Journal homepage
www.ajas.uoanbar.edu.iq
Anbar Journal of Agricultural Sciences
(University of Anbar – College of Agriculture)

IMPACT OF OREGANO AND HIBISCUS SABDARIFFA ESSENTIAL OILS ON THE SPOILAGE INDEX AND SENSORY CHARACTERISTICS OF KAURMA

N. A. Mirzan

Department of Food Sciences and Quality Control, College of Agricultural Engineering Sciences, University of Sulaimani.

***Correspondence to:** Naska Abdulqadir Mirzan, Department of Food Sciences and Quality Control, College of Agricultural Engineering Sciences, University of Sulaimani, Iraq.
Email: naska.muhamad@univsul.edu.iq

Article info

Received: 2024-11-03
Accepted: 2024-12-25
Published: 2024-12-31

DOI-Crossref:
10.32649/ajas.2024.154979.1469

Cite as:
Mirzan, N. A. (2024). Impact of oregano and hibiscus sabdariffa essential oils on the spoilage index and sensory characteristics of kaurma. Anbar Journal of Agricultural Sciences, 22(2): 1621-1636.

Abstract

Kaurma, a traditional Kurdish meat product, contains a high percentage of fats (30–40%) and is highly susceptible to lipid oxidation and microbial spoilage during storage, which drastically reduces its shelf life and commercial potential. Due to the increasing demand for natural food preservatives, this study investigates the effectiveness of oregano and Hibiscus sabdariffa essential oils as natural additives in improving the oxidative, microbial, and sensory stability of kaurma stored under refrigeration. The kaurma samples were divided into four groups: control (no essential oils), oregano oil (1%), Hibiscus sabdariffa oil (1%), and a combination of both oils (0.5% each). Lipid oxidation, as measured by chemical analyses (peroxide value and thiobarbituric acid-reactive substances (TBARS), was lower in the groups treated with essential oils than in the control ($p < 0.05$). Microbial analysis revealed their antimicrobial properties as evidenced by reduced total viable counts and inhibition of mold and yeast growth in the treated samples. Sensory analysis showed improvements in flavor, texture, and general acceptability among the groups, with the highest scores for those treated with oregano oil. These results show that oregano and Hibiscus sabdariffa essential oils are effective natural preservatives for

extending the shelf life of high-fat meat products as well as can be viable substitutes for synthetic additives.

Keywords: Preservation technique, Kaurma, Shelf life, Essential oils.

تأثير الزيوت العطرية للزعتر والكركديه على مؤشرات التلف والخصائص الحسية للقاورمة

ناسكة عبدالقادر مرزان

قسم علوم الاغذية والسيطرة النوعية- جامعة السليمانية-كلية هندسة العلوم الزراعية.

***المراسلة الى:** د. ناسكة عبدالقادر مرزان، قسم علوم الاغذية والسيطرة النوعية، كلية هندسة العلوم الزراعية، جامعة السليمانية، العراق.

البريد الالكتروني: naska.muhamad@univsul.edu.iq

الخلاصة

القاورمة من الأطعمة الكردية التقليدية، تتراوح نسبة الدهون فيها عادةً بين ٣٠-٤٠٪. هذا المحتوى العالي من الدهون يجعل المنتج عرضة سريعة لأكسدة الدهون، وهذا ما يشكل تحديات كبيرة لإمكانية خزنه وتوافره تجاريا. ونظرًا لتزايد قلق المستهلكين من المضافات الغذائية الاصطناعية، هناك رغبة متزايدة نحو استكشاف البدائل الطبيعية. هدفت هذه الدراسة استكشاف فعالية الزيوت الأساسية المستخلصة من الزعتر والكركديه واستخدامها كمضافات طبيعية لتعزيز مدة صلاحية القاورمة من خلال تقليل التحلل الميكروبي والتأكسدي لمنتج القاورمة. ولتحقيق ذلك، تم إعداد عينات القاورمة بالطرائق المحلية القياسية ومن ثم تم تقسيمها إلى أربع مجموعات تضمنت مجموعة الكونترول من دون اي اضافات، المجموعة الثانية تضمنت اضافة زيت الأوريجانو بتركيز 1٪، اما المجموعة الثالثة تضمنت زيت الكركديه سبداريفا بتركيز 1٪، اخر مجموعة تم خلط مزيج من زيوت الأوريجانو والكركديه سبداريفا بتركيز 0.5 ٪ لكل منهما. تم قياس الاكسدة عن طريق دراسة التحليلات الكيميائية عبر تقدير عدد حمض الثيوباربيتوريك (TBARS) والرقم البيروكسيدي حيث أظهرت التحليلات المختبرية في نهاية فترة البحث أن المجموعات المعالجة بهذه الزيوت الأساسية أظهرت مستويات أقل من عدد حمض الثيوباربيتوريك (TBARS) والرقم البيروكسيدي مقارنة بمجموعة السيطرة (الكونترول). بالإضافة إلى ذلك، أظهرت هذه المجموعات نموا ابطا في التلف الميكروبي وحصلت على درجات تقييم حسية أعلى بعد فترة التخزين البارد، مما يبرز إمكانيات هذه الإضافات الطبيعية في الحفاظ على جودة القاورمة وإطالة مدة صلاحيتها. تساهم هذه الدراسة في تقديم رؤى قيمة حول إمكانيات المواد الحافظة الطبيعية، مما يعزز اهميتها في صناعة المواد الغذائية ومعالجة مطالب المستهلكين الواعين بالصحة. وتؤكد النتائج على أهمية استكشاف البدائل الطبيعية للمواد الحافظة الاصطناعية، لا سيما في المنتجات الغذائية الغنية بالدهون.

كلمات مفتاحية: طريقة حفظ، القاورمة، مدة الحفظ، الزيوت الاساسية.

Introduction

Kaurma, a popular traditional dish, holds a venerable place in the culinary heritage of many cultures, especially in North Iraq. Typically made from finely chopped meat—often beef or lamb—cooked in its fat, it embodies the essence of age-old culinary practices (19). The process involves slow-cooking the meat until it becomes tender and succulent, and often seasoned with an array of herbs and spices that enhances its savory profile. Along with its popularity, modern consumers are increasingly seeking food products that offer not only exceptional taste but also nutritional benefits and extended shelf life (21) thus growing the need for jet-milled essential oils from plants such as oregano and Hibiscus sabdariffa (also called roselle). These essential oils are highly regarded not only for their potent flavors but also for their health-promoting properties and preservative effects. Oregano essential oil has a pronounced aromatic flavor and digestive properties, while Hibiscus sabdariffa comes with a tart but floral note and antioxidant benefits (12).

With the advancement of food science, there is an increasing prominence in using natural ingredients like essential oils to make traditional recipes like karuma. Studying how oregano, Hibiscus sabdariffa, and essential oils can improve flavor while also offering health benefits and making food last longer, makes it possible to derive new versions of old favorites without changing what makes them special (17). Herbs, including the essential oils of oregano and Hibiscus sabdariffa extract, are critical for food preservation because they promise enhanced shelf life for kaurma. Oregano (Origanum vulgare) contains many bioactive compounds, the most important being carvacrol, thymol, p-cymene, and γ-terpinene, as they contain strong antimicrobial and antioxidant properties. These compounds inhibit the reproduction of microorganisms and the oxidative reactions that spoil food (13). Hibiscus sabdariffa extract, known for its high phenolic content, acts as a potent natural preservative. The organic acids and flavonoids present in hibiscus contribute to its antimicrobial activity against common foodborne pathogens thus making it effective in preventing microbial contamination in kaurma, and ensuring its safety and longer shelf life (22).

Adding oregano and Hibiscus sabdariffa essential oils to kaurma not only makes it taste better, but also much healthier. These essential oils are rich in bioactive compounds that confer various health benefits, transforming a traditional meat dish into a functional food with added nutritional merits. Oregano essential oil is renowned for its potent anti-inflammatory and antioxidant properties (30 and 31). Thus, regular consumption of oregano-infused kaurma may enhance overall health by reducing chronic inflammation and shielding cells from free radical damage. Hibiscus sabdariffa essential oil brings a wealth of vitamins, particularly vitamin C, along with minerals like calcium and iron (7), and is packed with anthocyanins - powerful antioxidants known for their role in cardiovascular health. By infusing kaurma with Hibiscus sabdariffa essential oils, the dish gains an added layer of nutritional enrichment that supports heart health and boosts immunity (9). Overall, the fusion of these essential oils into kaurma does not merely elevate its taste; it imbues the dish with substantial nutritional benefits that support holistic well-being (6).

This study examined the important issue of lipid oxidation and microbial spoilage in kaurma, a traditional Kurdish cooked meat product that is especially at risk because of its high fat content. It looks into whether oregano and Hibiscus sabdariffa essential oils, which are natural preservatives, are as effective as synthetic additives, an issue that has gained much attention over health and safety concerns. This study shows that these essential oils improve the shelf life, microbial stability, and the taste of kaurma, thereby addressing the industry's meat preservation issue and also increasing consumer acceptance of less processed and healthier foods. Ultimately, the findings underscore the potential of essential oils as functional ingredients in food technology, fostering advancements in sustainable food preservation practices.

Materials and Methods

Materials for plants: The essential oils were separated through steam distillation using a Clevenger (Wisd-Wise Therm) apparatus after grinding the dried oregano and dried Hibiscus sabdariffa leaves, as outlined by (4).

Examination of volatile constituents: The volatile components of the essential oils were identified by gas chromatography-mass spectrometry (GC-MS) as described by (8). The isolation and characterization of essential oil constituents was performed using a Perkin Elmer Auto system XL Gas Chromatograph (GC; Perkin Elmer, USA). This setup featured a flame ionization detector (FID) and a CP-Wax 52 CB column (50 m×0.32 mm). The operational conditions included a detector and injector temperature of 240 °C, with an oven temperature programmed to 60 °C for an initial 5 min, followed by an increase to 220 °C for 20 min. Helium was utilized as the carrier gas, while hydrogen served as the fuel gas at a flow rate of 40 $mL \cdot min^{-1}$. The split ratio was maintained at 1:20, and a syringe with a capacity of 5 µL was used for sample injection.

Sampling and Packing Process: The experimental groups were set up with various concentrations of oregano and Hibiscus sabdariffa essential oils into the kaurma samples. Initially, approximately 4 kg of excess fat and connective tissue was removed from the beef. The meat was then cut into portions measuring approximately 3×4×5 cm^3 and sorted into four equal portions for both the control and experimental groups. It was boiled for about 140–160 minutes, stirred occasionally and mixed well for even cooking and heat distribution. The meat was deemed ready when its internal color turned from red to dark gray, indicating elasticity loss and ease of hand splitting. Each pot containing 2 kg of meat was placed in covered pottery containers for cooking (19).

A meat grinder was used to process the animal fat, specifically tail fat (sheep fat), which was then melted in a separate container. The beef chunks were precooked with the addition of 2% salt and 20% of the total melted fat. Following this, the remaining 80% of the animal fat was incorporated into the groups, and the meat cooked at 150 °C for 140-160 minutes. Once the kaurma's temperature reached 60 °C, the essential oils were introduced into the respective groups (Figure 1). After cooling to 4 °C, each kaurma sample was cut into uniform portions. Groups A, B, C, and K (the control group) were then packed in 15×25 cm containers and stored at +4 °C for 90 days. Microbiological, chemical, and sensory tests were done on weeks 0, 4, 8, and 12 to

determine the impact of the essential oils on the quality and ability of the kaurma to remain fresh.

Microbiological Analysis: For microbiological examination, 10 g of kaurma samples were mixed with 90 mL of physiological saline solution (PSS) and homogenized using a stomacher for 2 min. This homogenized sample was then used to prepare serial decimal dilutions for microbiological assessments. Total viable counts (TVC) were determined by plating on plate count agar (PCA) and incubating at 30 °C for 48 hrs.

The total psychrotrophic bacteria (TPB) counts were assessed using PCA incubated at 7 °C for 10 days. Additionally, lactic acid bacteria (LAB) were cultivated on modified Chalmers agar (HKM 027301) and incubated at 30 °C for 3-5 days, adhering to established microbiological protocols (14).

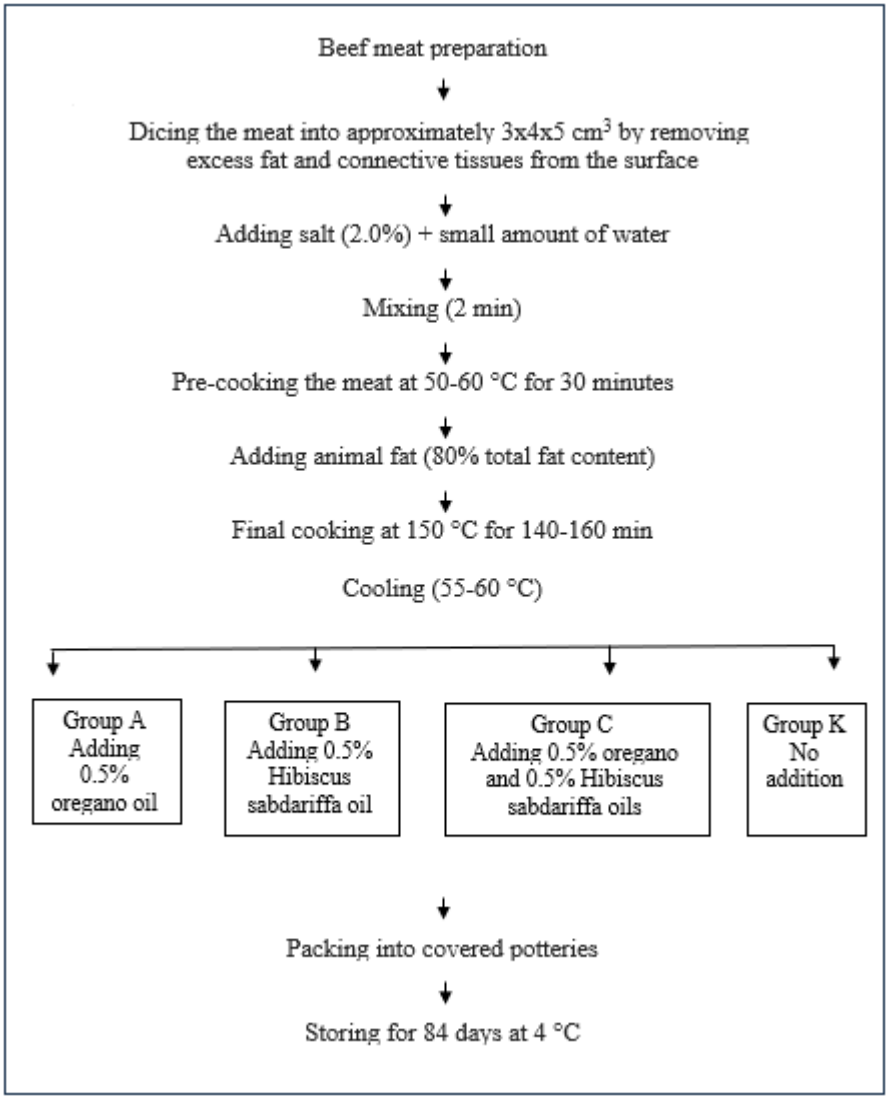

Fig. 1: Flow diagram of the kaurma experiment preparation process.

Chemical Analysis:

Peroxide Analysis: The peroxide value was determined based on the oxidation of potassium iodide by peroxide oxygen present in the oil, resulting in the release of free iodine. The free iodine concentration was subsequently quantified through titration using sodium thiosulfate, following the procedure outlined by (20).

Analysis of Thiobarbituric Acid-reactive Substances: Before conducting the assay, fats from the kaurma were melted at 25 °C and its TBARS values were determined using spectrophotometry. A standard solution of 20 μmol·L^{-1} was prepared by diluting 0.494 mL of 1,1,3,3-tetraethoxypropane (D.0.02; 97%; molecular weight: 220.3). From this standard solution, further dilutions of 2.5, 5, 7.5, and 10 μmol·L^{-1} were made and analyzed by measuring their optical densities at 535 nm against a blank, based on the method described by (5).

pH Measurement: A 10 g sample of kaurma from each group was weighed and subsequently homogenized with 100 mL of distilled water. The resulting samples was assessed using a digital pH meter based on the methodology by (15) for the accurate determination of pH in meat products.

Sensory Evaluation: Sensory evaluations were conducted by a panel of eight individuals with expertise in meat technology and processing. They were selected due to their knowledge and experience in the area, which provided a balanced assessment of all sensory characteristics being studied. Samples were removed from storage and allowed to equilibrate to room temperature on the day of analysis. Each individual sample was then rated on flavor, appearance (color and liquid leakage), smell, and textural consistency based on a score of 1 (lowest quality) to 10 (highest quality) according to their sensory perceptions. This scoring system was adapted from the methodology described by (32).

Statistical Analysis: Statistical analyses were conducted using the SPSS software package (version 18). The data were subjected to analysis of variance (ANOVA), and mean differences were assessed using Duncan's Multiple Range Test (7). To ensure reliability, the entire experiment was replicated three times, each conducted at separate intervals.

Results and Discussion

Table 1 shows the main constituents of the oregano and Hibiscus sabdariffa essential oils as determined using gas chromatography-mass spectrometry.

Table 1: Primary constituents of oregano and hibiscus sabdariffa essential oils identified using gas chromatography-mass spectrometry.

Main components					
Oregano essential oils			Hibiscus sabdariffa essential oils		
Compounds	**Retention time**	**%**	**Compounds**	**Retention time**	**%**
p-Cymene	13.75	2.0	Hibiscus acid	8.10	15.0
γ-Terpinene	14.55	2.5	Myrcene	10.25	5.0
Thymol	15.10	5.5	Sabdaret	11.40	10.0
Carvacrol	15.62	74.0	Alpha-humulene	13.70	18.0
β-Caryophyllene	17.80	16.0	Beta-caryophyllene	15.95	22.0
			Citronellol	18.30	12.0
			Geraniol	19.85	18.0

During the initial four weeks of the study, mold and yeast counts in most of the experimental groups remained below 1 log CFU·g^{-1} (Table 2). In the first treatment (Group A), no growth of any microorganisms was observed. A statistically significant reduction in bacterial counts was noted among groups B and C compared to the

control group K ($P < 0.05$). Notably, Group A consistently maintained counts below the detectable threshold throughout the storage period, attributed primarily to the potent antimicrobial properties of oregano essential oil. Oregano oil contains abundant phenolic compounds, principally carvacrol and thymol, which are responsible for its effectiveness. These compounds are known to disrupt membrane architecture in order to break down bacterial cell integrity. The hydrophobic properties of carvacrol and thymol allow them to fit within the lipid bilayers of bacterial membranes, causing the effusion of essential ions and intracellular components, which ultimately leads to the death of bacterial cells. This mechanism underscores the promising potential of oregano essential oil as a potent natural preservative for enhancing food safety (25 and 33).

Table 2: Microbial analysis of kaurma treated with varying concentrations of oregano and Hibiscus sabdariffa essential oils during cold storage (log 10 CFU·g^{-1}).

Group/Storage period (weeks)	Total viable count ± SE	Total psychrotrophic bacterial count ± SE	Lactic acid bacterial count ± SE	Total mold and yeast count ± SE
A				
0	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
4	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
8	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
12	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
B				
0	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
4	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
8	1.42±0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
12	2.96±0.003	0.00± 0.00	0.00± 0.00	0.00± 0.00
C				
0	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
4	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
8	1.12± 0.011	0.00± 0.00	0.00± 0.00	0.00± 0.00
12	2.20± 0.115	0.00± 0.00	0.00± 0.00	0.00± 0.00
K				
0	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
4	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
8	0.00± 0.00	0.00± 0.00	2.76 ± 0.144	3± 0.577
12	3.91 ± 0.052	1.32 ± 0.160	4.92 ± 0.374	5.02 ± 0.111

A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% beef fat + 0.5% oregano + 0.5% Hibiscus sabdariffa oils; K: control - 100% beef kaurma.
* CFU indicates colony-forming units; SE signifies standard error.

The microbiological assessment results for the control samples (Group K) without essential oils and samples treated with 1% oregano essential oil (Group A), 1% Hibiscus sabdariffa oil (Group B), and a combination of 0.5% each (Group C) are presented in Tables 3 and 4.

Table 3: Statistical results averaged across storage duration on the impact of essential oils on the microbial parameters of the kaurma samples (P < 0.005).

Group/Storage time	Total viable count	Total psychrotrophic bacterial count	Lactic acid bacterial count	Total mold and yeast count
A	0.00[b]	0.00[b]	0.00 [c]	0.00 [b]
B	1.09[a]	0.00[b]	0.00[c]	0.00 [b]
C	0.83[a]	0.00[b]	0.69[b]	0.00[b]
K	0.98[a]	0.33[a]	1.92[a]	2.00[a]

* Letters a–c represent statistical differences between groups within the same column.
*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma +1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

By week 12, the control group (K) demonstrated the highest increase in total viable microbial counts among the groups tested, indicating enhanced microbial growth due to the lack of antimicrobial agents. Conversely, groups A, B, and C, which were treated with oregano oil, Hibiscus sabdariffa, or their combination, respectively, showed markedly reduced microbial counts. This reduction highlights the effective antimicrobial properties of the essential oils used, suggesting their potential role in inhibiting microbial proliferation within food products (23).

In the initial four weeks of the study, mold and yeast counts within all experimental groups remained below 1 log CFU·g^{-1}. However, a notable increase in these counts was observed in the control group (K) post the fourth week, contrasting with the stabilized levels in groups A, B, and C, where essential oils were utilized. At the end of the storage period, a significant divergence ($P < 0.05$) was evident between the control and the essential oil-treated groups, with the latter showing markedly reduced growth of mold and yeast. This aligns with the findings of previous research, underscoring the efficacy of oregano and Hibiscus sabdariffa essential oils in inhibiting fungal species (10, 24 and 26).

Table 4: Impact of storage time on the microbial parameters of the kaurma samples (P < 0.005).

Storage time (weeks)	Total viable count	Total psychrotrophic bacterial count	Lactic acid bacterial count	Total mold and yeast count
0	0.00[c]	0.00 [b]	0.00 [c]	0.00 [c]
4	0.00 [c]	0.00 [b]	0.00 [c]	0.00 [c]
8	0.65[b]	0.00 [b]	0.69 [b]	0.75 [b]
12	2.27[a]	0.33[a]	1.23[a]	1.25[a]

* Letters a–c represent statistical differences between groups within the same column.
*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

Essential oils derived from oregano and Hibiscus sabdariffa exhibit potent antimicrobial activities, which are instrumental in inhibiting microbial degradation in kaurma. These oils function by destabilizing microbial cell membranes, causing cellular demise. The antimicrobial efficacy of these essential oils varies with the microbial species and the surrounding environmental conditions (5 and 6). Further, the presence of hydroxyl (OH) groups in the molecular structures of these oils contributes to their bactericidal actions, rendering them harmful to certain bacterial

cells. Previous studies have also indicated that the combined application of different essential oils, such as those from rosemary and clove, enhances microbial inhibition through a synergistic interaction, amplifying their protective effects in food preservation contexts (27).

Table 5: Statistical results averaged across the storage duration showing the impact of essential oils on the chemical parameters of the kaurma samples (P < 0.005).

Group	TBARS (mg·kg^{-1})	pH	Peroxide number (mequiv. g·kg^{-1})
A	2.45^{b}	5.94^{a}	2.15^{b}
B	2.60^{b}	5.90^{a}	2.00^{c}
C	2.63^{b}	5.94^{a}	2.15^{b}
K	4.01^{a}	5.93^{a}	2.65^{a}

* Letters a–c represent statistical differences between groups within the same column.
*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

Thiobarbituric acid-reactive substances (TBARS), which show oxidative breakdown, tend to rise in meat products over time, especially when they are stored in cold places (28). As seen in Table 5, TBARS values in the control group (K) are elevated after the storage period, contrasting with a decline in groups treated with essential oils (A, B, C). This suggests that the essential oils of oregano and hibiscus have strong antioxidant properties that keep kaurma from going bad (16) Notably, the TBARS levels in the essential oil-treated groups remained below the permissible limit of 3 mg MDA·kg^{-1} (MDA-malondialdehyde) throughout the storage duration. Conversely, levels in the control groups surpassed this threshold after the 12th week. This differential in TBARS levels can be attributed to the antioxidative constituents of the essential oils. The compounds within the chemical profiles of oregano and Hibiscus sabdariffa essential oils have been documented to significantly influence TBARS values (3, 16 and 18).

Table 6: Influence of storage time on the chemical parameters of the kaurma samples (P < 0.005).

Storage time (weeks)	TBARS (mg·kg^{-1})	pH	Peroxide number (mequiv. g·kg^{-1})
0	2.39^{c}	5.97^{a}	1.77^{c}
4	3.10^{b}	5.80^{a}	0.45^{d}
8	2.29^{c}	5.96^{a}	2.25^{b}
12	3.93^{a}	6.00^{a}	4.48^{a}

* Letters $^{a–c}$ represent statistical differences between groups within the same column.
*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

At the end of the storage period, TBARS values were noted to have increased in all groups, with inter-group variations achieving statistical significance (P < 0.05), as detailed in Table 5. Notably, the control group (K) had the highest TBARS values throughout the storage period, indicating significant lipid peroxidation. Conversely, Group A, which received treatment with essential oils, displayed the lowest TBARS values, underscoring the potent antioxidant efficacy of oregano and Hibiscus sabdariffa essential oils (26 and 27). The incorporation of these essential oils

significantly mitigated the increased TBARS levels within the kaurma samples, echoing the findings of (2).

Table 7: Chemical analysis of kaurma treated with different concentrations of oregano and Hibiscus sabdariffa essential oils over cold storage duration.

Group/Storage period (weeks)	TBARS ($mg \cdot kg^{-1}$) ± SE	pH ± SE	Peroxide number (mequiv. $G \cdot kg^{-1}$) ± SE
A			
0	3.40 ± 0.624	5.83 ± 0.597	0.500 ± 0.057
4	2.20 ± 0.472	5.96 ± 0.235	2.20 ± 0.152
8	1.72 ± 0.133	6.02 ± 0.594	2.00 ± 0.288
12	2.50 ± 0.577	5.95 ± 0.275	3.90 ± 0.230
B			
0	2.18 ± 0.453	5.80 ± 0.493	0.300 ± 0.115
4	3.20 ± 0.472	6.05 ± 0.621	2.03 ± 0.033
8	1.95 ± 0.312	5.83 ± 0.438	2.60 ± 0.346
12	3.10 ± 0.173	5.93 ± 0.230	3.13 ± 0.033
C			
0	3.62 ± 0.397	5.80 ± 0.057	0.300 ± 0.115
4	2.10 ± 0.230	5.95 ± 0.275	1.20 ± 0.435
8	1.53 ± 0.315	6.02 ± 0.075	2.10 ± 0.378
12	3.30 ± 0.230	6.00 ± 0.577	5.00 ± 0
K			
0	3.20 ± 0.472	5.73 ± 0.142	0.700 ± 0.230
4	2.08 ± 0.360	5.92 ± 0.075	1.70 ± 0.404
8	3.94 ± 0.472	6.00 ± 0.057	2.30 ± 0.461
12	6.82 ± 0.587	6.13 ± 0.085	5.90 ± 0.435

*TBARS – thiobarbituric acid-reactive substances; SE – standard error; and mequiv. – milli-equivalent.

*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control – 100% beef kaurma

The pH values of the control group (K) and the experimental groups (A, B, and C) did not show any statistically significant differences at the start of the cold storage period. However, by the 12^{th} week of storage, a significant variation was observed between the groups ($P < 0.05$), as detailed in Table 5. The K control group recorded

initial pH values of the kaurma samples at 6.13. Throughout the storage period, the pH values demonstrated fluctuating trends, with both increases and decreases noted at various intervals. Nonetheless, consistent with the observations reported by (1), a slight elevation in pH was recorded across all groups by the end of the storage period. This may be attributed to the metabolic activity of spoilage microorganisms and proteolytic enzymes, which become more pronounced over extended storage durations, influencing the chemical composition and stability of the meat (2 and 29).

Table 8: Sensory evaluation of kaurma treated with different concentrations of oregano and Hibiscus sabdariffa essential oils over cold storage duration.

Group/Storage period (weeks)	Rating			
	Flavor ± SE	Appearance ± SE	Smell ± SE	Cutting ± SE
A				
0	6.89 ± 0.225	8.96 ± 0.254	6.88 ± 0.194	7.50 ± 0.763
4	7.45 ± 0.259	7.91 ± 0.239	6.44 ± 0.983	6.94 ± 0.470
8	7.80 ± 0.173	6.78 ± 0.475	7.86 ± 0.033	6.80 ± 0.493
12	6.98 ± 0.277	6.32 ± 0.160	6.96 ± 0.543	6.84 ± 0.181
B				
0	5.92 ± 0.223	8.62 ± 0.397	6.31 ± 0.003	6.89 ± 0.177
4	6.88 ± 0.219	6.95 ± 0.246	6.24 ± 0.794	6.46 ± 0.284
8	7.59 ± 0.222	6.46 ± 0.254	7.63 ± 0.003	6.43 ± 0.003
12	6.73 ± 0.145	5.97 ± 0.263	6.86 ± 0.461	5.95 ± 0.246
C				
0	5.12 ± 0.397	8.32 ± 0.587	5.32 ± 0.715	6.77 ± 0.003
4	5.92 ± 0.248	2.76 ± 0.530	5.95 ± 0.246	6.88 ± 0.213
8	7.00 ± 0.577	6.95 ± 0.476	6.69 ± 0.106	6.24 ± 0.124
12	6.62 ± 0.397	6.41 ± 0.003	6.37 ± 0.003	6.22 ± 0.133
K				
0	8.32 ± 0.190	7.92 ± 0.586	7.33 ± 0.010	7.23 ± 0.003
4	8.95 ± 0.246	7.14 ± 0.702	7.15 ± 0.637	6.89 ± 0.255
8	7.20 ± 0.404	5.22 ± 0.617	5.85 ± 0.453	6.44 ± 0.238
12	5.48 ± 0.271	4.28 ± 0.831	5.24 ± 0.653	4.22 ± 0.111

*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma

Table 9: Influence of storage time on the sensory parameters of the kaurma samples (P < 0.005).

Storage period (weeks)	Rating			
	Flavor	Appearance	Smell	Cutting
0	6.56^{bc}	8.45^{a}	6.46^{d}	7.1^{a}
4	7.30^{ab}	7.47^{b}	6.44^{b}	6.79^{b}
8	7.55^{a}	6.35^{c}	7.02^{a}	6.48^{c}
12	6.45^{c}	5.75^{c}	6.29^{c}	5.80^{d}

* Letters $^{a–d}$ represent statistical differences between groups within the same column

*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

Table 10: Statistical results averaged across the storage duration showing the impact of essential oils on the sensory parameters of the kaurma samples (P < 0.005).

Group	Rating			
	Flavor	Appearance	Smell	Cutting
A	7.28[a]	7.49[a]	7.04[a]	7.02[a]
B	6.77[ab]	7[a]	6.76[b]	6.43[b]
C	6.16[b]	7.39[a]	6.08[d]	6.53[ab]
K	7.48[a]	6.14[b]	6.39[c]	6.19[b]

* Letters [a–d] represent statistical differences between groups within the same column
*A: 99% beef kaurma + 1% oregano oil; B: 99% beef kaurma + 1% Hibiscus sabdariffa oil; C: 99% kaurma + 0.5% oregano and 0.5% Hibiscus sabdariffa oils; K: Control - 100% beef kaurma.

The sensory evaluation of kaurma incorporating essential oils (EO) highlighted their different impacts on flavor, appearance, aroma, and textural properties over the 12-week cold storage period. The 1% oregano oil application consistently maintained superior sensory scores, supporting its efficacy in preserving or enhancing the meat's flavor profile. This observation corroborates previous studies suggesting the viability of oregano EOs in significantly improving the palatability of meat products (6).

On the other hand, kaurma treated with Hibiscus sabdariffa essential oil gradually lost its appearance and texture values. This observed variability could stem from alterations in the EO's chemical profile or its dynamic interactions with food constituents throughout the storage period. These changes show the complexities involved in the use of EOs in maintaining the freshness of food as well as highlight the extent of research required on the stability and interaction mechanisms of Hibiscus sabdariffa in meat products (5).

The sensory quality scores of the control groups showed a decline. At the end of the cold storage period, there were statistically significant differences between the groups treated with EOs and those that were not ($P < 0.05$), as detailed in Table 9. The control group (K), which did not contain the essential oils, was initially rated highly for aroma by the panelists. However, some found the particularly intense aroma of Group C, with the EO combination, unpleasant. At the beginning of the study, participants perceived groups A and B, which also contained the oils, to have strong aromas. Consistent with findings from (34), the EO aroma intensities diminished over the storage period and became increasingly acceptable. This was likely due to the volatilization of EO components over time, as noted by (11 and 28). Additionally, ease-of-cutting scores improved significantly ($P < 0.05$) with the incorporation of oregano or Hibiscus sabdariffa oils. The addition of EO resulted in a significant improvement by reducing the pH, which improved the texture and made cutting easier. By the end of the study, Group A emerged as the most preferred by the panelists, while the control group (K) received the lowest scores. Despite some initial concerns, the panelists ultimately regarded all EO-treated groups favorably and found them acceptable in terms of sensory quality.

Conclusions

Lipid oxidation poses a significant challenge in the preservation of meat products. Kaurma is particularly prone to oxidative and microbial degradation, which can

compromise its quality and shelf life. This study's goal was to use natural compounds instead of synthetic preservatives (nitrites, nitrates) that are commonly used in the meat industry because of their health hazards.

Hibiscus sabdariffa and oregano essential oils were added as new ingredients for Kaurma, a traditional Turkish meat dish. The oils stopped the growth of microbes and slowed their oxidative breakdown in the meat. The treated samples showed lower peroxide and TBARS values compared to the controls. Besides, the application of these essential oils retained the sensory characteristics of kaurma, thereby enhancing its attractiveness. The results show that clove and Hibiscus sabdariffa essential oils aid in the preservability of kaurma by maintaining its chemical, microbial, and sensory stability. They are safe, natural, and effective. Future studies need to address optimizing dosages to improve their sensory characteristics while maintaining preservative efficacy.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

A single-author paper.

Funding:

This research received no external funding.

Institutional Review Board Statement:

The study was conducted following the protocol authorized by the Head of the Ethics Committee, University of Sulaimani, Iraq Republic.

Informed Consent Statement:

No Informed Consent Statement.

Data Availability Statement:

No Data Availability Statement.

Conflicts of Interest:

The authors declare no conflict of interest.

Acknowledgments:

This research was conducted at the Department of Food Science and Quality Control, College of Agricultural Engineering Sciences, Sulaimani University, Kurdistan Region, Iraq. Many thanks to everyone who helped and supported this work.

References

1. Aksu, M. I. (2007). The effect of α-tocopherol, storage time and storage temperature on peroxide value, free fatty acids and ph of kavurma, a cooked meat product. Journal of Muscle Foods, 18(4): 370-379. https://doi.org/10.1111/J.1745-4573.2007.00092.X.

2. Aksu, M. I., and Kaya, M. (2005). The effect of α-tocopherol and butylated hydroxyanisole on the colour properties and lipid oxidation of kavurma, a cooked meat product. Meat Science, 71(2): 277-283. https://doi.org/10.1016/J.MEATSCI.2005.03.023.
3. Ali, B. H., Wabel, N. A., and Blunden, G. (2005). Phytochemical, pharmacological and toxicological aspects of Hibiscus sabdariffa L.: a review. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 19(5): 369-375. https://doi.org/10.1002/ptr.1628.
4. Aytaç, E. (2020). Comparison Essential Oil Contents Origanum Majorana L. Obtained by Clevenger and SFE. Hacettepe Journal of Biology and Chemistry, 48(3): 239-244. https://doi.org/10.15671/hjbc.514042.
5. Bakkali, F., Averbeck, S., Averbeck, D., and Idaomar, M. (2008). Biological effects of essential oils – A review. Food and Chemical Toxicology, 46(2): 446-475. https://doi.org/10.1016/j.fct.2007.09.106.
6. Bozkurt, H., and Belibağli, K. B. (2009). Use of rosemary and Hibiscus sabdariffa in production of kavurma, a cooked meat product. Journal of the Science of Food and Agriculture, 89(7): 1168-1173. https://doi.org/10.1002/jsfa.3570.
7. Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods—a review. International journal of food microbiology, 94(3): 223-253. https://doi.org/10.1016/j.ijfoodmicro.2004.03.022.
8. Buzina, T. S., Belyakova, A. Y., and Ivanyo, Y. M. (2021). Method of statistical tests in solving problems of food production management. In IOP Conference Series: Earth and Environmental Science, 839(3): 032051. DOI: 10.1088/1755-1315/839/3/032051.
9. Cagliero, C., Bicchi, C., Marengo, A., Rubiolo, P., and Sgorbini, B. (2022). Gas chromatography of essential oil: State-of-the-art, recent advances, and perspectives. Journal of Separation Science, 45(1): 94-112. https://doi.org/10.1002/JSSC.202100681.
10. Clifford, T., Howatson, G., West, D. J., and Stevenson, E. J. (2015). The potential benefits of red beetroot supplementation in health and disease. Nutrients, 7(4): 2801-2822. https://doi.org/10.3390/nu7042801.
11. Espina, L., Somolinos, M., Lorán, S., Conchello, P., García, D., and Pagán, R. (2011). Chemical composition of commercial citrus fruit essential oils and evaluation of their antimicrobial activity acting alone or in combined processes. Food Control, 22(6): 896-902. https://doi.org/10.1016/j.foodcont.2010.11.021.
12. Guerra-Rivas, C., Vieira, C., Rubio, B., Martínez, B., Gallardo, B., Mantecón, A. R., Lavín, P., and Manso, T. (2016). Effects of grape pomace in growing lamb diets compared with vitamin E and grape seed extract on meat shelf life. Meat Science, 116: 221-229. https://doi.org/10.1016/j.meatsci.2016.02.022.
13. Gullón, B., Pintado, M.E., Pérez-Álvarez, J.A., and Viuda-Martos, M. (2016). Assessment of polyphenolic profile and antibacterial activity of pomegranate peel (Punica granatum) flour obtained from co-products of juice extraction. Food Control, 67: 193-201. https://doi.org/10.1016/j.foodcont.2016.02.042.

14. Gyawali, R., and Ibrahim, S. A. (2014). Natural products as antimicrobial agents. Food control, 46: 412-429. https://doi.org/10.1016/j.foodcont.2014.05.047.
15. Harrigan, W. F. (1998). Laboratory methods in food microbiology (Vol. 308). Academic Press.
16. Honikel, K. O. (1998). Reference methods for the assessment of physical characteristics of meat. Meat Science, 49(4): 447-457. https://doi.org/10.1016/S0309-1740(98)00034-5.
17. Ibraheem, M. W., Farhan, A. A., Salih, S. M., and Mohammed, T. T. (2022). Carcass characteristics of Awwasi lambs supplemented with Selenium and Vitamin D3. Iranian Journal of Ichthyology, 9: 355-359.
18. Ju, J. (2023). Essential Oils as Antimicrobial Agents in Food Preservation. CRC Press, 314. https://doi.org/10.1201/9781003329268.
19. Kumar Pandey, V., Shams, R., Singh, R., Dar, A. H., Pandiselvam, R., Rusu, A. V., and Trif, M. (2022). A comprehensive review on clove (Caryophyllus aromaticus L.) essential oil and its significance in the formulation of edible coatings for potential food applications. Frontiers in Nutrition, 9: 987674. https://doi.org/10.3389/fnut.2022.987674.
20. Lagouri, V., and Boskou, D. (1996). Nutrient antioxidants in oregano. International journal of food sciences and nutrition, 47(6): 493-497. https://doi.org/10.3109/09637489609031878.
21. Mirzan, N. A., Khudhair, M. Y., and Rashid, R. M. (2024). Chemical and oxidative stability of lamb and turkey kaurma with beeswax as a fat replacer during cold storage in kurdistan-iraq. Journal of Life Science and Applied Research, 5(1): 1-7. https://doi.org/10.59807/jlsar.v5i1.92.
22. Munteanu, I. G., and Apetrei, C. (2021). Analytical methods used in determining antioxidant activity: A review. International journal of molecular sciences, 22(7): 3380. https://doi.org/10.3390/ijms22073380.
23. Napiórkowska, A., Khaneghah, A. M., and Kurek, M. A. (2024). Essential Oil Nanoemulsions—A New Strategy to Extend the Shelf Life of Smoothies. Foods, 13(12): 1854. https://doi.org/10.3390/foods13121854.
24. Nirmal, N. P., Sarkar, T., Dwivedy, A. K., Hussain Dar, A., Pandiselvam, R., In, A. C., Rusu, A. V., Singh, R., Pandey, V. K., Shams, R., and Trif, M. (n.d.). OPEN ACCESS EDITED BY A comprehensive review on clove (Caryophyllus aromaticus L.) essential oil and its significance in the formulation of edible coatings for potential food applications.
25. Numonde, E., Momoh, I., Sheneni, V., Okosesi, E. A., and Ibrahim, M. O. (2024). Comparative Nephro-Hepatoprotective Effects of Herbal Teas from Hibiscus sabdariffa, Moringa oleifera, Zingiber officinale, and Azadirachta indica in Alloxan-Induced Diabetic Male Wistar Rats: A Preclinical Study. https://doi.org/10.1101/2024.06.17.599331.
26. Olivas-Méndez, M. A., Ponce-Alquicira, E., Torres-González, O. A., Macías-Rodríguez, M. E., and Sirocchi, V. (2022). The impact of Hibiscus Sabdariffa on yeast and mold inhibition in processed foods. Journal of Applied Microbiology, 132(4): 2984-2997.

27. Romanazzi, G., Feliziani, E., Baños, S. B., and Sivakumar, D. (2017). Shelf life extension of fresh fruit and vegetables by chitosan treatment. Critical reviews in food science and nutrition, 57(3): 579-601. https://doi.org/10.1080/10408398.2014.900474.
28. Pandey, A. K., Kumar, P., Singh, P., Tripathi, N. N., and Bajpai, V. K. (2017). Essential oils: Sources of antimicrobials and food preservatives. Frontiers in microbiology, 7: 2161. https://doi.org/10.3389/fmicb.2016.02161.
29. Sabow, A. (2024). Effects Of Various Thawing Methods On Physicochemical And Structural Properties Of Beef. Anbar Journal Of Agricultural Sciences, 22(1), 301–317. https://doi.org/10.32649/ajas.2024.149228.1237.
30. Skandamis, P. N., and Nychas, G. J. E. (2001). Effect of oregano essential oil on microbiological and physico-chemical attributes of minced meat stored in air and modified atmospheres. Journal of Applied Microbiology, 91(6): 1011-1022. https://doi.org/10.1046/J.1365-2672.2001.01467.X.
31. Teixeira, B., Marques, A., Ramos, C., Serrano, C., Matos, O., Neng, N. R., Nogueira, J. M. F., Saraiva, J. A., and Nunes, M. L. (2013). Chemical composition and bioactivity of different oregano (Origanum vulgare) extracts and essential oil. Journal of the Science of Food and Agriculture, 93(11): 2707-2714. https://doi.org/10.1002/JSFA.6089.
32. Tsai, P. J., and Sheu, C. H. (2006). “Antioxidant and antimicrobial properties of hibiscus sabdariffa extract.” Food Chemistry, 98(4): 684-690.
33. Ventanas, S., González-Mohino, A., Estévez, M., and Carvalho, L. (2020). Innovation in sensory assessment of meat and meat products. Meat quality analysis, 393-418. https://doi.org/10.1016/B978-0-12-819233-7.00021-5.
34. Yamileva, K., Parrotta, S., and Multia, E. (2024). In Vitro Evaluation of Anti-Inflammatory, Anti-Plaque Efficacy, and Biocompatibility of Norway Spruce (Picea abies) Resin Extract for Oral Care Applications. https://doi.org/10.1101/2024.09.17.613464.