlein (2019). Samples were fried for taste scoring. Changes in the superscript letters above mean values indicate significant differences.

2.4. Statistical analysis

SPSS version 20 was used to analyze the data. The significance of the differences in the mean values of the groups under investigation was determined using ANOVA analysis and the Duncan post hoc value. A significance level of $p < 0.05$ was deemed significant.

3.

4.

3. RESULTS

The findings shown in Table (1) indicate that the tested additives (1.0%) had a positive impact on the sensory attributes and overall acceptability of the chicken drumstick samples that were treated and stored under refrigeration. The control samples showed signs of organoleptic deterioration by the sixth day of storage (score: <1), according to the results; however, the groups that received frankincense treatments were still suitable by the ninth day of storage (score: 3.5). When compared to the other additives under investigation, frankincense extract displayed greater acceptability rates.
As shown in Tables (2-5), a promising significant (when $p \leq 0.05$) antimicrobial activity of the tested additives was observed through significant retardation in the microbial replication and multiplication represented by their count/g of the treated samples; where the total bacterial count (TBC) (CFU/g) for clove oil, lavender oil, and frankincense extract treated samples were $4.5x10^{6}$, $8.2x10^{5}$ and $4.5x10^{5}$, respectively. Although, all of the examined additives showed antimicrobial activity, frankincense aqueous extract had a higher inhibitory effect on microbial growth, especially against *Staph. aureus* and fungal counts, followed by lavender and clove oils, respectively; however, they did not show reductions in their counts, only retardation in growth in comparing with the control group's count in the same day of examination, total bacterial count and *E. coli* counts had a various reduction value in different treated groups.

Table 1. The effects of the examined additives (1.0%) on the overall acceptability of chicken drumstick samples stored at 4ºC

Groups	Tested parameter	Control		Clove oil		Lavender oil		Frankincense extract	
Zero day	Color	5		5		5		5	
	Odor	5		4.5		4.5		5	
	Taste	5		5		4.8		5	
	Texture	5		5		5		5	
	Overall	5.0 ± 0.0^{a}	VG	4.8±0.5	VG	4.8±0.2	VG	5.0±0.0	VG
3^{nd} day	Color	3.2		4.0		4.2		4.6	
	Odor	2.6		3.8		4.0		4.4	
	Taste	3		4.4		4.6		4.7	
	Texture	3.2		4.2		4.4		4.8	
	Overall	3.0 ± 0.2^{c}	A	4.1±0.4	G	4.3±0.3	G	4.6±0.3	G
6^{th} day	Color	<1		3.2		3.8		4.2	
	Odor	<1		2.8		3.2		3.8	
	Taste	<1		3.2		3.4		3.8	
	Texture	<1		3.0		3.6		4.4	
	Overall	<1	S.	3.1±0.3	A	3.5±0.3	A	4.1±0.4	G
9^{th} day	Color	<1		2.6		2.5		3.2	
	Odor	<1		2.6		3.0		3.0	
	Taste	<1		2.8		2.5		3.4	
	Texture	<1		2.4		2.8		3.2	
	Overall	<1	S	2.6±0.3	U	2.7±0.2	U	3.5±0.4	A

Zero time is 24h post soaking in the relevant extract. 5: Very good (VG) 4: Good (G) 3: Acceptable (A) 2: Unacceptable (U) 1: Bad (B) S: Spoiled (S)

Table, 2. The average of total bacterial counts (CFU/g) in the examined chicken drumstick samples stored at 4ºC.

Storage time	Control	Clove oil (1%)	R%	Lavender oil (1%)	R%	Frankincense extract (1%)	R%
Pre-treatment	$2.0×10^5± 0.37×10^{5a}$	$2.0×10^5± 0.4×10^{5a}$	--	$2.0×10^5± 0.37×10^{5a}$	--	$2.0×10^5± 0.37×10^{5a}$	--
Zero time	$9.5×10^5± 1.2×10^{5a}$	$1.0×10^5± 0.2×10^{5b}$	50.0	$0.9×10^5± 0.01×10^{5b}$	55.0	$0.85×10^5± 0.01×10^{5b}$	57.5
3rd day	$6.4×10^6± 1.2×10^{6a}$	$7.2×10^5± 0.5×10^{5b}$	Increased count	$0.75×10^5± 0.06×10^{5c}$	62.5	$0.26×10^5± 0.03×10^{5d}$	87.0
6th day	Grossly Spoiled	$1.2×10^6± 0.2×10^{6a}$	Increased count	$3.0×10^5± 0.43×10^{5b}$	Increased count	$0.68×10^5± 0.07×10^{5c}$	66.0
9th day	Grossly Spoiled	$4.5×10^6± 0.5×10^{6a}$	Increased count	$8.2×10^5± 0.75×10^{5b}$	Increased count	$4.5×10^5± 0.54×10^{5c}$	Increased count

Results are presented as mean ± standard error
Zero time began after overnight soaking of the treated samples in the used extract in refrigerator.
[abc] Different superscript letters within the same raw were considered as significant different when $p \leq 0.05$.
R% (Reduction %) was calculated in relation to the initial bacterial count ($2.0x10^5$ CFU/g)
Increased count: mean the present count exceeded the initial bacterial count ($2.0x10^5$ CFU/g)

Table 3: The average of *E. coli* counts (CFU/g) in the examined chicken drumstick samples stored at 4ºC.

Storage time	Control	Clove oil (1%)	R%	Lavender oil (1%)	R%	Frankincense extract (1%)	R%
Pre-treatment	$6.4×10^2± 0.6×10^{2a}$	$6.4×10^2± 0.6×10^{2a}$	--	$6.4×10^2± 0.6×10^{2a}$	--	$6.4×10^2± 0.6×10^{2a}$	--
Zero time	$7.5×10^2± 0.8×10^{2a}$	$1.2×10^2± 0.1×10^{2b}$	81.2	$0.9×10^2± 0.1×10^{2d}$	85.9	$1.5×10^2± 0.2×10^{2b}$	76.6
3rd day	$10×10^2± 2.0×10^{2a}$	$5.1×10^2± 0.7×10^{2b}$	20.3	$1.3×10^2± 0.2×10^{2d}$	79.7	$7.6×10^2± 0.6×10^{2b}$	Increased count
6th day	Grossly Spoiled	$9.5×10^2± 1.0×10^{2b}$	Increased count	$7.2×10^2± 0.7×10^{2d}$	Increased count	$9.8×10^2± 0.8×10^{2b}$	Increased count
9th day	Grossly Spoiled	$28×10^2± 3.0×10^{2b}$	Increased count	$12×10^2± 1.0×10^{2d}$	Increased count	$18×10^2±2.0×10^{3b}$	Increased count

Results are presented as mean ± standard error
Zero time began after overnight soaking of the treated samples in the used extract in refrigerator.
[abc] Different superscript letters within the same raw were considered as significant different when $p \leq 0.05$.
R% (Reduction %) was calculated in relation to the initial bacterial count ($6.4x10^2$ CFU/g)
Increased count: mean the present count exceeded the initial bacterial count ($6.4x10^2$ CFU/g)

Table 4: The average of *S. aureus* counts (CFU/g) in the examined chicken drumstick samples stored at 4ºC.

Storage time	Control	Clove oil (1%)	Lavender oil (1%)	Frankincense extract (1%)
Pre-treatment	1.0×102± 0.1×102a	1.0×102± 0.1×102a	1.0×102± 0.1×102a	1.0×102± 0.1×102a
Zero time	$8.6×10^2± 1.9×10^{2a}$	$1.2×10^2± 0.2×10^{2b}$	$1.1×10^2± 0.3×10^{2b}$	$1.0×10^2± 0.3×10^{2b}$
3rd day	$14×10^2± 2.0×10^{2a}$	$7.2×10^2± 0.3×10^{2b}$	$2.3×10^2± 0.2×10^{2c}$	$2.0×10^2± 0.2×10^{2d}$
6th day	Grossly Spoiled	$18×10^2± 2.0×10^{2a}$	$2.8×10^2± 0.3×10^{2b}$	$2.6×10^2± 0.3×10^{2c}$
9th day	Grossly Spoiled	$38×10^2± 4.0×10^{2a}$	$15×10^2± 0.2×10^{2b}$	$8.2×10^2± 1.0×10^{2c}$

Results are presented as mean ± standard error
Zero time began after overnight soaking of the treated samples in the used extract in refrigerator.
[abc] Different superscript letters within the same raw were considered as significant different when $p \leq 0.05$.
Reduction of *S. aureus* count was not recorded in all the treated samples, only growth retardation in relation to the control group's count in the same day of examination.

Table 5: The average of total fungal counts (CFU/g) in the examined chicken drumstick samples stored at 4ºC.

Storage time	Control	Clove oil (1%)	Lavender oil (1%)	Frankincense extract (1%)
Pre-treatment	$1.8×10^2± 0.4×10^{2a}$	$1.8×10^2± 0.4×10^{2a}$	$1.8×10^2± 0.4×10^{2a}$	$1.8×10^2± 0.4×10^{2a}$
Zero time	$3.0×10^2± 0.3×10^{2a}$	$2.6×10^2± 0.3×10^{2b}$	$2.3×10^2± 0.3×10^{2c}$	$2.0×10^2± 0.4×10^{2d}$
3rd day	$5.4×10^2± 0.7×10^{2a}$	$4.6×10^2± 0.5×10^{2b}$	$3.7×10^2± 0.4×10^{2c}$	$3.5×10^2± 0.5×10^{2d}$
6th day	Grossly Spoiled	$6.2×10^2± 0.7×10^{2a}$	$5.0×10^2± 0.7×10^{2b}$	$4.6×10^2± 0.6×10^{2c}$
9th day	Grossly Spoiled	$7.9×10^2± 0.8×10^{2a}$	$6.7×10^2± 0.8×10^{2b}$	$5.5×10^2± 0.7×10^{2c}$

Results are presented as mean ± standard error
Zero time began after overnight soaking of the treated samples in the used extract in refrigerator.
[abc] Different superscript letters within the same raw were considered as significant different when $p \leq 0.05$.
Reduction of *total fungal count* was not recorded in all the treated samples, only growth retardation in relation to the control group's count in the same day of examination.

4. DISCUSSION

Any further processing changes of muscle following an animal's slaughter results in meat products; which are vital and indispensable in a balanced diet due to their high-water content and high nutritional value proteins. But for the same reasons, it's highly conducive to the growth of microbes, which primarily occur in slaughterhouses; where, 80–90% of the microbiota in meat originates there (Shaltout et al., 2022).

The agri-food industry is regarded as one of those that has a direct impact on human existence. The food sector needs to be able to supply meals that will probably guarantee consumers' nutritional satisfaction. Many ancient cultures have been using herbal byproducts for ages to enhance the flavor and scent of their meal. Additionally, because of their antibacterial qualities, they have been utilized as a food preservative (Hintz et al., 2015). According to data on foodborne illnesses worldwide, two-thirds of foodborne disease outbreaks are caused by bacterial food poisoning (Abebe et al., 2020). Salmonella spp., *E. coli*, and *Staph. aureus* are the primary microbes linked to manipulation techniques (Bukhari et al., 2021).

Referring to the obtained results in Table (1), the used extracts revealed significant sensory improvement of the treated samples. Although, clove and lavender oils had an enhancement effect on the overall sensory quality, odor and taste were slightly adversely affected immediately after overnight soaking that may be referred to their powerful odor and the volatile substances in the oily extracts (Guo and Wang, 2020). On the other hand, frankincense aqueous extract showed a remarkable ripening effect in the treated samples, with improving taste and overall acceptability represented by elongation in the shelf life up to the 9th day of the cold storage.

Enhanced sensory characteristics of the treated drumstick may be linked with the bioactive contents of the used additives that play powerful antimicrobial and antioxidant effects (Riyad et al., 2020).

Because meat and meat products are perishable and high in vital nutrients, they are especially susceptible to microbial deterioration. Improper preservation can lead to public health issues. Novel ingredient systems linked to natural and organic foods have been used recently to improve the microbiological quality of meat and meat products. The antibacterial properties of natural antimicrobials derived from plants have been shown in numerous studies to be present in meat and meat products. However, using various methods, cutting-edge technology can enhance the sensory quality and microbiological stability of meat products that contain natural extracts and essential oils (Aminzare et al., 2016).

The food business is paying more and more attention to natural antimicrobials. Plant essential oils are increasingly being used as natural antibacterial agents (Bassolé and Juliani, 2012). One significant aromatic spice is clove (*Syzygium aromaticum*). In addition to having a wide variety of biologically active components, cloves have extensive and potent antibacterial properties (Sebaaly et al., 2015). The primary chemical components found in its essential oil are phenylpropanoids, including eugenol, β-caryophyllene, and α-humulene (Gülçin et al., 2012).

The antimicrobial effects of the applied additives, as shown in Tables (2–5), were consistent with the findings of Wang et al. (2018), Hassanien et al. (2019), and Zaqzouq et al. (2022), who found a noteworthy improvement in the meat samples treated with clove oil. Eugenol, together with a tiny amount of cariophyllene and humulene, is responsible for cloves' antimicrobial properties and unique scent through its effects by the lipophilic nature of components which facilitate penetrating bacterial cell membrane and mitochondria lead to proton pump fail and ATP pool depletion causing cytoplasmic protein denaturation and cell membrane lysis (Daniel et al., 2009; Nazzaro et al., 2013; Safrudin et al., 2015).

Due to its essential oil (EO) qualities, lavender species are among the most widely grown in the world; numerous research studies have demonstrated their biological and antibacterial capabilities (Carrasco et al., 2016). The essential oil of lavender is yellow and has a strong floral aroma. It is mostly extracted using steam or hydro-distillation, yielding a yield of about 3%. The main components of this oil are oxygenated monoterpenes, monoterpene hydrocarbons, and sesquiterpenes, with the highest concentrations being linalool, linalyl acetate, (Z)-β-ocimene, terpinen-4-ol, lavandulyl acetate, β-caryophyllene, (E)-β-ocimene, α-terpineol, and 1,8-cineole that enhancing its antibacterial effect and enabling to prevent bacterial cell attachment, protein denaturation and promote microbiological stability (Sadeghi et al., 2013; Pieracci et al., 2021). Because of its bioactive components, which have the potential to benefit human health, lavender species, and their essential oils have been employed in popular medicine since ancient times. In particular, the richness in phenolic compounds confers to lavender EOs a high antioxidant activity due to a protective effect against the oxidative damage caused by free radicals (Turgut et al., 2017).

Referring to the recorded results of the lavender oil antimicrobial activity in Tables (2-5), came in agreement with those recorded by Predoi et al. (2018) and Atia (2019) who recorded a significant antimicrobial effect of lavender oil against foodborne *K. pneumonia* and *S. aureus.* Authors attributed their antimicrobial activity to their bioactive compounds, especially linalool, and other compounds.

The resin of frankincense is derived from Boswellia trees, members of the Burseraceae family. It is one of the earliest aromatic and therapeutic herbs (Khalifa et al., 2023). A combination of water-soluble gums (polysaccharides), alcohol-soluble resins (diterpenes and triterpenes), and essential oils (mono- and sesquiterpenes) make up the oleo-gum resin of frankincense (Hamm et al., 2005). Since 5000 years ago, Indians have documented the health benefits of frankincense powder and extracts, as they were utilized as anti-inflammatory agents and in combination to treat various infections (Lemenih and Teketay, 2003; Mertens et al., 2009). It is thought that frankincense extract antimicrobial effect may be referred to as its ability to reduce bacterial cell membrane integrity and decline extracellular polysaccharide production (Abers et al., 2021).

The obtained results in Tables (2-5) agree with those of Abdallah et al (2009) and Al-Kharousi et al. (2023), who recorded the variable antimicrobial activity of different frankincense extracts against different foodborne and environmental pathogens, especially *E. coli* and *S. aureus* including MRSA strains.

5. CONCLUSIONS

After all, the used clove, lavender, and frankincense byproducts revealed significant enhancement in the sensory, microbial, and keeping quality of the treated drumstick samples in the refrigeration storage; where frankincense aqueous extract had more preferable action than the other used treatments.

6. REFERENCES

1. Abdallah, E.M., Khalid, A.S., Ibrahim, N., 2009. Antibacterial activity of oleo-gum resins of *Commiphora molmol* and *Boswellia papyrifera* against methicillin resistant *Staphylococcus aureus* (MRSA). Sci. Res. Essay 4, 351–356.
2. Abebe, E., Gugsa, G., Ahmed, M., 2020. Review on major food-borne zoonotic bacterial pathogens. J. Trop. Med. 2020, 4674235-4674240.
3. Abers, M., Schroeder, S., Goelz, L., Sulser, A., Rose, T.S., Puchalski, K., Langland, J., 2021. Antimicrobial activity of the volatile substances from essential oils BMC complement. Med. Ther. 21, 1-14.
4. Al-Kharousi, Z.S., Mothershaw, A.S., Nzeako, B., 2023. Antimicrobial activity of frankincense (*Boswellia sacra*) oil and smoke against pathogenic and airborne microbes. *Foods* 12, 3442-3451.
5. Almeida-da-Silva, C.L.C., Sivakumar, N., Asadi, H., Chang-Chien, A., Qoronfleh, M.W., Ojcius, D.M., Essa, M.M., 2022. Effects of frankincense compounds on infection, inflammation, and oral health. *Molecules 27*, 4174-4180.
6. Almutairi, M.B.F., Alrouji, M., Almuhanna, Y., Asad, M., Joseph, B., 2022. *In-Vitro* and *In-Vivo* antibacterial effects of frankincense oil and its interaction with some antibiotics against multidrug-resistant pathogens. Antibiotics 11, 1591-1600.
7. Aminzare, M., Hashemi, M., Azar, H., Hejazi, J., 2016. The use of herbal extracts and essential oils as a potential antimicrobial in meat and meat products: A review. J. Hum. Environ. Health Promot. 1, 63-74.
8. Atia, W., 2019. Studying the virulence factors of pathogenic bacteria isolated from some food products. Thesis, Master of Science, Zagazig Univ., Egypt.
9. Barros, M., Redondo, L., Rego, D., Serra, C., Miloudi, K., 2022. Extraction of essential oils from plants by hydrodistillation with pulsed electric fields (PEF) pre-treatment. *Appl. Sci.* 12, 8107-8114.
10. Bassolé, I.H.N., Juliani, H.R., 2012. Essential oils in combination and their antimicrobial properties. *Molecules* 17, 3989-4006.
11. Bukhari, M., Banasser, T., El-Bali, M., Bulkhi, R., Qamash, R., Trenganno, A., Khayyat, M., Kurdi, M., Al Majrashi, A., Bahewareth, F., 2021. Assessment of microbiological quality of food preparation process in some restaurants of Makkah city. Saudi J. Biol. Sci. 28, 5993-5997.
12. Carrasco, A., Thomas, V., Tudela, J., Miguel, M.G., 2016. Comparative study of GC-MS characterization, antioxidant activity and hyaluronidase inhibition of different species of *Lavandula* and *Thymus* essential oils. Flavour Fragr. J. 31, 57–69.
13. Choi, J., Kong, B., Bowker, B.C., Zhuang, H., Kim, W.K., 2023. Nutritional strategies to improve meat quality and composition in the challenging conditions of broiler production: A review. Animals 13, 1386-1406.
14. Chouhan, S., Sharma, K., Guleria, S., 2017. Antimicrobial activity of some essential oils-present status and future perspectives. Med. 4, 58-64.
15. Daniel, A.N., Sartoretto, S.M., Schmidt, G., Caparroz-Assef, S.M., Bersani Amado, C.A., Cuman, R.K.N., 2009. Anti-inflammatory and antinociceptive activities of eugenol essential oil in experimental animal models. Revista Brasileira de Farmacognosia 19, 212-217.

16. Ez zoubi, Y., Bousta, D., Farah, A., 2020. A phytopharmacological review of a Mediterranean plant: *Lavandula stoechas* L. Clin. Phyto. Sci. 2020, 6-9.
17. Gülçin, İ, Elmastaş, M., Aboul-Enein, H., 2012. Antioxidant activity of clove oil – A powerful antioxidant source. Arab. J. Chem. 5, 489-499.
18. Guo, X., Wang, P., 2020. Aroma characteristics of lavender extract and essential oil from *Lavandula angustifolia* Mill. Molecules 25, 5541-5549.
19. Hamm, S., Bleton, J., Connan, J., Tchapla, A., 2005. A chemical investigation by headspace SPME and GC-MS of volatile and semi-volatile terpenes in various olibanum samples. Phytochem. 66, 1499–1514.
20. Haro-González, J.N., Castillo-Herrera, G.A., Martínez-Velázquez, M., Espinosa-Andrews, H., 2021. Clove essential oil (*Syzygium aromaticum* L. Myrtaceae): Extraction, chemical composition, food applications, and essential bioactivity for human health. Molecules 26, 6387-6392.
21. Hassanien, F.S., Shaltout, F.A., Homouda, S.N., Arakeeb, S.M., 2019. Natural preservatives in raw chicken meat. Benha Vet. Med. J. 37, 41-45.
22. Hintz, T., Matthews, K.K., Di, R., 2015. The use of plant antimicrobial compounds for food preservation. Biomed. Res. Int. 2015, 246264-246275.
23. ISO 16649-2, 2018. International Organization for Standardization. No. 16649, part 2. Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of glucuronidase-positive *Escherichia coli*.
24. ISO 21527-1, 2008. International Organization for Standardization. No. 21527-1. Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of yeasts and moulds — Part 1: Colony count technique in products with water activity greater than 0,95.
25. ISO 4833-1, 2013. International Organization for Standardization. No.4833-1. Microbiology of the food chain — Horizontal method for the enumeration of microorganisms — Part 1: Colony count at 30 °C by the pour plate technique.
26. ISO 6887-1, 2017. International Organization for Standardization. No.6887-1. Microbiology of the food chain — Preparation of test samples, initial suspension and decimal dilutions for microbiological examination — Part 1: General rules for the preparation of the initial suspension and decimal dilutions.
27. ISO 6888-1, 2003. International Organization for Standardization. No. 6888-1:1999, A1:2003. Microbiology of food and animal feeding Stuffs-Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species)-Part 1: Technique using Baird-Parker agar medium (includes amendment A1:2003).
28. Katiyo, W., de Kock, H., Coorey, R., Buys, E., 2020. Sensory implications of chicken meat spoilage in relation to microbial and physicochemical characteristics during refrigerated storage. LWT 128, 109468-109476.
29. Khalifa, S.A.M., Kotb, S.M., El-Seedi, S.H., Nahar, L., Sarker, S.D., Guo, Z., Zou, X., Musharraf, S.G., Jassbi, A.R., Du, M., 2023. Frankincense of *Boswellia sacra*: Traditional and modern applied uses, pharmacological activities, and clinical trials. Ind. Crops Prod. 203, 117106-117110.
30. Kwiatkowski, P., Łopusiewicz, Ł., Kostek, M., Drozłowska, E., Pruss, A., Wojciuk, B., Sienkiewicz, M., Zielińska-Bliźniewska, H., Dołęgowska, B., 2019. The antibacterial activity of lavender essential oil alone and in combination with octenidine dihydrochloride against MRSA strains. Molecules 25, 95-105.
31. Lemenih, M., Teketay, D., 2003. Frankincense and myrrh resources of Ethiopia: Medicinal and industrial uses. Ethiop. J. Sci. Sustain. 26, 161–172.
32. Mertens, M., Buettner, A., Kirchhoff, E., 2009. The volatile constituents of frankincense-a review. Flavour Fragr. J. 24, 279–300.
33. Mörlein, D., 2019. Sensory evaluation of meat and meat products: fundamentals and applications. The 60th International Meat Industry Conference MEATCON2019. IOP Conf. Series: Earth and Environmental Science. Doi:10.1088/1755-1315/333/1/012007
34. Nazzaro, F., Fratianni, F., Demartino, L., Coppola, L., Defeo, V., 2013. Effect of essential oils on pathogenic bacteria. Pharmaceutic 6(12), 1451-1474.
35. Nuñez, L., D'Aquino, M., Chirife, J., 2001. Antifungal properties of clove oil (*Eugenia caryophylata*) in sugar solution. Braz. J. Microbiol. 32, 123–126.
36. Pieracci, Y., Ciccarelli, D., Giovanelli, S., Pistelli, L., Flamini, G., Cervelli, C., Mancianti, F., Nardoni, S., Bertelloni, F., Ebani, V.V., 2021. Antimicrobial activity and composition of five rosmarinus (now *Salvia* spp. and varieties) essential oils. Antibiotics 10, 1090-1097.
37. Predoi, D., Iconaru, S.L., Buton, N., Badea, M.L., Marutescu, L., 2018. Antimicrobial activity of new materials based on lavender and basil essential oils and hydroxyapatite. Nanomaterials 8, 291-310.
38. Riyad, Y.M., Barakat, H.A., Amer, S.A., 2020. Evaluation of the properties of frankincense powder and its water extracts and the effect of its addition on guava nectar characteristics. Egypt. J. Food. Sci. 48, 159-171.
39. Sadeghi, E., Akhondzadeh Basti, A., Noori, N., Khanjari, A., Partovi, R. 2013. Effect of *Cuminum cyminum* I. essential oil and *Lactobacillus acidophilus* (a probiotic) on *Staphylococcus aureus* during the manufacture, ripening and storage of white brined cheese. J. Food Proc. Preserv. 37, 449-455.
40. Safrudin, I., Maimulyanti, A., Prihadi, A.R., 2015. Effect of crushing of clove bud (Syzygiumaromaticum) and distillation rate on main constituents of the essential oil. Am. J. Essent. Oil. Nat. Prod. 2, 1-12.
41. Sebaaly, C., Jraij, A., Fessi, H., Charcosset, C., Greige-Gerges, H., 2015. Preparation and characterization of clove essential oil-loaded liposomes. Food Chem. 178, 52-62.
42. Shaltout, F., 2020. Microbiological quality of chicken carcasses at modern poultry plant. J. Nutr. Food Proc. 3, 18-24.
43. Shaltout, F., Barr, A., Abdelaziz, A., 2022. Pathogenic microorganisms in meat products. Biomed. J. Sci. & Tech. Res. 41, 32836-32843.
44. Shaltout, F., Thabet, M.G., Koura, H.A., 2017. Impact of some essential oils on the quality aspect and shelf life of meat. J. Nutr. Food Sci. 7, 6-13.
45. Turgut, A.C., Emen, F.M., Canbay, H.S., Demirdöğen, R.E., Çam, N., Kılıç, D., Yeşilkaynak, T., 2017. Chemical characterization of *Lavandula angustifolia* Mill. as a phytocosmetic species and investigation of its antimicrobia in cosmetic products. J. Turk. Chem. Soc. Sect. Chem. 4, 283-298.
46. Wang, Y., Jia, J., Tian, Y., Shu, X., Ren, X., Guan, Y., Yan, Z., 2018. Antifungal effects of clove oil microcapsule on meat products. LWT 89, 604-609.
47. Zaqzouq, G.S., Ebeed, S., El shorbagy, I., Ali, E., 2022. Effect of clove and garlic oils on minced meat quality and some foodborne pathogens. Damanhour J. Vet. Sci. 8, 11-15.