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The microbiological and sensory quality of fish *(Cyprinus carpio)* meatballs prepared with different essential oils

La calidad microbiológica y sensorial de las albóndigas de pescado *(Cyprinus carpio)* elaboradas con diferentes aceites esenciales

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ABSTRACT

In this study, the shelf life of fish meatballs made from common carp *(Cyprinus carpio)* and flavoured with lemon, ginger and mint essential oils was investigated under refrigeration conditions (4 ± 1 °C). In the study, fish mince obtained from common carp was mixed with breadcrumbs, cumin, salt, black pepper, allspice, garlic powder, sweet paprika and sunflower oil to form the experimental control group, whilst the remaining fish mince was mixed with essential oils to form four different groups. The fish meatballs were stored under refrigeration conditions, and microbiological and sensory analyses were conducted on the analysis days. As a result of these analyses, the shelf life of the fish meatballs was determined to be 20 days. Microbiologically, the limit value (6 log CFU/g) for total mesophilic aerobic bacteria was exceeded in Group control patty samples on the 10th day of storage, in Group ginger and mint patty samples on the 15th day, and in Group lemon patty samples on the 20th day. The evaluation of sensory analyses also revealed that the group of fish cake samples receiving the highest sensory approval was the group to which lemon essential oil had been added. It was concluded that offering fish-based meatballs created by adding essential oils which are natural additives in a variety of flavours would broaden the product range, further encourage consumption, and contribute to the shelf life of the resulting products.

Key words: *Cyprinus carpio*; essential oil; fish meatballs; microbiological quality; sensory quality.

RESUMEN

En este estudio se investigó la vida útil de las albóndigas de pescado elaboradas con carpa común *(Cyprinus carpio)* y aromatizadas con aceites esenciales de limón, jengibre y menta en condiciones de refrigeración (4 ± 1 °C). En el estudio, la carne picada de carpa común se mezcló con pan rallado, comino, sal, pimienta negra, pimienta de Jamaica, ajo en polvo, pimentón dulce y aceite de girasol para formar el grupo de control experimental, mientras que el resto de la carne picada se mezcló con aceites esenciales para formar cuatro grupos diferentes. Las albóndigas de pescado se almacenaron en condiciones de refrigeración y se realizaron análisis microbiológicos y sensoriales en las fechas de análisis. Como resultado de estos análisis, se determinó que la vida útil de las albóndigas de pescado fue de 20 días. Desde el punto de vista microbiológico, se superó el valor límite (6 log UFC/g) para el recuento total de bacterias aeróbicas mesófilas en las muestras de albóndigas del Grupo control al décimo día de almacenamiento, en las muestras de los Grupos jengibre y menta al decimoquinto día, y en las del Grupo limón al vigésimo día. La evaluación de los análisis sensoriales reveló también que el grupo de muestras de albóndigas de pescado que recibió la mayor aceptación sensorial fue aquel al que se le había añadido aceite esencial limón. Se concluyó que ofrecer albóndigas a base de pescado elaboradas mediante la adición de aceites esenciales que son aditivos naturales en una variedad de sabores ampliaría la gama de productos, fomentaría aún más el consumo y contribuiría a la vida útil de los productos resultantes.

Palabras clave: *Cyprinus carpio*; aceite esencial; albóndigas de pescado; calidad microbiológica; calidad sensorial.

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INTRODUCTION

There are numerous primary preservation methods that can be used to reduce the spoilage time of fish and enable it to be stored for long periods. These include refrigeration, freezing, salting, canning, smoking, marinating, surimi production and drying [1]. The shelf life of seafood products can also be extended by adding food additives [2]. Today, people prefer products treated with natural, plant-based additives [3, 4, 5].

The relationship between plants and humans (the use of plants as food or medicine), passed down from generation to generation throughout history, has been continuously studied as part of cultural heritage. The scientific discipline conducting research in this field is known as ethnobotany [6].

This country is extremely rich in terms of ethnobotany [5]. Furthermore, the trade in spices and aromatic plants, as well as agriculture, holds significant importance in the country. Although the country has a favourable position in terms of geographical features and plant diversity, these resources have not been sufficiently utilised [7].

Scientists have conducted studies analysing the volatile components of plants in Türkiye, their identification and cultivation, the effect of essential oils on food, and the effect of essential oils on fish and fillets to which they have been applied [6, 7, 8].

Essential oils, which are commonly referred to by various names such as ‘spirit’, ‘essence oil’ or ‘ether oil’, contain important components from a phytochemical perspective [9].

Essential oils are oily products obtained from various parts of plants or plant sources—such as roots, leaves, stems, fruits, bark, and flowers—using different methods. They are generally colourless or pale yellow, volatile, and have a strong odour; they remain liquid at room temperature, can sometimes solidify, and crystallise easily. As they can evaporate even at room temperature when left in the open air, they are referred to as ‘essential oils’; due to their pleasant scent and use in perfumery, they are also known as ‘essential oils’ or ‘etheric oils’ because they evaporate like ethers [10].

Constituting a significant proportion of traditional pharmacology, essential oils are generally obtained from aromatic plants grown in countries with warm climates, particularly those in the temperate Mediterranean region [10, 11]. These oils are both fragrant and volatile substances that can generally be obtained from the leaves, flowers, seeds, roots and bark of plants using steam distillation or various other extraction methods [11].

The fish species used in the study is the common carp *(Cyprinous carpio)*, which is primarily found in the Euphrates and Tigris rivers in Türkiye; as its flesh is relatively tasty, it is particularly popular among the people of the South-Eastern Anatolia Region and is therefore considered to be of economic importance [12].

The aim of this study was to investigate how lemon *(Citrus limon)*, ginger *(Zingiber officinale)*, and mint *(Mentha spicata L.)* essential oils affect the microbiological and sensory properties of fish meatballs made from common carp *(Cyprinus carpio)*.

MATERIALS AND METHODS

Materials used in the study

For the production of fish meatballs in this study, *Cyprinus carpio* fish, which are abundant in the freshwater bodies of Pertek district and its surroundings, were used (FIG. 1). The fish used were 90–100 cm in length (Simisso, Türkiye) and weighed 4.0–4.7 kg (Camry Neck, Chinese). The fish, obtained fresh from fishermen immediately after being caught, were transported to the Munzur University Pertek Sakine Genç Vocational School of Applied Sciences laboratory under refrigerated conditions (Vestel, Türkiye) and processed on the same day (d). The ginger essential oil, menta essential oil and lemon essential oil used in the production of fish meatballs in this study were sourced from Klasec® (Inc, Kalamazoo).

FIGURE 1. Image of *Cyprinous carpio* (Original)

Preparation of fish cakes

Cyprinus carpio fillets were deboned and skinned, and the internal organs, backbone and bones were removed before being minced (TEFAL) to produce the fish mince. Subsequently, breadcrumbs, cumin *(Cuminum cyminum)*, salt, black pepper *(Piper nigrum)*, allspice *(Pimenta dioica)*, garlic *(Allium sativum)* powder, sweet paprika *(Capsicum annuum)* and sunflower *(Helianthus annuus)* oil were added to the fish mince to form the experimental control group (Group C), whilst the remaining fish meat was divided into four different groups, each receiving the same proportion of essential oils. Sunflower oil was added last to these groups.

In addition to the additions to the minced fish, 240 µL of mint oil (M group), lemon essential oil (L group) and ginger oil (G group) were added to the sunflower oil in the fish mince. These were then vortexed (VM-96A, Jeio Tech, South Korea) together in two separate tubes at 3000 g for 30 seconds (s) before being incorporated into the fish meatballs, resulting in four distinct groups: three groups with added essential oils and the C group.

The mixture ratios for the fish meatballs are presented in TABLE I. The project proposal specified that 86 % fish meat would be added. However, as this amount was not well-received in terms of sensory evaluation in the meatballs, the quantity was reduced and the amount of boiled potato was increased.

TABLE I
Mixture ratios in fish meatballs

	Control (C) %	Mint (M) %	Ginger (G) %	Lemon (L) %
Fish	66	66	66	66
Crackers	3.500	3.500	3.500	3.500
Potatoes (boiled)	25.000	25.000	25.000	25.000
Salt	2.000	2.000	2.000	2.000
Black pepper	0.410	0.410	0.410	0.410
Cumin	0.410	0.410	0.410	0.410
New seasoning	0.410	0.410	0.410	0.410
Paprika	0.410	0.410	0.410	0.410
Garlic powder	1.000	1.000	1.000	1.000
Sunflower oil	0.860	0.860	0.859	0.859
Mint		0.001		
Ginger			0.001	
Lemon				0.001

C: Control, M: Mint, G: Ginger, L: Lemon.

The prepared experimental groups C, M, G and L were kneaded in a food mixer (KitchenAid, USA) until a homogeneous consistency was achieved; all patty sample groups were then left to rest in the refrigerator (Vestel, Türkiye) for 1 hour (h) to allow the flavour to develop. Meatballs were formed by hand using 30 ± 3 g of the mixture. All experimental meatball samples were arranged on polystyrene trays, wrapped in cling film and stored (Vestel, Türkiye) at 4 ± 1°C. The study was conducted in duplicate, and the samples were examined microbiologically and organoleptically on specific d of storage (on the 1st, 10th, 15th, and 20th d).

Analyses of fish meatballs

Microbiological analyses

For microbiological analyses, samples were first weighed (Camry Neck, Chinese) into Stomacher bags at 10 g each; 90 mL of pre-prepared, sterilised 0.1 % peptone water was added to the product and homogenised. From each dilution of the samples, 1 mL was taken and inoculated in duplicate using the pour plate method, followed by counting [13].

Total mesophilic bacterial count

Plate Count Agar (PCA) was used to determine the total mesophilic bacterial count. The colonies that formed after the plates were incubated (Nüve, FN120, Türkiye) at 37 °C for 48 ± 3 h were evaluated [13].

Total psychrophilic aerobic bacterial count

Plate Count Agar was used for the total psychrophilic aerobic bacterial count. The plates were incubated at 5 ± 1 °C for 7–10 d and the resulting colonies were evaluated (ICMFS 1986) [14].

Lactic acid bacteria count

Man, Rogosa and Sharpe Agar MRS Agar was used to count lactic acid bacteria (LAB093), and after the inoculated plates were incubated at 28 °C for 48 h, the number of colonies that had grown was counted [13].

Yeast and mould count

Potato Dextrose Agar (PDA) was used to determine the yeast and mould count in the samples (LAB098); after inoculation, the plates were incubated at 25–28 °C for 4–5 d, after which the resulting colonies were counted [13].

Sensory analysis

For the sensory analysis, the patty samples were baked in a baking bag in the oven (Bosch, Germany) (180 °C) until both sides were browned (5 mins). During the project presentation, it was stated that they should be deep-fried. However, as it was determined that the aromatic effect of essential oils was more pronounced when the meatballs were individually packaged and cooked in oven bags, it was deemed appropriate to proceed with this method. The meatball samples were presented to experienced panelists for sensory evaluation. In assessing the sensory quality of the fish meatballs, the following characteristics were examined: appearance, aroma, colour, flavour and overall acceptability (FIG. 2). Volunteer panelists (5 individuals) rated the meatball samples on a scale of 1–9 [15].

FIGURE 2. . Appearance of the meatball samples as presented to the panelists.

Statistical analyses

In this study, the IBM SPSS®22 (SPSS Inc., Chicago, IL, USA) statistical software package was used to assess differences between groups. The analysis of variance (ANOVA) test within the programme was used to determine the statistical significance of differences between groups and storage days ($P < 0.05$) [16].

RESULTS AND DISCUSSION

The microbiological and sensory values of the experimentally prepared fish meatballs are presented in TABLES II, III and IV.

The microbiological data of the experimental patty samples during the production stage are as shown in TABLE II. The total mesophilic bacterial count (TMA) in the fish meat was 3.75 ± 0.52 log CFU/g. After the preparation of the fish meatball dough, the TMA were 3.67 ± 0.62, 3.09 ± 0.38, 3.39 ± 0.84, and 3.59 ± 0.10 log CFU/g for the C; L; G; and M groups, respectively. Although the L group showed the lowest bacterial count, the differences among the groups were not statistically significant ($P > 0.05$). The lower bacterial count observed in the L group may be attributed to the antimicrobial activity of lemon essential oil, which has been reported to inhibit the growth of microorganisms.

Polat *et al.* [17], in their study, determined that the TMA bacterial count in the dough mixture of fish meatballs made with *Luciobarbus esocinus* and containing mint essential oil was 3.41 ± 0.64 log CFU/g. This data is consistent with our findings. Karaton-Kuzgun and Gürel-İnanlı [18], in their study, determined the TMA in *L. esocinus* fillets to be 2.65 ± 0.81. This value is similar to present study.

The total psychrophilic aerobic bacterial count (TP) in the fish meat samples was determined to be 3.89 ± 0.43 log CFU/g. In the control group and in the fish cake dough samples treated with essential oil, the TP bacterial count was determined to be between 3.24 ± 0.30 and 3.76 ± 0.59 log CFU/g. In their study, Polat *et al.* [17] found that in fish meatballs made from Luciobarbus esocinus, the TP bacterial count in the meatball mixture to which mint essential oil had been added was 3.41 ± 0.64 log CFU/g, whilst the TP bacterial count in the fish meat was 3.73 ± 1.19 log CFU/g. These data are consistent with our own, although the total plate count in Luciobarbus esocinus meat is lower than in our data. We may attribute this to the difference in fish species.

Information regarding the lactic acid bacteria count in the experimental samples is presented in TABLE II. Accordingly, the lactic acid (LA) bacteria count in fish meat was determined to be 3.89 ± 0.43 log CFU/g; the lowest count of 3.41 ± 0.11 was observed in the group with added mint after the meatball mixture was prepared, whilst the highest value of 3.98 ± 0.44 was recorded in the control group. In their study, Polat *et al.* [17] determined the LA bacterial count in fish meat to be 4.27 ± 0.89 log CFU/g, and in the mixture of the group to which mint oil was added, 3.55 ± 1.12 log CFU/g.

The yeast and mould count (YM) in the fish meat of the meatball samples was determined to be 3.24 ± 0.23 log CFU/g. In the control group and in the meatball dough samples treated with essential oil, the YM was determined to be between 3.09 ± 0.38 and 3.41 ± 0.11 log CFU/g. In their study, Polat *et al.* [17] determined the YM in Luciobarbus esocinus meat to be 3.91 ± 1.39 log CFU/g. They determined the YM count in the meatball mixture they prepared by adding peppermint essential oil to be 3.90 ± 0.79 log CFU/g. These values are similar to those obtained in the present study.

As shown in Table III, the TMA was monitored during refrigerated storage of fish meatballs treated with 3 different essential oils.The acceptable limit for the TMA microorganisms in fresh fish has been reported by the ICMSF [14] as 6 log CFU/g. On the first d of storage, the TMA bacteria was found to be lowest in the group with added lemon essential oil at 3.06 ± 0.51 cfu/g, whilst on the final day of storage, the highest value was determined to be 7.25 ± 0.22 cfu/g.

TABLE II

Microbiological values of fish meatballs during the production stage

		Dough			
	Fish (log CFU/g)	C (log CFU/g)	L (log CFU/g)	G (log CFU/g)	M (log CFU/g)
Total mesophilic b.	3,75 ± 0,52	3,67 ± 0,62	3,09 ± 0,38	3,39 ± 0,84	3,59 ± 0,10
Total psychrophilic aerobic b.	3,89 ± 0,43	3,76 ± 0,59	3,24 ± 0,30	3,44 ± 0,82	3,43 ± 0,11
Lactic acid b.	3,89 ± 0,43	3,98 ± 0,44	3,39 ± 0,15	3,90 ± 0,43	3,41 ± 0,11
YM	3,24 ± 0,23	3,40 ± 0,86	3,09 ± 0,38	3,39 ± 0,84	3,41 ± 0,11

C: Control group; L: Group to which lemon essential oil was added; G: Group to which ginger essential oil was added; M: Group to which peppermint essential oil was added.
MAB: Mesophilic aerobic bacteria; TPB: Psychrotrophic bacteria; LAB: Lactic acid bacteria; YM: Yeasts and molds.

TABLE III
Microbiological values of fish meatballs throughout their shelf life

	Group	Storage Days				
		0	5	10	15	20
TMA (log CFU/g)	C	3,77 ± 0,08^{xya1}	4,34 ± 0,65^{a2}	6,38 ± 0,35^{xa3}	7,74 ± 0,21^{xa4}	8,33 ± 0,18^{xa5}
	L	3,06 ± 0,51^{yb1}	4,16 ± 0,22^{b2}	5,02 ± 0,46^{yb3}	5,44 ± 0,47^{yb4}	6,27 ± 0,36^{yb5}
	G	3,48 ± 0,39^{xyab1}	4,37 ± 0,66^{ab2}	5,08 ± 0,53^{yab3}	6,03 ± 0,17^{yzab4}	7,25 ± 0,22^{zab5}
	M	4,10 ± 0,51^{yab1}	5,01 ± 0,70^{ab2}	5,54 ± 0,16^{xyab3}	6,20 ± 6,16^{zab4}	7,23 ± 7,25^{zab5}

$^{x, y, z}$; Means denoted by different letters within the same column indicate variations between groups and within specific days (P<0.05).
$^{a, b, c}$; Means denoted by different letters within the same column indicate statistically significant differences between groups (P<0.05).
$^{1, 2, 3}$: Differences between means bearing different numbers in the same row indicate statistical differences between days (P<0.05)

TP (log CFU/g)	C	3,84 ± 0,10^{xya1}	4,33 ± 0,66^{a2}	6,40 ± 0,37^{xa3}	7,76 ± 0,23^{xa4}	8,32 ± 0,21^{xa5}
	L	3,11 ± 0,50^{ya1b}	4,21 ± 0,18^{ab2}	5,02 ± 0,45^{yab3}	5,44 ± 0,46^{yab4}	6,27 ± 0,36^{yab5}
	G	3,53 ± 0,31^{xyab1}	4,40 ± 0,66^{ab2}	5,09 ± 0,52^{yab3}	6,03 ± 0,17^{yzab4}	7,22 ± 0,19^{zab5}
	M	4,11 ± 0,49^{xb1}	5,00 ± 0,70^{b2}	5,54 ± 0,14^{xyb3}	6,25 ± 0,09^{zb4}	7,27 ± 0,15^{zb5}

$^{x, y, z}$; Means denoted by different letters within the same column indicate variations between groups and within specific days (P < 0.05).
$^{a, b, c}$; Means denoted by different letters within the same column indicate statistically significant differences between groups (P < 0.05).
$^{1, 2, 3, 4, 5}$: Differences between means bearing different numbers in the same row indicate statistical differences between days (P < 0.05)

LA (log CFU/g)	C	4,70 ± 0,18^{xa1}	5,38 ± 0,07^{xa2}	6,45 ± 0,09^{xa2}	7,30 ± 0,15^{xa3}	7,97 ± 0,36^{xa4}
	L	3,40 ± 0,61^{yb1}	4,17 ± 0,21^{yb2}	4,63 ± 0,40^{yb2}	5,76 ± 0,19^{yb3}	6,36 ± 0,26^{yb4}
	G	3,73 ± 0,30^{xyb1}	4,78 ± 0,16^{xyb2}	5,02 ± 0,70^{yb2}	6,13 ± 0,25^{yb3}	7,09 ± 0,45^{xyb4}
	M	4,20 ± 0,55^{xyab1}	4,99 ± 0,72^{xyab2}	5,53 ± 0,05^{xyab2}	6,09 ± 0,14^{yab3}	7,05 ± 0,52^{xyab4}

$^{x, y}$; Means denoted by different letters within the same column indicate variations between groups and within specific days (P < 0.05).
$^{a, b}$; Means denoted by different letters within the same column indicate statistically significant differences between groups (P < 0.05).
$^{1, 2, 3, 4}$: Differences between means bearing different numbers in the same row indicate statistical differences between days (P < 0.05)

YM (log CFU/g)	C	4,27±0,36^{xa1}	5,16±0,35^{a1}	6,47±0,36^{xa2}	7,30±0,15^{xa3}	7,97±0,36^{xa4}
	L	3,46±0,50^{yb1}	3,58±0,52^{b1}	4,34±0,10^{yb2}	5,16±0,31^{yb3}	6,08±0,44^{yb4}
	G	3,67±0,21^{xyab1}	4,45±0,66^{ab1}	5,05±0,41^{zab2}	6,04±0,16^{zab3}	7,33±0,14^{xzab4}
	M	3,90±0,42^{xyab1}	4,38±0,23^{ab1}	5,47±0,14^{zab2}	6,22±0,17^{zab3}	7,02±0,38^{zab4}

$^{x, y, z}$; Means denoted by different letters within the same column indicate variations between groups and within specific days (P < 0.05).
$^{a, b}$; Means denoted by different letters within the same column indicate statistically significant differences between groups (P < 0.05).
$^{1, 2, 3, 4}$: Differences between means bearing different numbers in the same row indicate statistical differences between days (P < 0.05).
C: Control group;L: Group to which lemon essential oil was added; G: Group to which ginger essential oil was added; M: Group to which peppermint essential oil was added
MAB: Mesophilic aerobic bacteria; TPB: Psychrotrophic bacteria; LAB: Lactic acid bacteria; YM: Yeasts and molds.

For the C group, the limit values were reached from the 10th d onwards. However, microbiological inoculation continued until the day when the other groups also exceeded the limit value. It was observed that the difference in TMA bacterial counts between the groups on the 1st, 10th, 15th and 20th d of storage was statistically significant (P < 0.05). It was determined that the difference in TMA bacterial counts was statistically significant (P < 0.05) on the storage d throughout the storage period.

Özpolat and Çoban [19], on the other hand, reported that the fish cakes they prepared using yellowfish and blackfish had spoiled after 20 d in the refrigerator. However, no microbiological analysis was carried out in the present study; the storage period was evaluated solely on the basis of chemical analyses. In another study conducted by Öksüztepe *et al*. [20], it was reported that the TMA bacterial count of fish cakes made from trout and stored in the refrigerator exceeded 7 cfu/g by the 6th d of storage. Essential oils were not used in this study. The longer shelf life observed in the present study may be attributed to the use of different fish species and differences in the shelf life of groups containing essential oils.

The results of analyses of the TP bacterial count in fish meatballs containing various essential oils, stored at +4 °C under refrigerator conditions, are shown in TABLE III. Changes in the TP bacterial count were lowest in the L group at 3.11 ± 0.50 throughout storage in the refrigerator, whilst the highest TP bacterial count was observed in the M group on the final d of storage at 7.27 ± 0.15 cfu/g.

The TP bacterial count increased steadily in all groups throughout the storage period. It was determined that the difference in TP bacterial counts between groups during storage (on the 1st, 10th, 15th, and 20th d) was statistically significant (P < 0.05), whilst the difference across d was also found to be statistically significant (P < 0.05).

Research has shown that essential oils slow down the activity of psychrophilic bacteria [18, 21]. This finding is in agreement with the results obtained in the present study. In their study, Erol and İlhak [22] determined the shelf life of their trout fish cakes to be 8 d and the TP bacterial count to be 4.35–6.92 CFU/g. The shorter shelf life reported in that study, compared with the present study, may be related to differences in fish species and meatball composition.

The LA bacteria counts in the fish patty samples are presented in TABLE III. At the start of storage, the LA bacteria count was found to range between 3.11 ± 0.50 and 4.20 ± 0.55 CFU/g. During storage under refrigerator conditions, the increase in the C group reached levels requiring the study to be terminated after the 10th d of storage, and this change was found to be statistically significant (P < 0.05). It was determined that the difference in LA bacteria count between the groups was not significant (P > 0.05). Polat *et al*. [17] investigated the effect of different essential oils on the shelf life of meatballs and found that mint and thyme were the most effective against LA bacteria.

The YM for the experimental fish meatball samples are presented in TABLE III. The yeast and mold counts in the fish cake samples ranged from 3.46 ± 0.50 to 4.27 ± 0.36 CFU/g at the start of storage, while these values increased to 6.08 ± 0.44–7.97 ± 0.36 CFU/g on the final d of storage. Many researchers have reported that the application of essential oils in fish leads to a decrease in YM [21, 23, 24, 25].

It was found that the values of all sensory parameters for all sample groups decreased with storage (TABLE IV). As a result of the sensory evaluation, significant changes (P < 0.05) were observed in appearance, taste, odor, color, and overall acceptability parameters among the C, L, G, and M group meatball samples during the storage period on the same d (on the 1st and 10th d of storage). Additionally, it was found that the differences between storage d were also significant (P < 0.05). When evaluated for appearance, taste, odor, color, and overall acceptability, the group to which lemon essential oil was added received the highest overall acceptability.

CONCLUSION

In conclusion, fish meatballs made from common carp (Cyprinus carpio) and flavored with L), G, and M essential oils were found to have a shelf life of 20 d under refrigeration (at 4 ± 1 °C).

Microbiologically, the limit value (6 log CFU/g) for TMA bacteria was exceeded on the 10th d of storage day in the C group meatball samples, on the 15th d in the G and M group samples, and on the 20th d in the L group samples. The evaluation of the sensory analyses also revealed that the group of meatball samples that received the highest sensory approval was the one to which lemon essential oil had been added.

TABLE IV

Sensory characteristics of fish meatballs throughout their shelf life

	Group	Storage Days 1	5	10	15	20
Appearance	C	7,60 ± 0,49^{x1}	7,00 ± 0,63^{2}	3,60 ± 0,49^{x3}	N/A	N/A
	L	8,80 ± 0,40^{xy1}	8,20 ± 0,75^{2}	6,20 ± 1,16^{y3}	5,40 ± 0,49^{4}	4,00 ± 1,10^{4}
	G	8,40 ± 0,49^{xy1}	7,20 ± 0,75^{2}	5,20 ± 0,75^{y3}	3,40 ± 0,49^{4}	N/A
	M	8,00 ± 0,63^{y1}	7,00 ± 0,89^{2}	5,00 ± 0,89^{y3}	3,20 ± 0,4^{4}	N/A

$^{x, y, z}$: Means denoted by different letters within the same column indicate differences between groups and variations within specific days (P < 0.05). $^{1, 2, 3, 4}$: Differences between means denoted by different numbers within the same row indicate statistically significant differences between days (P < 0.05).

	Group	1	5	10	15	20
Taste	C	7,60 ± 0,49^{x1}	7,00 ± 0,63^{2}	3,60 ± 0,49^{x3}	N/A	N/A
	L	9,00 ± 0,00^{xy1}	8,00 ± 0,89^{2}	6,00 ± 0,89^{y3}	5,60 ± 0,493^{4}	3,80 ± 1,16^{5}
	G	8,40 ± 0,49^{yz1}	7,00 ± 0,63^{2}	5,00 ± 0,63^{yz3}	3,40 ± 0,493^{4}	N/A
	M	8,00 ± 0,63^{z1}	6,80 ± 0,98^{2}	4,80 ± 0,75^{z3}	3,20 ± 0,403^{4}	N/A

$^{x, y, z}$: Means denoted by different letters within the same column indicate differences between groups and variations within specific days (P < 0.05). $^{1, 2, 3, 4, 5}$: Differences between means denoted by different numbers within the same row indicate statistically significant differences between days (P < 0.05).

	Group	1	5	10	15	20
Odor	C	7,60 ± 0,49^{x1}	7,00 ± 0,62^{2}	3,60 ± 0,49^{x3}	N/A	N/A
	L	9,00 ± 0,00^{xy1}	8,20 ± 0,75^{2}	6,2 ± 1,16^{y3}	5,20 ± 0,75^{4}	3,40 ± 0,49^{4}
	G	8,40 ± 0,49^{yz1}	7,20 ± 0,75^{2}	5,00 ± 0,63^{y3}	3,40 ± 0,49^{4}	N/A
	M	8,00 ± 0,63^{z1}	7,00 ± 0,89^{2}	4,80 ± 0,75^{z3}	3,20 ± 0,40^{4}	N/A

$^{x, y, z}$: Means denoted by different letters within the same column indicate differences between groups and variations within specific days (P < 0.05). $^{1, 2, 3, 4}$: Differences between means denoted by different numbers within the same row indicate statistically significant differences between days (P < 0.05).

	Group	1	5	10	15	20
Color	C	7,60 ± 0,49^{x1}	7,00 ± 0,63^{1}	3,60 ± 0,49^{x2}	N/A	N/A
	L	8,80 ± 0,40^{xy1}	8,20 ± 0,75^{1}	6,20 ± 0,63^{y2}	4,00 ± 0,89^{3}	3,20 ± 0,40^{4}
	G	8,40 ± 0,49^{xy1}	7,20 ± 0,75^{1}	5,00 ± 0,63^{y2}	3,40 ± 0,49^{3}	N/A
	M	8,00 ± 0,63^{y1}	7,00 ± 0,89^{1}	4,80 ± 0,75^{z2}	3,20 ± 0,40^{3}	N/A

$^{x, y, z}$: Means denoted by different letters within the same column indicate differences between groups and variations within specific days (P < 0.05)- $^{1, 2, 3, 4}$: Differences between means denoted by different numbers within the same row indicate statistically significant differences between days (P < 0.05).

	Group	1	5	10	15	20
Overall acceptability	C	7,60 ± 0,49^{x1}	7,00 ± 0,63^{1}	5,60 ± 0,80^{x2}	N/A	N/A
	L	9,00 ± 0,00^{xy1}	8,00 ± 0,89^{1}	7,40 ± 0,63^{x2}	4,00 ± 0,89^{3}	3,20 ± 0,40^{4}
	G	8,40 ± 0,49^{yz1}	7,20 ± 0,74^{1}	5,00 ± 0,64^{x2}	3,40 ± 0,49^{3}	N/A
	M	8,00 ± 0,63^{z1}	7,00 ± 0,89^{1}	4,80 ± 0,75^{y2}	3,20 ± 0,40^{3}	N/A

$^{x, y, z}$: Means with different letters in the same column show variations between groups and within specific days (P<0.05). $^{1, 2, 3, 4}$: Differences between means with different numbers in the same row show statistically significant differences between days (P<0.05).C: Control group;L: Group to which lemon essential oil was added; G: Group to which ginger essential oil was added; M: Group to which peppermint essential oil was added, N/A: Not included in the evaluation.

It was concluded that offering fish meatballs, created by adding essential oils which are natural additives in various flavours would broaden the product range, further encourage consumption, and also contribute to the shelf life of the resulting products.

Conflicts of interest

The author declare no competing interests.

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