https://doi.org/10.17221/56/2024-CJFS

Effect of rosemary and clove essential oils on lipid oxidation, microbial, sensorial properties and storage stability of kavurma, a cooked meat product

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Citation: Harmankaya S., Harmankaya A., İşbaralı K., Istanbullu Paksoy Ö. (2024): Effect of rosemary and clove essential oils on lipid oxidation, microbial, sensorial properties and storage stability of kavurma, a cooked meat product. Czech J. Food Sci., 42: 251–262.

Abstract: Kavurma is a traditional cooked meat product of Türkiye containing a high percentage of animal fat (30–40%). Therefore, kavurma can undergo lipid oxidation easily. This may cause a major problem in the storage and marketing of the product. Synthetic additives used in foods cause anxiety in consumers and this situation increases the search for natural alternatives. Plant essential oils can be reliable additives to extend the shelf life of foods. The protective effect of rosemary and clove essential oils on kavurma meat against microbiological and oxidative deterioration was investigated in this study. For this purpose, kavurma samples were divided into five groups after being produced by standard methods, the essential oils (rosemary and clove) obtained by distillation method were added to the kavurma fat in various proportions, alone or in combination. At the end of the study, the thiobarbituric acid-reactive substance (TBARS) and peroxide values of the groups containing plant essential oils were found to be lower than the control groups. The groups containing rosemary and clove essential oil showed that microbiological deterioration was delayed and, the sensory evaluation scores were higher than the control groups at the end of the cold storage period.

Keywords: food preservation; herbal essential oil; packaging; shelf life

The storage conditions of animal originated foods directly affect their quality. Many food preservation methods, especially cooling, are used to extend the shelf life of red meat. One of these methods is cooking meat with animal fats and salt at a certain temperature and time. Kavurma, a traditional product produced with this method, is offered for sale in slices and vacuum packages (Oğraş et al. 2018). Since kavurma is a meat product containing a high percentage of animal fat, it can easily undergo fat oxidation. The quality of oil and fat-containing foods is significantly influenced by oxidation, making it a crucial factor in their overall quality. Fat oxidation changes the flavour and triggers the discolouration of the muscle tissue, which reduces the shelf life of meat, and some compounds that occur because of oxidation can also damage body cells (Gray et al. 1996). Free radicals constitute the lipid peroxidation process in an organism. Thiobarbitu-

Supported by the Scientific Research Projects Coordinator's Office at Kafkas University (Project No. 2019-TS-23).

https://doi.org/10.17221/56/2024-CJFS

ric acid-reactive substance (TBARS) is one of the end products of the peroxidation of polyunsaturated fatty acids in cells. As it is known, the tendency of today's modern society is towards natural preservatives that will ensure the minimum level of processing of foods and at the same time provide assurance against both spoilage-causing and pathogenic microorganisms.

In this context, focus is directed towards extracts from certain medicinal plants and spices, traditionally employed for years to prolong the shelf life of foods and enhance their sensory properties (Bekhit et al. 2003; Aminzare et al. 2019; Echegaray et al. 2021). Plant essential oils are regarded as 'natural substitutes' for chemical preservatives, and their incorporation into food is believed to align with consumers' preferences for minimally processed food products (Özbek-Yazıcı et al. 2020; Santos et al. 2022).

In addition, different packaging methods are applied to keep the shelf life of foods under control. Extending the shelf life of meat and meat products is achievable through refrigerated storage coupled with vacuum packaging. However, microaerobic psychrotrophic microorganisms preserve their vitality and reproduce. Subsequently, the food spoils in the later stages of storage, as well as the loss of consumption qualities of the meat product due to oxidation of fats, especially moisture is still a major problem for high-content, vacuum-packed (VP) meat and meat products (Aksu and Kaya 2005; Nacak et al. 2023). In this regard, the combination of natural additives and effective packaging methods can lead to success (Oral et al. 2009; Realini and Marcos 2014; Huang et al. 2022).

Rosemary and clove plants are known to have antioxidant properties as well as antimicrobial effects (Deveci et al. 2016; Martínez et al. 2019; Pateiro et al. 2021). In addition, this study aimed to control the fat oxidation and microorganism elimination of kavurma, which has an important place in Turkish cuisine, by using rosemary and clove essential oils (EO) and their combinations, which have antimicrobial and antioxidant properties, in conjunction with vacuum packaging, with the objective of extending the shelf life of kavurma.

MATERIAL AND METHODS

Plant materials

Initially, the essential oils were extracted through steam distillation in a Clevenger (Wisd-Wise Therm) apparatus after grinding the leaves of the dried rosemary plant and the flower buds of the clove plant (Aytaç 2020).

Determination of volatile components

Chemical components of essential oils were made with gas chromatography-mass spectrometry (GC-MS) according to the method specified by Cagliero et al. 2022. The components of the essential oil were isolated using a Perkin Elmer Autosystem XL Gas Chromatograph (GC; Perkin Elmer, USA). In this gas chromatograph with flame ionisation detector (FID) detector and column CP-Wax 52 CB (50 m × 0.32 mm): detector and injector temperature 240 °C; oven temperature 60 °C for 5 min, 220 °C for 20 min; carrier gas: He; fuel gas: H_2 (40 mL·min^{-1}); split rate 1/20 mL·min^{-1}; and the syringe capacity was set to 5 µL.

Sampling and packing

Experimental groups were prepared by adding rosemary and clove oils at different levels. Initially, around 4 kg of visible fat and excessive connective tissues were trimmed from the beef. It was then cut into chunks with an average size of 4 × 5 cm. Beef chunks were divided into five equal parts for the control and experimental groups. A closed boiler with a steam jacket (Yılmazlar, Türkiye) with adjustable temperature was used in roasting production. The animal fat was passed through a meat grinder and melted in a separate pot. The beef chunks were precooked by adding 2% salt and 20% of the total melted fat. Then the remaining 80% animal fat was added to the groups and the meats were cooked at 100 °C for 90 minutes. After the kavurma was cooled to 60 °C, the essential oils were added to the groups (Figure 1). Each kavurma sample was sliced into equal sizes after cooling to 4 °C. A, B, C, and K1 (control group) were vacuum packed (15 × 25 cm, PA/PE; Sudpack Verpackungen, Germany) and stored at +4 °C in a refrigerator for 90 days. K2 (non-vacuum control group) was stored at +4 °C after vacuum packaging and without any additions (Figure 1). Microbiological, chemical and sensory analyses were performed by taking a sample from each group during the 0st, 4th, 7th, 9th, 11th, and 13th week of the storage period.

Microbiological analysis

To perform microbiological analysis, 90 mL of physiologic saline solution (PSS) was added to a 10 g kavurma sample and homogenised in the stomacher for 2 min, and decimal dilutions were prepared for the assessment of total viable counts (TVC), plate count agar (Oxoid CM0325) was incubated at 30 °C for 48 hours. Total psychrotrophic bacteria (TPB) were determined using plate count agar (Oxoid CM0325) incubated at 7 °C for 10 days. Lactic acid bacteria (LAB) were enu-

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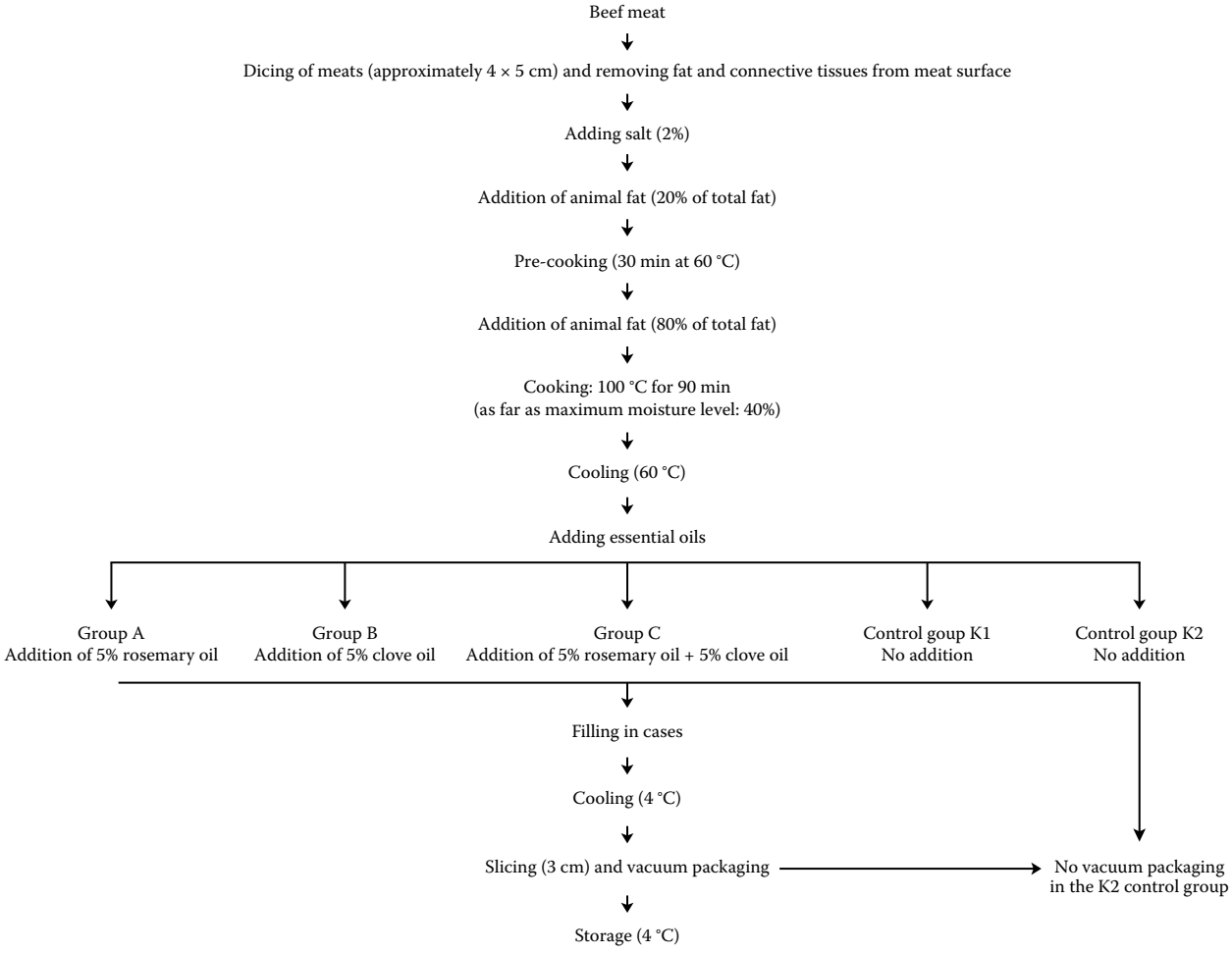

Figure 1. Kavurma production scheme

merated on modified Chalmers agar (HKM 027301) and incubated at 30 °C for 3 to 5 days. Total mold and yeast counts (TYM) were conducted on Potato Dextrose Agar (BAM Media M127) incubated at 25 °C for 3 to 5 days (Harrigan 1998).

Chemical analysis

Peroxide analysis. Peroxide number was determined by potassium iodide being oxidised with peroxide oxygen in oil and iodine becoming free, and the amount it was found by titration of this free iodine with thiosulfate (Munteanu and Apetrei 2021).

Thiobarbituric acid-reactive substance analysis. Before analysis, kavurma fats were liquefied at 25 °C. The TBARS values of kavurma were assessed using a spectrophotometric method. A standard solution of 20 μmol·L^{-1} was obtained with 0.494 mL of 1,1,3,3-tetraethoxypropane (D.0.02; 97%; MW: 220.3). From this solution, dilutions of 2.5, 5, and 10 μmol·L^{-1} were prepared and evaluated by reading their optical densities against the blank at 535 nm (Bozkurt and Belibagli 2009).

pH measurement. A 10 g sample of kavurma from each group was weighed and homogenised with 100 mL of distilled water. The pH of the samples was then determined using a digital pH meter (HANNA HI 2002-02 Edge; Hanna Instruments, Germany) (Honikel 1998).

Sensory analysis

A panel of 5 people was selected from the lecturers of KAU KMYO Food Processing Department to carry out a sensory analysis. Before the sensory session, panelists underwent training using high-quality commercial kavurma. On each analysis day, after the samples removed from the cooler were allowed to reach room temperature, the packages were opened and evaluated in terms of flavour, appearance (colour, liquid leakage), smell and consistency structure. Panelists assigned scores to each sample based on their evaluations of flavour, appearance,

https://doi.org/10.17221/56/2024-CJFS

smell, and ease of cutting score, using a scale ranging from 1 (worst) to 10 (best) (Ventanas et al. 2019).

Statistical analysis

Statistical analyses were conducted using the SPSS software package (version 18). The gathered data underwent the analysis of variance (ANOVA), and means were differentiated using Duncan's Multiple Range Test (Buzina et al. 2021).

The study was performed in triplicate with the whole setup re-established at different times.

RESULTS AND DISCUSSION

This study explored the impact of different concentrations of rosemary and clove essential oils on the shelf life of vacuum-packed kavurma. The compositions of EO from rosemary leaves and clove buds were determined by GC-MS. Many factors affect the composition of the plant EO. The genetics of the plants, harvesting times, and drying methods are among the factors affecting the composition (Pateiro et al. 2021). The main components of rosemary EO were determined as 1,8-cineole (25.32%), α-pinene (17.82%), camphor (13.51%), and borneol (12.98%), respectively. The main component of clove EO was determined as Eugenol (88.4%). Table 1 displays the primary components of rosemary and clove essential oils as analysed by GC-MS. These findings are partially consistent with the outcomes of prior studies (Harmankaya and Vatansever 2017; Martínez et al. 2019; Özbek-Yazıcı et al. 2020).

The microbiological analysis results for control samples (K1: vacuum-packed group, K2: non-vacuum-packed group), 1% rosemary EO (A), 1% clove EO (B), and 0.5% rosemary + 0.5% clove EO (C) treated vacuum-packed samples are presented in Tables 2, 3, and 4. Until the 9th week, the number of bacteria in the groups was determined as < 1 log CFU·g^{-1} (CFU – colony forming unit). A significant difference was observed between the control groups (K1, K2) and the A, B, and C groups ($P < 0.05$). The number of total viable count in group B was less than < 1 log CFU·g^{-1} during the storage period. This was thought to be due to the high antimicrobial effect of clove essential oil due to Eugenol (Marchese et al. 2017). At the end of the 13th week, the highest total viable count growth was observed in the control groups (K1, K2) to which no supplement was made. Numerous other researchers have previously achieved similar results (Koplay and Sezer 2013; Pateiro et al. 2021; Olivas-Méndez et al. 2022).

The number of total psychrophilic bacteria and lactic acid bacteria was determined to be < 1 log CFU·g^{-1} in all groups until the 13th week. ($P < 0.05$). The results were found to be compatible with the results of other researchers (Sirocchi et al. 2017; Olivas-Méndez et al. 2022).

Until the 7th week, the number of total mold and yeast bacteria in the groups was determined as < 1 log CFU·g^{-1}. In the control groups (K1, K2), the total number of mold and yeast continued to increase throughout the storage period after the 7th week. There was a significant difference between the control groups (K1, K2) and groups A, B, and C ($P < 0.05$) at the end of the storage period. It was observed that the addition of essential oil significantly reduced the growth of mold and yeast numbers in the groups. It has been

Table 1. Main components of rosemary and clove essential oils (EO) analysed by gas chromatography-mass spectrometry (GC-MS)

Main components of rosemary EO			Main components of clove EO		
Compounds	retention time	%	compounds	retention time	%
α-pinene	15.65	17.82	eugenol	22.71	88.4
β-pinene	16.25	8.96	α-humulene	24.31	6.0
1,8-cineole	17.30	25.32	α-farnesene	24.98	3.1
δ-terpinene	17.80	2.77	methyl salicylate	25.11	2.1
Linalool	18.43	1.71	caryophyllene oxide	25.86	0.4
Camphor	19.05	13.51	–	–	–
Borneol	19.51	12.98	–	–	–
α-terpineol	19.93	7.50	–	–	–
Bornyl acetate	21.43	4.30	–	–	–
Z-caryophyllene	23.35	4.15	–	–	–
α-humulene	24.13	0.98	–	–	–

https://doi.org/10.17221/56/2024-CJFS

Table 2. Microbial analysis results of kavurma treated with various concentrations of rosemary and clove essential oils (EO) during cold storage (log10 CFU·g^{-1})

Storage time (week)	Total viable count ± SE	Total psychrotrophic bacteria ± SE	Lactic acid bacteria ± SE	Total mold and yeast ± SE
A (1% rosemary oil)				
0	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
4	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
7	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
9	2.30 ± 0.04	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
11	2.64 ± 0.02	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
13	3 ± 0.04	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
B (1% clove oil)				
0	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
4	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
7	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
9	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
11	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
13	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
C (0.5% rosemary oil + 0.5% clove oil)				
0	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
4	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
7	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
9	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
11	2.38 ± 0.02	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
13	2.77 ± 0.05	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
K1 (control)				
0	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
4	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
7	< 1 ± 0.00	< 1 ± 0.00	2.20 ± 0.02	< 1 ± 0.00
9	< 1 ± 0.00	< 1 ± 0.00	2.62 ± 0.02	2.34 ± 0.04
11	< 1 ± 0.00	< 1 ± 0.00	3.04 ± 0.05	4.27 ± 0.02
13	1.38 ± 0.01	1.24 ± 0.06	5.14 ± 0.03	5.38 ± 0.02
K2 (vacuumless control)				
0	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
4	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00	< 1 ± 0.00
7	< 1 ± 0.00	< 1 ± 0.00	2.30 ± 0.08	< 1 ± 0.00
9	< 1 ± 0.00	< 1 ± 0.00	2.68 ± 0.02	2.38 ± 0.01
11	< 1 ± 0.00	< 1 ± 0.00	3.34 ± 0.02	4.30 ± 0.04
13	2.01 ± 0.06	1.92 ± 0.04	5.65 ± 0.04	5.71 ± 0.04

CFU – colony forming unit; SE – standard error; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

https://doi.org/10.17221/56/2024-CJFS

Table 3. Statistical results (averaged over storage time) for the effect of essentials oils (EO) addition on microbial parameters of the kavurma samples ($P < 0.005$)

Samples	Total viable count	Total psychrotrophic bacteria	Lactic acid bacteria	Total mould and yeast
A	1.32^{b}	$< 1^{b}$	$< 1^{b}$	$< 1^{b}$
B	$< 1^{d}$	$< 1^{b}$	$< 1^{b}$	$< 1^{b}$
C	0.85^{c}	$< 1^{b}$	$< 1^{b}$	$< 1^{b}$
K1	1.99^{a}	0.23^{a}	0.20^{a}	2.16^{a}
K2	2.05^{a}	0.40^{a}	0.32^{a}	2.31^{a}

$^{a–c}$ Statistical difference between groups in the same column; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

reported in many studies that the main components of rosemary and clove essential oils have a suppressive effect on mold and yeast species (Özcan and Chalchat 2008; Marchese et al. 2017; Simsek and Duman 2017). In this study, it was not observed that EO addition prevented mold and yeast growth in the groups.

The effectiveness of rosemary and clove essential oils against many types of microorganisms that can cause deterioration in kavurma has been documented (Sirocchi et al. 2017; Dabija et al. 2019). The components in the structure of essential oils have a bactericidal effect against bacteria. Rosemary oil comprises terpenes and terpenoids. The lipophilic characteristics of terpenes and terpenoids enable them to disrupt the lipopolysaccharide chain in the bacterial membrane. If the damage is extensive, they penetrate the cytoplasm, disrupting essential cell functions (Olivas-Méndez et al. 2022). In addition, OH groups in the structures of essential oils can be toxic to some bacteria cell. It is also reported that combinations of rosemary and clove oil have a synergistic effect on microorganisms (Fu et al. 2007).

It is expected that peroxide numbers will increase during the storage period due to oxidative deterioration in meat products (Domínguez et al. 2019). In this study, while the highest increase in the number of peroxides during storage was in the K2 control group, the lowest value was determined in the A group. A statistically significant difference was identified among groups ($P < 0.05$). Similar to the study of Aksu (2007), it was observed that the addition of EO to kavurma affected the peroxide number. Tables 5 and 6 show the peroxide values of samples measured during cold storage.

TBARS increases in meat products due to oxidation (Hejazy et al. 2021). At the end of the storage period, it was observed that the TBARS value increased in the control groups (K1, K2) and decreased in the EO groups (A, B, C). In the groups to which essential oil was added, the TBARS value remained below the legal limit (3 mg MDA·kg^{-1}; MDA – malondialdehyde) throughout the storage period. In the control groups, it exceeded this limit after the 11th week. It is thought that this change in TBARS level is due to some antioxidant components contained in essential oils. It is thought that the substances in the chemical composition of clove and rosemary essential oils are effective on the TBARS value (Jirovetz et al. 2006; Hernández-Hernández et al. 2009). At the end of the storage period, it was observed that the TBARS values of the groups increased. The difference between groups at the end of the storage period was found to be statistically significant ($P < 0.05$)

Table 4. Statistical results for the effect of storage time on microbial parameters of the kavurma samples ($P < 0.005$)

Storage time (week)	Total viable count	Total psychrotrophic bacteria	Lactic acid bacteria	Total mould and yeast
0	$< 1^{d}$	$< 1^{b}$	$< 1^{b}$	$< 1^{d}$
4	$< 1^{d}$	$< 1^{b}$	$< 1^{b}$	$< 1^{d}$
7	$< 1^{d}$	$< 1^{b}$	$< 1^{b}$	0.90^{c}
9	1.38^{c}	$< 1^{b}$	$< 1^{b}$	1.04^{b}
11	2.68^{b}	$< 1^{b}$	$< 1^{b}$	1.27^{b}
13	3.29^{a}	0.67^{a}	0.63^{a}	2.16^{a}

$^{a–d}$ Statistical difference between groups in the same column

https://doi.org/10.17221/56/2024-CJFS

Table 5. Statistical results (averaged over storage time) for the effect of essential oils (EO) addition on chemical parameters of the kavurma samples ($P < 0.005$)

Samples	TBARS (mg·kg^{-1})	pH	Peroxide (mequiv. g·kg^{-1})
A	2.39^{c}	5.91^{a}	2.16^{c}
B	2.84^{c}	5.91^{a}	2.26^{b}
C	2.76^{c}	5.95^{a}	2.23^{b}
K1	3.28^{b}	5.97^{a}	2.43^{a}
K2	4.16^{a}	5.96^{a}	2.70^{a}

$^{a–c}$ Statistical difference between groups in the same column; TBARS – thiobarbituric acid-reactive substance; mequiv. – milli-equivalent; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

(Table 5). The TBARS value was highest in the control groups (K1, K2) during the storage period. At the end of the storage period, the lowest TBARS was detected in the A group, while the highest TBARS value was observed in the control groups (K1, K2), which did not have EO. These results revealed the high antioxidant properties of rosemary and clove EOs. The application of EOs together with vacuum packaging prevented the increase of TBARS content of kavurma samples. Our findings have been compatible with those of Aksu and Kaya (2005).

Initially, there was no statistically significant difference among the pH values of the control groups (K1, K2), A, B, and C groups. However, by the 13th week of cold storage, a statistically significant difference was observed among the groups ($P < 0.05$). Tables 5, 6, and 7 show the pH values of the samples measured throughout the cold storage period. In kavurma meats, the initial pH value was determined as 6.18 and 6.16 in the K1 and K2 control groups, respectively. The pH values exhibited varying rates of decrease or increase during different storage periods. However, similar to the findings in Aksu's (2007) study, a marginal increase in pH value was observed in all groups on the final day of storage.

Chemical analysis results of kavurma samples are shown in Tables 5, 6, and 7.

It was found that the sensory quality scores of the control groups decreased at the end of the storage period. The difference between EO groups and control groups during the storage period was found to be statistically significant. ($P < 0.05$). Tables 8, 9, and 10 show the changes in the scores of the sensory quality of the kavurma during cold storage. At the beginning of the study, the smell of groups not containing EO (K1, K2) was highly evaluated by the panelists. It was stated by the panelists that the C group, in particular, had a disturbingly intense smell. Other EO-containing groups (A, B) were rated as having intense aroma by panelists. As in the study of Aksoy and Sezer (2019), the intense EO smell in the groups decreased during the storage period and was considered acceptable by the panelists towards the end of the storage. This may be due to the fact that the volatile components of plant essential oils have been decreased over time (Boutekedjiret et al. 2003). Ease-of-cutting scores increased ($P < 0.05$) with addition of rosemary or clove oils. The addition of essential oil reduces the pH, contributes to the 'roasting' gaining a better texture and can increase its ability to be cut easily. At the end of the study, group B was the most

Table 6. Statistical results for the effect of storage time on chemical parameters of the kavurma samples ($P < 0.005$)

Storage time (week)	TBARS (mg·kg^{-1})	pH	Peroxide (mequiv. g·kg^{-1})
0	3.48^{b}	5.76^{a}	0.56^{e}
4	2.61^{c}	5.94^{a}	1.76^{d}
7	1.60^{d}	6.02^{a}	1.92^{d}
9	2.36^{c}	5.92^{a}	2.36^{c}
11	3.52^{b}	5.95^{a}	3.44^{b}
13	4.94^{a}	6.04^{a}	4.12^{a}

$^{a–e}$ Statistical difference between groups in the same column; TBARS – thiobarbituric acid-reactive substance; mequiv. – milli-equivalent

https://doi.org/10.17221/56/2024-CJFS

Table 7. Chemical analysis results of kavurma treated with various concentrations of rosemary and clove essential oils (EO) during cold storage

Storage time (week)	TBARS (mg·kg^{-1}) ± SE	pH ± SE	Peroxide (mequiv. g·kg^{-1}) ± SE
A (1% rosemary oil)			
0	3.52 ± 0.04	5.78 ± 0.04	0.4 ± 0.06
4	2.58 ± 0.07	6.02 ± 0.04	2.2 ± 0.03
7	1.43 ± 0.02	6.02 ± 0.02	1.8 ± 0.04
9	1.72 ± 0.04	5.88 ± 0.07	2.8 ± 0.05
11	2.58 ± 0.05	5.86 ± 0.07	3.4 ± 0.05
13	2.49 ± 0.04	5.92 ± 0.011	2.4 ± 0.09
B (1% clove oil)			
0	2.20 ± 0.05	5.82 ± 0.07	0.6 ± 0.05
4	3.45 ± 0.05	5.91 ± 0.05	2.0 ± 0.05
7	1.72 ± 0.04	6.06 ± 0.04	1.6 ± 0.06
9	3.56 ± 0.06	5.83 ± 0.04	2.2 ± 0.11
11	3.54 ± 0.03	5.90 ± 0.03	3.2 ± 0.08
13	2.58 ± 0.08	5.96 ± 0.02	4.0 ± 0.04
C (0.5% rosemary oil + 0.5% clove oil)			
0	3.76 ± 0.04	5.79 ± 0.05	0.4 ± 0.01
4	2.79 ± 0.04	5.93 ± 0.03	1.6 ± 0.09
7	1.62 ± 0.02	6.05 ± 0.09	1.8 ± 0.08
9	1.81 ± 0.07	5.98 ± 0.04	2.4 ± 0.04
11	2.85 ± 0.06	5.97 ± 0.02	3.6 ± 0.05
13	3.70 ± 0.04	6.01 ± 0.02	3.6 ± 0.05
K1 (control)			
0	3.20 ± 0.02	5.70 ± 0.04	0.8 ± 0.02
4	1.95 ± 0.02	5.94 ± 0.04	1.4 ± 0.02
7	1.62 ± 0.01	6.00 ± 0.07	2.0 ± 0.06
9	1.91 ± 0.04	6.02 ± 0.04	2.2 ± 0.01
11	3.74 ± 0.08	6.01 ± 0.09	3.2 ± 0.05
13	7.27 ± 0.03	6.18 ± 0.04	5.0 ± 0.03
K2 (vacuumless control)			
0	4.70 ± 0.03	5.75 ± 0.04	0.6 ± 0.05
4	2.29 ± 0.03	5.90 ± 0.05	1.6 ± 0.04
7	1.62 ± 0.04	6.00 ± 0.04	2.4 ± 0.08
9	2.81 ± 0.07	5.93 ± 0.05	2.2 ± 0.06
11	4.89 ± 0.03	6.04 ± 0.02	3.8 ± 0.04
13	8.64 ± 0.04	6.16 ± 0.04	5.6 ± 0.03

TBARS – thiobarbituric acid-reactive substance; SE – standard error; mequiv. – milli-equivalent; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

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Table 8. Sensory analysis results of kavurma treated with various concentrations of rosemary and clove essential oils (EO) during cold storage

Storage time (week)	Flavour score ± SE	Appearance score ± SE	Smell score ± SE	Ease-of cutting scores ± SE
A (1% rosemary oil)				
0	5.02 ± 0.00	8.12 ± 0.00	6.12 ± 0.00	6.58 ± 0.00
4	5.24 ± 0.02	7.24 ± 0.02	6.28 ± 0.00	6.84 ± 0.00
7	7.02 ± 0.01	6.88 ± 0.01	6.14 ± 0.02	6.36 ± 0.01
9	7.56 ± 0.00	6.36 ± 0.02	7.24 ± 0.00	6.14 ± 0.00
11	6.89 ± 0.01	6.08 ± 0.01	7.12 ± 0.03	5.96 ± 0.02
13	6.62 ± 0.01	5.92 ± 0.00	6.76 ± 0.00	5.90 ± 0.00
B (1% clove oil)				
0	6.04 ± 0.00	8.24 ± 0.00	6.23 ± 0.00	7.24 ± 0.01
4	6.84 ± 0.03	7.84 ± 0.01	6.12 ± 0.01	6.84 ± 0.01
7	7.24 ± 0.00	6.94 ± 0.00	6.33 ± 0.00	6.46 ± 0.00
9	7.52 ± 0.00	6.48 ± 0.00	7.86 ± 0.01	6.36 ± 0.01
11	7.02 ± 0.02	6.14 ± 0.00	7.22 ± 0.00	6.19 ± 0.00
13	6.86 ± 0.00	6.00 ± 0.01	6.94 ± 0.01	6.04 ± 0.00
C (0.5% rosemary oil + 0.5% clove oil)				
0	5.02 ± 0.00	8.22 ± 0.00	5.02 ± 0.00	6.58 ± 0.01
4	5.82 ± 0.01	7.82 ± 0.02	5.92 ± 0.02	6.84 ± 0.00
7	6.12 ± 0.01	7.14 ± 0.00	6.06 ± 0.00	6.36 ± 0.00
9	7.02 ± 0.00	6.92 ± 0.01	6.66 ± 0.00	6.14 ± 0.00
11	6.78 ± 0.00	6.68 ± 0.00	7.12 ± 0.03	5.96 ± 0.01
13	6.32 ± 0.00	6.32 ± 0.00	6.28 ± 0.00	6.02 ± 0.00
K1 (control)				
0	8.18 ± 0.01	7.88 ± 0.01	7.12 ± 0.00	7.24 ± 0.00
4	8.56 ± 0.00	7.22 ± 0.00	7.18 ± 0.02	6.84 ± 0.01
7	7.88 ± 0.00	6.02 ± 0.00	6.48 ± 0.00	6.46 ± 0.00
9	7.16 ± 0.00	5.16 ± 0.00	5.02 ± 0.00	6.36 ± 0.00
11	6.82 ± 0.00	5.02 ± 0.00	5.88 ± 0.00	6.19 ± 0.00
13	6.68 ± 0.00	4.34 ± 0.00	5.68 ± 0.00	4.28 ± 0.00
K2 (vacuumless control)				
0	8.22 ± 0.00	7.82 ± 0.00	7.24 ± 0.00	7.14 ± 0.01
4	8.22 ± 0.01	7.04 ± 0.00	7.05 ± 0.01	6.88 ± 0.00
7	7.48 ± 0.00	5.88 ± 0.00	6.02 ± 0.00	6.52 ± 0.00
9	7.08 ± 0.00	5.12 ± 0.00	5.80 ± 0.00	6.34 ± 0.01
11	6.22 ± 0.01	4.64 ± 0.02	5.60 ± 0.00	6.16 ± 0.00
13	5.38 ± 0.00	4.18 ± 0.00	5.14 ± 0.00	4.02 ± 0.00

SE – standard error; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

https://doi.org/10.17221/56/2024-CJFS

Table 9. Statistical results (averaged over storage time) for the effect of essential oils (EO) addition on sensory parameters of the kavurma samples ($P < 0.005$)

Samples	Flavour score	Appearance score	Smell score	Ease-of cutting scores
A	6.39[c]	6.76[a]	6.61[a]	6.29[a]
B	6.92[b]	6.94[a]	6.78[a]	6.52[a]
C	6.18	7.18[a]	6.17[b]	6.31[a]
K1	7.54[a]	5.94[b]	6.22[b]	6.22[a]
K2	7.10[a]	5.78[b]	6.14[b]	6.17[a]

[a–c] Statistical difference between groups in the same column; A – 99% beef fat + 1% rosemary oil; B – 99% beef fat + 1% clove oil; C – 99% beef fat + 0.5% rosemary oil + 0.5% clove oil; K1 – control 1 – 100% beef fat; K2 – vacuumless control – 100% beef fat

Table 10. Statistical results for the effect of storage time on sensory parameters of the kavurma samples ($P < 0.005$)

Storage time (week)	Flavour score	Appearance score	Smell score	Ease-of cutting scores
0	6.49[c]	8.05[a]	6.34[b]	7.03[a]
4	6.93[b]	7.43[b]	6.51[a]	6.70[a]
7	7.14[a]	6.57[c]	6.20[b]	6.01[b]
9	7.26[a]	6.00[d]	6.51[a]	5.63[c]
11	6.74[b]	5.71[d]	6.59[a]	5.39[d]
13	6.37[c]	5.35[e]	6.16[b]	5.24[d]

[a–e] Statistical difference between groups in the same column

liked group by the panelists, while the control without vacuum packaging (K2) got the lowest score. Other EO groups were also favored by the panelists and were still considered acceptable.

CONCLUSION

Lipid oxidation is a relevant problem during the preservation process of kavurma which is an important traditional meat product in Turkish cuisine. The results we obtained from this study are important in terms of being alternatives to chemical preservatives such as nitrite-nitrate, which are frequently used in meat products and are known to have harmful effects on human health.

In this study, it was determined that the addition of rosemary and clove EOs to kavurma, which has an important place in Turkish cuisine, inhibited the growth of microorganisms. Clove and rosemary oils also delayed oxidative deterioration by preventing the increase in the peroxide value and TBARS value of the kavurma samples. In line with the positive results we obtained, it is possible to extend the shelf life of kavurma with natural plant based essential oils. It was concluded that clove and rosemary EO can be used to extend the shelf life of roasting due to their positive effects on microbial, chemical and sensory quality. As a result, plant oils can be used by making necessary sensory refining processes or dose adjustments in order to prolong the shelf life of kavurma with high oil content, which is particularly sensitive to oxidative deterioration.

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Received: March 19, 2024
Accepted: June 21, 2024
Published online: August 8, 2024