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Impacts of Essential Oils on Minced Meat Quality and Microbial Stability

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Abstract

THIS EXPERIMENT examined the preservative effects of 1% natural essential oils—ginger, basil, and thyme—on minced meat stored at 3±1°C, focusing on microbial growth, chemical spoilage indicators, and sensory quality over 15 days. Initial microbial loads were similar across all samples. The control group exhibited rapid microbial proliferation with total aerobic plate counts (APC) rising from 1.7×10^4 to 3.3×10^6 CFU/g by day 6, leading to spoilage by day 9. In contrast, essential oil treatments significantly suppressed bacterial growth: thyme oil achieved the greatest reduction in APC (up to 88.6% by day 6) and extended shelf life to 15 days, while basil and ginger oils extended it to 12 days. Similar inhibitory effects were observed on coliform and *Staphylococcus* counts, with thyme oil consistently demonstrating superior antimicrobial activity. pH measurements revealed a slower increase in acidity loss in treated samples, particularly with thyme oil maintaining lower pH levels through day 15. Total Volatile Nitrogen (TVN) and Thiobarbituric Acid (TBA) assays, indicators of protein degradation and lipid oxidation respectively, showed delayed increases in oil-treated samples, confirming reduced spoilage rates. Sensory evaluation corroborated these findings, where thyme oil-treated meat maintained very good to acceptable sensory attributes until day 15, significantly longer than control samples which spoiled by day 9. Overall, thyme oil revealed the most effective preservative effect among the essential oils tested, effectively enhancing the microbial safety, chemical stability, and sensory quality of minced meat under refrigeration, suggesting its strong potential as a natural alternative to chemical preservatives.

Keywords: Minced meat, Ginger oil, Thyme oil, Basil oil.

Introduction

The global growth along with the awareness of people about healthy food guides researchers to seek different alternatives to rise shelf-life of food. Meat, as the most palatable and highly nutritional food, represents highly contaminated food with different microbes and chemicals at various stages of production cycles [1]. Grounding meat as one of the most consumed products acts as a good medium for most microbes, due to increasing surface area which elevates the chance for adherence and growth of bacteria [2,3]**.** Although microbial growth is the primary cause of meat spoilage, oxidation and enzymatic activities—such as lipid oxidation—also play a significant role. These processes notably affect the meat's flavor and nutritional quality [4]. Moreover, lipid oxidation results in changes to sensory attributes and produces harmful compounds like aldehydes [5].

To guarantee safety of food and extension of product lifespan, many food conservation methods are applicable in the meat industry. These include addition of organic acid to reserve the property of meat and prolong the lifespan of perishable food matters and bioactive natural compounds in meat [6]. So, the focus on using essential oils as anti-bacterial, anti-fungal and anti-viral activity, as well as anti-oxidant properties, in meat preservation increase greatly [7,8]. These chemicals slow down or prevent the growth of foodborne bacteria which modifies the chemical acceptability limits of meat and potentiate its shelf life **[**9**].**

Ginger EO, derived from the rhizome of the ginger plant (Zingiber officinale), represents a potent antibacterial and antioxidant agent due to their active components that act as a scavenger for free radicals and so lessen the oxidative stress [10]. It is a bioactive compound, representing as bioactive phenols (gingerols, and shogaols, and zingerones) [11]. It is effective against wide range of bacteria and fungi [12]. GEO is deemed as a biocompatible natural substance that has clinical significance in gastrointestinal and respiratory disease therapy [13].

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Basil (*Ocimum basilicum*), a widely used culinary herb from the Lamiaceae family, is recognized for its powerful antioxidant and antimicrobial properties. These benefits primarily stem from their plentiful contented of phenolic acids and aromatic compounds, which contribute to its strong biological activities [14,15]. It grows annually in temperate regions [14]. Traditionally, all parts of the basil plant have been used medicinally to treat a variety of ailments including headaches, coughs, diarrhea, constipation, warts, worms, kidney disorders, and digestive issues [16]. The in vitro activity of basil (*Ocimum basilicum*) essential oil has stated to display a broad range of biological effects, including antimicrobial, antifungal, anticancer, anticonvulsant, hypnotic, and antioxidant activities. These effects are indorsed to its valuable composition of bioactive compounds such as linalool, eugenol, and methyl chavicol, which contribute to its potent therapeutic properties [17,18].

Thyme (Thymus sp.) has attracted considerable attention due to its high content and broad spectrum of phenolic compounds, which contribute to its notable anti-microbial and anti-oxidant properties. These qualities make thyme particularly valuable for use in meat and meat products [19,20]. Additionally, the volatile oil constituents of thyme have long been known to possess antimicrobial properties against a number of bacterial and fungal species because of its potential to disrupt the bacterial lipid bi-layer and encourage the breakdown of the cell membrane [21].

The beneficial antibacterial impact of the essential oils listed above on meat preservation can be explained by their capacity in restricting multiplication of food borne pathogens and spoilage bacteria, prolonging shelf life and guaranteeing food safety. They contribute antioxidant action that prevent oxidation of lipids in meat products, maintaining quality and taste. The current analysis was therefore carried out to determine the effect of ginger, basil and thyme essential oils on the preservation of minced meat by determining the essential quality chemical factors, namely: pH, TVN and TBA.

Material and Methods

Sample Collection

Eight kilograms of fresh minced meat were obtained from various butcher shops in Benha city, Kalyobia governorate, Egypt. Samples were transported in ice boxes to the laboratory. The study examined the effects of ginger (*Zingiber officinale*), basil (*Ocimum basilicum*), and thyme (*Zataria multiflora* Boiss) essential oils on improving meat quality and extending shelf life.

Experimental Design

Meat was split into four groups (~2 kg each): control group and three treated groups with 1% of either ginger, basil, or thyme essential oil. Each specimen was wrapped individually in polyethylene bags.

Treatment Procedure [22].

Treated samples were dipped for 15 minutes in an emulsion containing 1% essential oil, then drained for 5 minutes on a sterile wire mesh. Control samples were dipped in sterile distilled water. All groups were kept at 3±1°C for 15 days.

Microbiological, chemical, and sensory analyses were conducted initially (within 2 hours post-treatment) and periodically every 3 days until spoilage signs appeared. Observations were recorded on days 0, 3, 6, 9, 12, and 15, with five repetitions per test.

Bacteriological Examination

Sample handling: under sterile conditions, 25 g samples were homogenized in 225 ml of 0.1% sterile peptone water, then serially diluted for analysis.

1. A*erobic Plate Count (APC)* [23]*:* Dilutions plated on plate count agar and incubated at 37°C for 24 hours; colonies between 30-300 counted.
2. *Coliform Count (MPN)* [23]: One milliliter from each decimal dilution was inoculated into three fermentation tubes containing 5 ml of Lauryl Sulphate Tryptose (LST) broth with inverted Durham tubes to detect gas production. Both inoculated and control tubes were incubated at 37°C for 24 hours. Tubes showing gas production were recorded as positive. A loopful from each positive tube was then transferred to 2% Brilliant Green Bile Lactose broth and incubated similarly. Gas production in these tubes was observed, and the results were used to determine the presumptive Most Probable Number (MPN) of coliform bacteria per gram using standard MPN tables.
3. *Staphylococcus Count* [24]*:* One ml from each of prepared serial dilutions was spread on Baird Parker agar, incubated at 37°C for 48 hours; shiny black colonies counted.

Chemical analysis

pH Measurement [25]: Ten grams of the sample were mixed with 10 milliliters of distilled water, and the pH was determined at 20°C with a calibrated pH electrode

Total Volatile Nitrogen (TVN) [26].

In a clean distillation flask, 10 g of the sample was mixed with 300 ml of distilled water using a probe mixer. Then, an antifoaming agent and 2 g of magnesium oxide were added. In a 500 ml receiving flask, 25 ml of 2% boric acid and a few drops of indicator were placed. The receiving flask was set up so that the receiver tube was submerged in the boric acid solution. The mixture in the distillation flask was heated until boiling within 10 minutes, then boiled for 25 minutes while distilling. After distillation, the amount of Total Volatile Nitrogen (TVN) collected in the boric acid was measured by titrating with 0.1 N sulfuric acid (H2SO4). TVN was calculated using the formula:

TVN (mg/100g) = (ml of H2SO4 used for the sample – ml used for the blank) × 14

Thiobarbituric Acid Number (TBA) [27].

The test measures malondialdehyde (MDA), a primary product of lipid peroxidation, to assess oxidative rancidity in meat. The result is expressed as the Thiobarbituric Acid (TBA) value, indicating milligrams of MDA per kilogram of sample, which reflects lipid oxidation and meat quality. For the test, ten grams of meat were homogenized with fifty ml distilled water and diluted hydrochloric acid, then antifoaming agents were added. The mixture was heated to distill 50 ml within 10 minutes of boiling. Next, 5 ml of the distillate was mixed with 5 ml of thiobarbituric acid reagent (prepared in 90% trichloroacetic acid). The mixture was boiled in a water bath for 35 minutes, cooled for 10 minutes, and its absorbance measured at 538 nm using a spectrophotometer (UNICAM969AA Spectronic, USA).

TBA value= absorbance of sample x 7.8 (malonaldehyde (mg) /Kg)

Sensory Evaluation [28]

A trained 6-member panel evaluated color, odor, appearance, and consistency using a 5-point scale (5 = very good to 1 = bad). Panelists evaluated randomized samples served on porcelain plates at room temperature.

Statistical analysis

The formed data were statistically analyzed using one-way analysis of variance (ANOVA) through the Statistical Package for the Social Sciences (SPSS) software, Windows version 16 (2007) (SPSS Inc., Chicago, IL, USA). Subsequently, Duncan's post hoc test was conducted to compare the means, with a significance level set at $P \leq 0.05$ to determine statistical significance.

Results and Discussion

Meat's high moisture content and abundant nutrients make it highly prone to spoilage quickly, even when stored under refrigeration, which shortens its shelf life [29]. Moreover, resorting to the use of chemical additives to increase the efficiency of meat has been diminished due to its carcinogenic effects [30,31]. Therefore, it has become important to explore alternative methods to provide antibacterial effects and extend shelf life. Recently, natural plant extracts have acquired marked interest in food preservation because of their ability to inhibit harmful microorganisms through their antibacterial and antioxidant properties [32]. Essential oils can help satisfy the increasing demand for "green food" products made from natural ingredients, as consumers increasingly prefer foods free from chemicals [33].

The results in Table (1,2,3) demonstrated that the treated minced meat with 1% natural essential oils (ginger, basil, and thyme) significantly reduced aerobic plate counts (APC), coliforms, and *Staphylococcus* counts compared to the control during storage at 3±1°C. By day 3, control samples showed sharp increases in microbial counts indicative of spoilage, while treated samples exhibited 49.3–75% reductions in APC, with thyme oil being the most effective. This trend continued through day 15, where thyme oil maintained lower bacterial levels and best preserved the meat, whereas controls were spoiled by day 9. Coliform and *Staphylococcus* count mirrored this pattern, with thyme oil consistently providing the greatest antimicrobial effect, extending shelf life and delaying spoilage onset. These mainly contributed to the presence of different active compounds on the examined essential oils that potentiate antibacterial effects, through its capability to penetrate the cell membrane and cytoplasmic membrane of bacterial cell and interact with wide range of bacterial cell components due to its hydrophobic nature. This interaction causes loss of cellular contents, damage to membrane structure and integrity, and disruption of the proton motive force, inhibiting critical processes like respiration and ion transport. As a result, protective enzymes are impaired, nutrient transport is disrupted, and vital molecules leak from the cell, ultimately leading to cell death [34].

The antibacterial activity of ginger attributed to the presence of several active compounds like "zingiberene, α-farnesene, 6-gingerol, and α-curcumene" that affect on the cell permeability and lead to bacterial death [35]. Based on our result, ginger helps in maintenance the shelf life of minced meat until the 12^{th} days of cold storage, this aligns with Lei et al. [36] and Ju et al. [37] who proved that ginger essential oils have broad spectrum antibacterial activity and can effectively resist the foodborne pathogenic bacteria. Moreover, the higher contents of phenolic acids and fragrant compounds in the basil oil potentiate its antibacterial and antioxidant activity [14], as seen in the results the 1% basil oil also help in keeping the shelf life of meat until the 12^{th} day of cold storage, these agree with Tankeo et al. [38], demonstrated that basil oil has great effect on both gram positive and gram negative bacteria. In addition, Suppakul et al. [39] claimed that basil oil has antibacterial effects against enterobacteriaceae families. Moreover, Sakkas and

Papadopoulou [40] found that the higher content of linalool and estragole in basil oil aggravates its action against *Staphylococcus* species.

The best actual essential oil among examined oils was thyme oil 1%, that showed extended effect over 15th days of cold storage, this attributed to their high content of thymol which represents a potent plant extract. The outcomes of the recent study agree with the findings of Salem et al. [41], clarified the strong effect of thyme oil in reduction of APC and coliform counts in the refrigerated minced meat. In addition, Helander et al. [42] found the highly effective action of thyme oil on *Staphylococcus aureus* as a result of its ability to bind hydrophobically with its membrane. These results are consistent with the previous studies and support the notion that essential oils, in particular thyme oil, could serve as a natural preservative in various meat products [43,44].

pH is a crucial marker of meat quality and freshness because it reflects the metabolic changes that occur during storage. Fresh meat usually has a slightly acidic pH, which can vary depending on the animal species, muscle type, and diet. Changes in pH can provide important information about meat condition, as spoilage often leads to an increase in pH due to microbial growth and the production of alkaline compounds like ammonia. Therefore, monitoring pH changes during storage helps detect microbial spoilage and ensures the safety and quality of meat products [45]. Regarding the results in Table (4), the pH values of minced meat treated with 1% ginger, basil, or thyme essential oils remained more stable during 15 days storage at 3±1°C compared to the control. While the control sample's pH increased significantly from around 5.65 to 6.85 by day 6—indicating spoilage—thyme oil showed the greatest efficacy in maintaining lower pH levels (5.71 on day 3 and 5.82 on day 6), followed by basil and ginger oils. Thyme-treated samples maintained acceptable pH values up to day 15 (6.50), delaying spoilage longer than other treatments. This effect is likely due to the antioxidant and antibacterial activities of the essential oils [46]. The addition of ginger oil 1% helps reduce pH to 6.7 within the 12th days of cold storage, this is constituted with Shaltout et al. [47] and Abd El-Aziz [48], who demonstrated that essential oil of ginger was more effective in lowing pH values. The addition of basil oil 1% showed better effect on pH of minced meat over the storage days and extend the shelf life to 12th days of storage with pH value 6.4, this aligns with the outcomes of Mohammed and Alrefiee [49] and Khald et al. [50], that detect the potent effect of basil oil in diminishing the pH value through the storage period. The most effective oil that lowering the pH level was the thyme oil that keep the pH within the acceptable level till the 15th days of storage "pH 6.5", this coincides with the results of Salem et al. [41], Kassem et al. [51] and Shaltout et al. [47] that found effective action of thyme oil in reducing pH value within storage period.

TBA and TVN are commonly used as indicators of meat quality and freshness. TVN measures volatile nitrogenous compounds like ammonia and amines, which are released during protein breakdown caused by proteolytic enzymes and microbial activity, with higher TVN levels indicating advanced spoilage and unpleasant odors [52]. The TBA assay measures malondialdehyde (MDA), a marker of lipid oxidation that occurs when unsaturated fats in meat react with oxygen, leading to lipid degradation through reactive oxygen species [53]. In this study, both TVN and TBA values gradually increased due to enzymatic and microbial lipolytic and proteolytic activities Table (5,6). At the start, all samples had low TVN (~2.5 mg/100g) and TBA (0.07 mg/Kg), indicating freshness. By day 3, TVN and TBA increased significantly in the control group, reflecting spoilage onset, while essential oil-treated samples showed notably lower values, with thyme oil most effective in delaying spoilage. At day 6, control TVN and TBA peaked sharply, but thyme oil maintained TVN at 7.72 mg/100g and TBA at 0.92 mg/Kg by day 15. The produced results are constituted with the findings of Elbalsy et al. [54], Eldahrawy et al. [55], Zhang et al. [56], Ibrahim et al. [57] reported significant antibacterial and antioxidant effects of the herbal extracts used in treated meat products, which positively influenced pH, TVN, and TBA values, consequently improving meat freshness, quality, and shelf life.

Lipid and pigment oxidation, along with the release of fatty acids, are considered the prime factors prompting the appearance and flavor of products during storage [58]. So, the sensory evaluation of the tested treated meat is mandatory, and this occurs through a panel of many experts to judge on the quality of meat [59]. Based on the recent study the sensory evaluation table (7) showed that all minced meat samples started with high quality scores. However, the control rapidly declined, becoming unacceptable on day 6 and spoiled by day 9. In contrast, treatments with 1% essential oils extended sensory shelf life significantly: ginger oil maintained good quality until day 6, basil oil preserved acceptability through day 12, and thyme oil showed the best preservation, sustaining acceptable quality up to day 15 without spoilage. This confirms essential oils, especially thyme, effectively maintain meat sensory attributes during refrigerated storage, this supports the conclusions of Sasse et al. [60], that found the addition of herbs to meat cause enhancement of colour and flavor due to their antioxidants. Also, Salem et al. [41] and

Shaltout et al. [47] demonstrated enhancement in meat sensory characters after addition of thyme with different concentrations. We focused the sensory evaluation on raw minced meat samples to specifically assess the impact of essential oils on spoilage-related attributes such as color, odor, and texture during refrigerated storage. Cooking can alter these sensory parameters and potentially mask early spoilage signs. However, assessing taste changes after cooking is indeed valuable for overall acceptability and consumer relevance. In future studies, we plan to include cooked sample evaluations to comprehensively evaluate how these essential oils affect flavor and sensory quality post-cooking.

Conclusion

The high moisture and nutrient content of meat make it highly susceptible to rapid spoilage, even under refrigeration, highlighting the need for effective preservation methods. The incorporation of chemical additives has dropped due to their potential health risks, prompting interest in natural alternatives such as essential oils, which possess strong antibacterial and antioxidant properties. This study demonstrated that natural essential oils, particularly thyme oil, effectively extend the shelf life and preserve the quality of minced meat during refrigerated storage by significantly reducing microbial growth and delaying spoilage markers such as pH rise, total volatile nitrogen, and lipid oxidation. Additionally, these oils maintain sensory attributes like color, odor, and texture for longer periods compared to untreated controls, making them promising natural preservatives that offer a safer, consumer-friendly alternative to chemical additives.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

TABLE 1. Influence of natural essential oils on APC/g for enhancement of minced meat storage duration (3±1°C).

EOS / Storage	Control	1% Ginger oil		1% Basil oil		1% Thyme oil	
		Count	**R %**	**Count**	**R %**	**Count**	**R %***
Zero time	$1.7\times10^{4}\pm 0.1\times10^{4}$	$1.7\times10^{4}\pm 0.1\times10^{4}$	------	$1.7\times10^{4}\pm 0.1\times10^{4}$	------	$1.7\times10^{4}\pm 0.1\times10^{4}$	------
3rd day	$4.8\times10^{5}\pm 0.5\times10^{5\,a}$	$6.2\times10^{4}\pm 0.7\times10^{4\,b}$	49.3	$5.3\times10^{4}\pm 0.4\times10^{4\,c}$	63.5	$3.9\times10^{4}\pm 0.3\times10^{4\,d}$	75
6th day	$3.3\times10^{6}\pm 0.2\times10^{6\,a}$	$2.8\times10^{5}\pm 0.2\times10^{5\,b}$	80.7	$2.0\times10^{5}\pm 0.1\times10^{5\,c}$	83.4	$9.6\times10^{4}\pm 1.1\times10^{4d}$	88.6
9th day	S	$7.9\times10^{5}\pm 0.7\times10^{5\,a}$	------	$6.2\times10^{5}\pm 0.7\times10^{5\,b}$	------	$4.5\times10^{5}\pm 0.3\times10^{5\,c}$	------
12th day	S	$1.5\times10^{6}\pm 0.1\times10^{6\,a}$	------	$9.8\times10^{5}\pm 1.1\times10^{5\,b}$	------	$7.4\times10^{5}\pm 0.8\times10^{5\,c}$	------
15th day	S	S	------	S	------	$1.0\times10^{6}\pm 0.1\times10^{6\,c}$	------

R %* = Reduction % **S** = Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 2. Influence of natural essential oils on coliform count/g for enhancement of minced meat storage duration (3±1°C).

EOS / Storage	Control	1% Ginger oil Count	1% Ginger oil R %	1% Basil oil Count	1% Basil oil R %	1% Thyme oil Count	1% Thyme oil R %*
Zero time	$6.5\times10^2\pm 0.6\times10^2$	$6.5\times10^2\pm 0.6\times10^2$	------	$6.5\times10^2\pm 0.6\times10^2$	------	$6.4\times10^2\pm 0.6\times10^2$	------
3rd day	$9.1\times10^3\pm 0.8\times10^{3\ a}$	$3.2\times10^3\pm 0.3\times10^{3\ b}$	37.2	$1.9\times10^3\pm 0.2\times10^{3\ c}$	56.4	$1.3\times10^3\pm 0.1\times10^{3\ d}$	73.1
6th day	$1.6\times10^5\pm 0.1\times10^{5\ a}$	$8.0\times10^3\pm 0.7\times10^{3\ b}$	66.7	$5.6\times10^3\pm 0.5\times10^{3\ c}$	79.8	$4.2\times10^3\pm 0.3\times10^{3\ d}$	84.7
9th day	S	$2.5\times10^4\pm 0.2\times10^{4\ b}$		$1.3\times10^4\pm 0.1\times10^{4\ b}$		$8.7\times10^3\pm 0.1\times10^{3\ c}$	
12th day	S	$7.1\times10^4\pm 0.4\times10^{4\ a}$		$4.8\times10^4\pm 0.5\times10^{4\ a}$		$2.3\times10^4\pm 0.2\times10^{4\ b}$	
15th day	S	S		S		$5.6\times10^4\pm 0.4\times10^{4\ b}$	

R %* = Reduction % **S** = Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 3. Influence of natural essential oils on *Staphylococcus* count/g for enhancement of minced meat storage duration (3±1°C).

EOS / Storage	Control	1% Ginger oil Count	1% Ginger oil R %	1% Basil oil Count	1% Basil oil R %	1% Thyme oil Count	1% Thyme oil R %*
Zero time	$3.0\times10^2\pm 0.2\times10^2$	$3.0\times10^2\pm 0.2\times10^2$	------	$3.0\times10^2\pm 0.2\times10^2$	------	$3.0\times10^2\pm 0.2\times10^2$	------
3rd day	$7.0\times10^3\pm 0.5\times10^{3\ a}$	$2.0\times10^3\pm 0.1\times10^{3\ b}$	60	$1.0\times10^3\pm 0.1\times10^{3\ c}$	75	$8.0\times10^2\pm 0.7\times10^{2\ d}$	83.3
6th day	$2.0\times10^4\pm 0.1\times10^{4\ a}$	$6.0\times10^3\pm 0.5\times10^{3\ b}$	76.7	$4.0\times10^3\pm 0.3\times10^{3\ c}$	86.7	$1.5\times10^3\pm 0.1\times10^{3\ d}$	94
9th day	S	$9.0\times10^3\pm 0.7\times10^{3\ a}$	------	$5.0\times10^3\pm 0.4\times10^{3\ b}$	------	$3.0\times10^3\pm 0.2\times10^{3\ c}$	------
12th day	S	$2.6\times10^4\pm 0.2\times10^{4\ a}$	------	$1.2\times10^4\pm 0.1\times10^{4\ b}$	------	$7.0\times10^3\pm 0.6\times10^{3\ c}$	------
15th day	S	S	------	S	------	$1.8\times10^4\pm 0.1\times10^{4\ c}$	------

R %* = Reduction % **S** = Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 4. Influence of natural essential oils on pH values for enhancement of minced meat storage duration (3±1°C).

EOS / Storage	Control	1% Ginger oil	1% Basil oil	1% Thyme oil
Zero time	5.66 ± 0.01	5.65± 0.01	5.65± 0.01	5.63± 0.01
3rd day	6.19 ± 0.01^a	5.83 ± 0.01^b	5.76 ± 0.01^b	5.71 ± 0.01^b
6th day	6.85 ± 0.01^a	6.10 ± 0.01^b	5.94 ± 0.02^c	5.82 ± 0.01^c
9th day	S	6.36 ± 0.01^a	6.13 ± 0.02^b	5.97 ± 0.01^c
12th day	S	6.71 ± 0.02^a	6.42 ± 0.03^a	6.19 ± 0.02^b
15th day	S	S	S	6.50± 0.02

R %* = Reduction % **S** = Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 5. Influence of natural essential oils on TVN values (mg/100g) for enhancement of minced meat storage duration (3±1°C).

EOS Storage	Control	1% Ginger oil	1% Basil oil	1% Thyme oil
Zero time	2.59 ± 0.14	2.52 ± 0.14	2.48 ± 0.14	2.46 ± 0.14
3rd day	11.94± 0.39 a	7.06± 0.31 b	6.62± 0.25 c	6.35± 0.17 d
6th day	23.65± 0.82a	10.81± 0.38 b	8.97± 0.34 c	7.72± 0.26 d
9th day	S	16.90± 0.53 a	14.05± 0.48 b	11.89± 0.40 c
12th day	S	21.43± 0.70 a	19.51± 0.59 a	16.28± 0.51b
15th day	S	S	S	20.79± 0.66

R %*= Reduction % **S**= Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 6. Influence of natural essential oils on TBA values (mg/Kg) for enhancement of minced meat storage duration (3±1°C).

EOS Storage	Control	1% Ginger oil	1% Basil oil	1% Thyme oil
Zero time	0.07± 0.01	0.07± 0.01	0.07± 0.01	0.07± 0.01
3rd day	0.59± 0.04 a	0.28± 0.02 b	0.19± 0.01 b	0.14± 0.01 b
6th day	1.22± 0.06 a	0.49± 0.03 b	0.35± 0.02 c	0.23± 0.01 c
9th day	S	0.76± 0.03 a	0.54± 0.02 b	0.37± 0.02 c
12th day	S	1.04± 0.05 a	0.81±0.04 a	0.58± 0.02 b
15th day	S	S	S	0.92± 0.05

R %*= Reduction % **S**= Spoiled

*Significantly different (P<0.05) between mean values with varying superscripts in the same row.

TABLE 7. Sensory characteristic traits of the control and essential oils treated minced meat samples (n=5).

Trait Storage time	Color (5)	Odor (5)	Appearance (5)	Consistency (5)	Overall (5)	Grade
Control:						
Zero time	**4.8**	**4.8**	**5.0**	**4.8**	**4.9**	**Very good**
3rd day	**3.6**	**3.0**	**2.8**	**3.4**	**3.2**	**Acceptable**
6th day	**2.0**	**1.8**	**1.6**	**1.8**	**1.8**	**Bad**
9th day	**S**	**S**	**S**	**S**	**S**	**Spoiled**
12th day	**S**	**S**	**S**	**S**	**S**	**Spoiled**
15th day	**S**	**S**	**S**	**S**	**S**	**Spoiled**
1% Ginger oil:						
Zero time	**4.8**	**4.8**	**5.0**	**4.8**	**4.9**	**Very good**
3rd day	**4.2**	**4.4**	**4.8**	**4.6**	**4.5**	**Very good**
6th day	**4.0**	**3.8**	**4.4**	**4.2**	**4.1**	**Good**
9th day	**3.4**	**3.6**	**3.8**	**3.6**	**3.6**	**Acceptable**
12th day	**2.8**	**2.4**	**3.0**	**3.0**	**2.8**	**Unacceptable**
15th day	**S**	**S**	**S**	**S**	**S**	**Spoiled**
1% Basil oil:						
Zero time	**4.8**	**4.8**	**5.0**	**4.8**	**4.9**	**Very good**
3rd day	**4.4**	**4.6**	**4.8**	**4.6**	**4.6**	**Very good**
6th day	**4.2**	**4.2**	**4.6**	**4.4**	**4.4**	**Good**
9th day	**3.8**	**3.4**	**4.2**	**4.0**	**3.9**	**Acceptable**
12th day	**3.2**	**2.8**	**3.4**	**3.4**	**3.2**	**Acceptable**
15th day	**S**	**S**	**S**	**S**	**S**	**Spoiled**

1% Thyme oil:						
Zero time	**4.8**	**4.8**	**5.0**	**4.8**	**4.9**	**Very good**
3rd day	**4.6**	**4.6**	**4.8**	**4.6**	**4.7**	**Very good**
6th day	**4.4**	**4.4**	**4.6**	**4.4**	**4.5**	**Very good**
9th day	**4.2**	**4.2**	**4.4**	**4.0**	**4.2**	**Good**
12th day	**3.6**	**3.6**	**3.8**	**3.4**	**3.6**	**Acceptable**
15th day	**2.8**	**2.6**	**2.6**	**2.8**	**2.7**	**Unacceptable**

4.5- 5: Very good **4-4.5:** Good **3-4:** Acceptable
2-3: Unacceptable **1-2:** Bad **S:** Spoiled

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تأثير الزيوت العطرية علي جودة اللحم المفروم واستقراره الميكروبي

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الملخص

هدفت هذه الدراسة إلى تقييم تأثير الزيوت العطرية الطبيعية بنسبة 1% من كلا من الزنجبيل، الريحان، والزعتر على حفظ اللحم المفروم المخزن عند درجة حرارة 3±1°م ، مع التركيز على نمو الميكروبات، مؤشرات التلف الكيميائي، والجودة الحسية لمدة 15 يومًا. وقد أظهر العد البكتيري الأولي نسبة متشابهة في جميع العينات. بينما أظهرت المجموعة الضابطة تكاثرًا ميكروبيًا سريعًا حيث ارتفع عدد البكتيريا الهوائية الكلية (APC) من 1.7×10^4 إلى 3.3×10^6 خلية/غرام بحلول اليوم السادس، مما أدى إلى تلف العينة بحلول اليوم التاسع. وبالمقابل، أدت معالجات الزيوت العطرية إلى تثبيط نمو البكتيريا بشكل كبير، حيث حقق زيت الزعتر أكبر انخفاض في عد البكتيريا الهوائية بنسبة تصل إلى 88.6% في اليوم السادس، وامتد عمر حفظ اللحم إلى 15 يومًا، بينما مدد زيت الريحان والزنجبيل فترة الحفظ إلى 12 يومًا. وقد لوحظت تأثيرات مثبطة مماثلة على أعداد بكتيريا القولون والبكتيريا العنقودية، مع بقاء الفعالية المضادة للميكروبات لزيت الزعتر متفوقة باستمرار. وقد كشفت قياسات الرقم الهيدروجيني عن التحكم في الأس الهيدروجين للاتجاه الحامضي في العينات المعالجة، خاصة مع زيت الزعتر الذي حافظ على مستويات pH منخفضة حتى اليوم الخامس عشر. كما أظهرت تحاليل النيتروجين الكلي المتطاير (TVN) وحمض الثيوباربيتوريك (TBA) التي تشير إلى تحلل البروتينات وأكسدة الدهون تأخيرات في الارتفاع عند العينات المعالجة بالزيوت، مما يؤكد تقليل معدلات التلف. وقد دعمت التقييمات الحسية هذه النتائج، حيث حافظ اللحم المعالج بزيت الزعتر على خصائص حسية جيدة إلى مقبولة حتى اليوم الخامس عشر، مما يعد فترة أطول بكثير مقارنة بالعينات الضابطة التي تلفت بحلول اليوم التاسع. بشكل عام، أظهر زيت الزعتر أقوى تأثير حفاظي بين الزيوت العطرية المختبرة، معززًا السلامة الميكروبية، الاستقرار الكيميائي، والجودة الحسية للحم المفروم تحت ظروف التبريد، مما يشير إلى إمكانيته الكبيرة كبديل طبيعي للمواد الحافظة الكيميائية.

الكلمات الدالة: لحم مفروم، زيت الزنجبيل، زيت الزعتر، زيت الريحان.