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Original article

Quality changes and storage life of common carp (*Cyprinus carpio*) with the use of Ginger (*Zingiber officinale*) essential oil

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Abstract

Ginger (*Zingiber officinale*) essential oil is considered safe. In this study, ginger (*Zingiber officinale*) essential oil was used to extend storage life of common carp (*Cyprinus carpio*) and detect its protective effects.

The following tests were performed to assess the shelf life of carp (C:control) treated with ginger essential oil (G). The microbiota growth of the carp, sensory properties, pH, TVB TBA values, the shelf life of the carp changed positively by adding ginger oil in different concentrations to the carp (C1, C2, C3: 0.1%, 0.25%, 0.5%ginger essential oil was added to carp samples).

On the other hand; ginger essential oil has a positive effect on TVB-N and TBA values of carp fillets. With reference to the results of microbiota growth, carp sample (C: control) showed the highest value ($P < 0.05$) on the 6th storage day.
The results show the importance of the use of *Zingiber officinale* essential oil to prevent food spoilage.

Key words: Ginger essential oil; *Cyprinus carpio*; storage life; food preservation; quality

Introduction

Common carp (*Cyprinus carpio*) is currently r ecognized as a freshwater fish s pecies w ith h igh economic value and often grown in aquaculture facilities in many countries (1). Due to its abundance, reasonable domestic price and delicious taste, carp has become a popular species for many producers and consumers. It is usually distributed as the fresh whole fish in markets. However, there is a growing tendency among consumers who prefer fresh or thawed fillets because of their convenience (2). There are many different studies on the storage life of the carp (3-5). Given that the shelf life of air-packaged carp fillets is relatively short, research on new packaging methods for fillets is required (2). This study is the first in terms of being a low amount of food additives to be used in the packaging of fish with a short shelf life.

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In recent years, consumers have started to use natural products due to the potential dangers of synthetic additives, and therefore the importance of natural additives has increased day by day (6). These natural additives called antioxidants have been used to stabilize fat-containing foods. Essential oil obtained from the roots and extracts of ginger has a high antioxidant effect (7). All the same time, Ginger essential oil is considered safe according to the Food and Drug Administration (8). Therefore this oil can be used to prolong seafood shelf life due to its protective effects against both microbiological and chemical deterioration thus preventing of flavors and formation of all the above toxic agents is provided (9).

Essential oils have been identified as natural food additives which can find useful application in food preservation (10). The essential oil obtained from the aromatic plant *Zingiber officinale* in a study on the food preservative capabilities of the essential oils obtained from this plant that can prevent food spoilage due to the antimicrobial compounds which are expressed (11). Treatment of fish fingers with 1% essential oil extended shelf lifeup to 17 days compared to only 5 days for untreated sample (12).

We have made this study because we think that ginger can beneficially effect the shelf life of carp due to its beneficial properties. Thus, our study proves that ginger essential oil can be used as a food additive as it is reliable and it has the feature of extending shelf life. The aim of this study is to define the importance of the use of ginger (*Z. officinale*) essential oil in common carp (*C. carpio*) preservation against spoilage.

Materials and Methods

2.1 Raw Material

In the study, economically valuable common carp obtained from an aquaculture farm located on The Keban Dam Lake were brought to the Fırat University Biology laboratory in styrofoam boxes in ice and made into fillets the same day. 45.54-55 cm length, 1250-1600 gr weighted 6 fish were used from the fish market. Ginger oil (100% oil) was purchased from the Kalsec Company (33-03, 864286). The study was conducted in three replicates and in two parallel studies.

2.2 Carp Fillets Preparation and Packaging

The carp fillets were divided in to four groups in total; the control sample without ginger oil, Ginger oils at ratio of 0.1 %, 0.25 % and 0.5 % oil (volume/weight of fish flesh = v / w) were used to the carp fillets. Ginger essential oil was added on both sides of each carp fillet using a micropipette. Then it was massaged with a sterile glove. Prepared carp fillets put in to low density polyethylene bags and packaged under aerobic conditions. On days 1 th, 3th, 6 th, 9 th, 12 th, 15 th, 18 th. They were stored at about 4 ± 0.5 ˚ C until necessary assessments were performed to determine chemical, microbiological and organoleptic changes and their effects on storage life.

2.3 Microbiological Assessment

Common carp (10 g) were stirred with 90 ml of sterile Ringer's solution and then shredded for 3 minutes. Moreover, serial dilutions of homogenized carp samples were made and then 0.1 ml of each dilution was added with pipette to the surface of Plate Count Agar (Merck 1.05463) plates for evaluation of aerobic bacteria incubated at 30 ± 1 ˚C for 3 days and psychrophile bacteria at 5 ± 1 ˚C for 7 days. For lactic acid bacteria, 0.1 ml of each dilution was added with pipette on to the surface of de Man Rogosa Shape agar (MRS; Merck 1.10660) and the plaques with approximately 2-3 mm MRS medium. After the sampels were cultured to to Potato Dextrose Agar medium (Merck 1. 10130) in plaques, incubated at 25 ± 1 ˚C for 4–5 days, the yeast and fungi colonies were counted (13).

2.4 Chemical Assessment

The pH values of all fillets samples were measured on homogenized fillets samples diluted in distilled water (1 : 10) using a pH meter (Thermo Scientific Orion 3-Star, UK) (14). The total volatile basic nitrogen content (TVB-N) was measured with the method of Connell and Shewan (15). Thiobarbituric acid reactive (TBAR) substances were evaluated with method of Tarladgis et al. to determine the oxidation changes (mg MA kg-1) in the fillets during storage (16).

2.5 Organoleptic Assessment

The academic staff were selected as experienced panellists. The samples were baked in a baking at 10 minutes at 180 ˚C, then the samples were served to the panellists and their approval, check mark were made. Panellists evaluated appearance, flavour, general acceptability of the samples on a hedonic scale (9-point) ranging from distate extremely (1) to like extremely (9). All samples were stored at 4 ˚C until organoleptic assesment was implemented (17).

2.6. Statistical Assessment

The statistical data obtained during the storage of the fillets were made by microbiological, chemical and organoleptic evaluation. For statistical assessment, the SPSS 15.0 soft ware package programe was used. The statistical comparisons ($P < 0.05$) were performed between the carp samples (control) and the essential oil + carp samples and storage days with variance analyzes (One-way Annova and Duncan, multiple range test) (18). The analyzes were conducted in duplicate.

Results and Discussion

3.1 Microbiological assessment

In the present study, the counts of aerobic bacteria, psychrophilic bacteria, lactic acid bacteria and yeast-mold of common carp samples treatment with ginger essential oil were given Table1-2. According to this finding; the population of aerobic bacteria in the working groups was determined to be in the ratio of 3.56 ± 0.09 to 7.26 ± 0.03 log cfu g^{-1}. The large amount of microorganisms shown on control samples (C) from day 6 th of storage**,** resulted into significant differences ($P < 0.05$) in the total aerobic bacteria quantity when compared with the other part samples.

According to ICMSF taking 7 days CFU / g as an acceptable amount for fresh water fish indicates that our results prolong the microbiological shelf life (19). Based on ICMSF (18); in the acceptable limits are not within that the levels of the aerobic bacteria, psychrophylic bacteria, lactic acid bacteria, yeast and mould from day 12 th in the C1 (0.1%, G was added to C samples), from day 15 th in the C2 (0.25% G was added to C samples) and from day 18 th in the C3 (0.5% G was added to C samples).

When the storage times of carp samples treated with G compared to the control samples; prolonged due to increased G essential oil. In the acceptable limits (7.0 log cfu / g, ICMSF (19) are not within that the levels of the aerobic bacteria, psychrophylic bacteria, lactic acid bacteria, yeast and mould from day 12 th in the C1, from day 15 th in the C2 and from day 18 th in the C3; but storage time was finished after day 6 th in the control group.

As shown Table 1., Initial psychrophilic bacteria amount in the C3 was lower than the other common carp samples during storage period (Initial populations of C; 3.87 ± 0.42 log cfu g^{-1} and C1: 3.96 ± 0.36, C2: 4.05 ± 0.05 and C3: 3.62 ± 0.15 log cfu g^{-1}, respectively). Throughout the storage period; the population of C groups and the other groups (C1, C2, C3) remained in the same way until the 6 th day (C1: 5.43 ± 0.49, C2: 4.96 ± 0.51 and C3: 5.37 ± 0.15 log cfu g^{-1}). Psychrophilic bacteria of group C and other groups were 6.15 ± 0.65, 6.20 ± 0.39, 5.68 ± 0.08 and 7.29 ± 0.40 log cfu g^{-1} at the end of the storage period respectively. The control group had the highest number of psychrotrophic bacteria on day 6 th (C: 7.15 ± 0.15 log cfu g^{-1}) while the number of bacteria in the other groups reached to the highest value12 th day, 15 th day and in 18 th days (C2: 7.007 ± 0.52, C2: 7.31 ± 0.56 and C3: 7.22 ± 0.14 log cfu g^{-1}). The results are proportional to the concentration values (C1: 0.1%, C2: 0.25% C3: 0.5%) at which ginger essential oil is used. That is, the higher the concentration value, the higher the storage time. Acording to the statistical analysis, No significant differences ($P > 0.05$) were found in the control group and the other groups treatment with ginger in different concentration for psychrophilic bacteria populations throughout storage.

The changes in the lactic acid bacteria are shown in Table 2. The lactic acid bacteria were determined as 3.27 ± 0.03- 7.09 ± 0.35 log cfu g^{-1} in all groups during storage. There is not significant different between both groups: C and C1, C2, C3 ($P > 0.05$). Depend on the increased concentration of essential oil; the amount of lactic acid bacteria in the other carp samples with

treatment ginger essential oil was reduced regularly until 9 th day compared to the control group.

The amount of yeast-mold of all the others samples has been detected during storage period (Table 2.) The yeast-mold population in C groups was determined as 7.38 ± 0.23 log cfu g^{-1} in 6 th day but, C1; 7.38 ± 0.23 log cfu g^{-1} in 12 th day, C2; 7.55 ± 0.02 log cfu g^{-1} in 15 th day, C3; 7.80 ± 0.15 log cfu g^{-1} in 18 th day. Additionaly, It was observed that the reductions of yeast-mold values in the all carp samples with applied ginger essential oil compared to the control group from 3 rd day. This results showed that ginger essential oils have a protective effect. The significant differences (P < 0.05) were found in the control group and the other groups treatment with ginger in different concentration for yeast-mold values throughout storage**.**

C: The common carp samples present not ginger essential oil; C1: 0.1% ginger essential oil was added to carp samples (volume/weight of fish flesh=v/w), C2: 0.25% ginger essential oil was added to carp samples and oil, C3: 0.5% ginger essential oil was added to carp samples. The vertical change shows differences between days. Significance was defined at p< 0.05, No significant difference was defined at p > 0.05. NA: None acceptabilty

The psychrophilic bacteria results were parallel other studies conducted on dipping carp fillets in carvacrol / thymol solution 1% both (4) also on common carp (*Cyprinus carpio*) fillets using 0.1 cinnamon essential oil (5). Additionaly, Karaton et al. found similar results in Luciobarbus esocinus fillets packaged with films prepared with the addition of different essential oils and chitosan (20).

C: The common carp samples present not ginger essential oil; C1: 0.1% ginger essential oil was added to carp samples (volume/weight of fish flesh=v/w), C2: 0.25% ginger essential oil was added to carp samples and oil, C3: 0.5% ginger essential oil was added to carp samples. Significance was defined at p< 0.05, No significant difference was defined at p > 0.05. NA: None acceptabilty

Ginger essential oil is considered safe. However; this essential oil has a protective effect on common carp. The higher the concentration of this essential oil, the longer the storage time. On the other hand; ginger essential oil has a positive effect on TVB-N and TBA values of carp fillets. There is a positive effect in terms of sensory quality on carp fillets.

In a study similarly devoted to this kind application to extend the shelf life of fishes, Emir Çoban reported that treatment of *Sarda sarda* fingers with 1% ginger essential oil extended shelf life up to 17 days compared to only 5 days for untreated samples (7), on ginger essential oils but there is no study avaliable to preserve the storage life of this fish species.

Table 1. Changes in microbial communities (log CFU/g) during storage of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3).

Microbial communities (log CFU/g)	**The Aerobic Bacteria**				**The Psychrophylic Bacteria**			
Storage time / days	C	C1	C2	C3	C	C1	C2	C3
0	3.87±0.60^{a}	3.96±0.51^{a}	4.05±0.81^{a}	3.62±0.61^{a}	4.30±0.99^{a}	3.53±0.8^{a}	4.80±0.9^{a}	4.03±0.6^{a}
3	5.03±0.61^{b}	4.65±0.25^{b}	4.75±0.21^{b}	5.09±0.02^{b}	4.80±0.17^{b}	5.7±0.34^{b}	5.38±0.1^{b}	4.70±0.3^{b}
6	7.15±0.2^{bc}	5.43±0.13^{bc}	4.96±0.72^{bc}	5.37±0.10^{bc}	5.63±0.63^{b}	5.53±0.8^{b}	5.77±0.2^{b}	5.60±0.1^{b}
9	NA	5.95±0.67^{c}	5.37±0.10^{c}	6.31±0.59^{c}	NA	6.8±0.28^{c}	6.85±0.1^{c}	6.13±0.7^{c}
12	NA	7.00±0.74^{cd}	6.14±0.76^{cd}	6.28±0.98^{cd}	NA	7.11±06^{c}	6.96±0.5^{c}	6.01±0.9^{c}
15	NA	NA	7.31±0.79^{d}	6.47±0.67^{d}	NA	NA	7.5±0.1^{c}	7.5±0.1^{c}
18	NA	NA	NA	7.2±0.14^{d}	NA	NA	NA	7.3±0.38^{c}

Table 2. Changes in microbial communities (log CFU/g) during storage of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3).

Microbial communities (log CFU/g)	**Lactic Acid Bacteria**				**Yeast and Mould**			
Storage time / days	C	C1	C2	C3	C	C1	C2	C3
0	3.45±0.34^{a}	3.49±0.58^{a}	3.38±0.12^{a}	3.56±0.11^{a}	3.32±0.21^{a}	3.64±0.31^{a}	3.72±0.34^{a}	3.4±0.01^{a}
3	3.38±0.12^{a}	3.73±0.61^{a}	3.58±0.15^{a}	3.27±0.32^{a}	5.07±0.66^{b}	4.39±1.3^{b}	4.64±1.6^{b}	4.08±1.5^{b}
6	6.12±0.73^{b}	4.43±0.05^{b}	5.81±0.23^{b}	4.56±0.04^{b}	7.03±0.33^{c}	4.9±0.44^{c}	5.6±0.21^{c}	5.4±0.47^{c}
9	NA	5.41±0.16^{b}	5.10±1.20^{b}	4.03±0.05^{b}	NA	6.05±0.8^{c}	5.57±0.04^{c}	5.5±0.08^{c}
12	NA	7.06±0.75^{c}	6.20±0.76^{c}	5.67±0.03^{c}	NA	7.33±0.03^{cd}	6.10±0.6^{cd}	6.03±0.3^{cd}
15	NA	NA	7.09±0.49^{c}	6.10±0.70^{c}	NA	NA	7.55±0.03^{de}	6.5±0.04^{de}
18	NA	NA	NA	6.71±0.18^{c}	NA	NA	NA	7.8±0.55^{e}

Additionally, The results of the study showed that it was in line with the positive results of the other studies (21).

In the yeast-mold values, the significant differences ($P < 0.05$) were found in the control group and the other groups treatment with ginger in different concentration throughout storage**.** Nguefack et al. has determined in a study that The essential oil from *Z. officinale* at 500 ppm significantly reduced the growth of three food spoilage and mycotoxin producing fungi, *Fusarium moniliforme*, *Aspergillus flavus* and *Aspergillus fumigatus* by 69%, 56% and 40% (11).

3.2 Chemical asessment

The physicochemical indices (TBA and TVB-N, pH, sensory values as an index of lipid oxidation/rancidity) play a role in determining the quality and freshness of various fish and seafood (22).

The pH value of C was decreased during 6 th day ($P < 0.05$) (Figure 1a.). The end of period of storage pH value in C, C1, C2 and C3 groups were 6.49 ± 0.12 in 6 th day, 6.54 ± 0.08 in 12 th day, 6.30 ± 0.09, 6.48 ± 0.04 in 15 th day and 6.48 ± 0.03 mg /100 g in 18 th day, respectively.

TBA value measures the malondialdehyde that is formed from unsaturated fatty acids resulting from oxidation of a lipid system (23). The results showed that carp sample (C: control) has the highest value ($P < 0.05$) 6th day and so storage period is over. It is observed that ginger essential oil decreased significantly ($P < 0.05$) the growing of microorganisms in the other carp samples (C1, C2, C3). The storage time is above the acceptable limits (7.0 log cfu / g^{-1}, to ICMSF) on day 12 th in the C1, on day 15 th in the C2 and on dat 18 th in the C3 (19). As compared to C; the TBA values (as an index of lipid oxidation / rancidity) decreased up to 12 days in C1, C2, C3. In terms of the TVB-N values decreased up to 6 th days in C, up to 12 th in C1, up to 15 th in C2 and C3. However, there were not found significant differences between groups in pH. Organoleptic quality determined that the highest mark was given to C1, C2 (8.66 ± 0.80, 8.40 ± 0.80 on day 0 th).

The TBA amounts were determined in the samples (Figure 1b.) and the initial (0 th days) all samples TBA amounts were C: 0.51 ± 0.078 mg MA / kg, C1: 0.37 ± 0.011 mg MA / kg, C2: 0.27 ± 0.003 mg MA / kg and C3: 0.143 ± 0.05 mg MA / kg respectively. The TBA amounts of control samples were increased reaching 3.43 ± 0.49 in 6 th days of storage (Figure 1b.). The

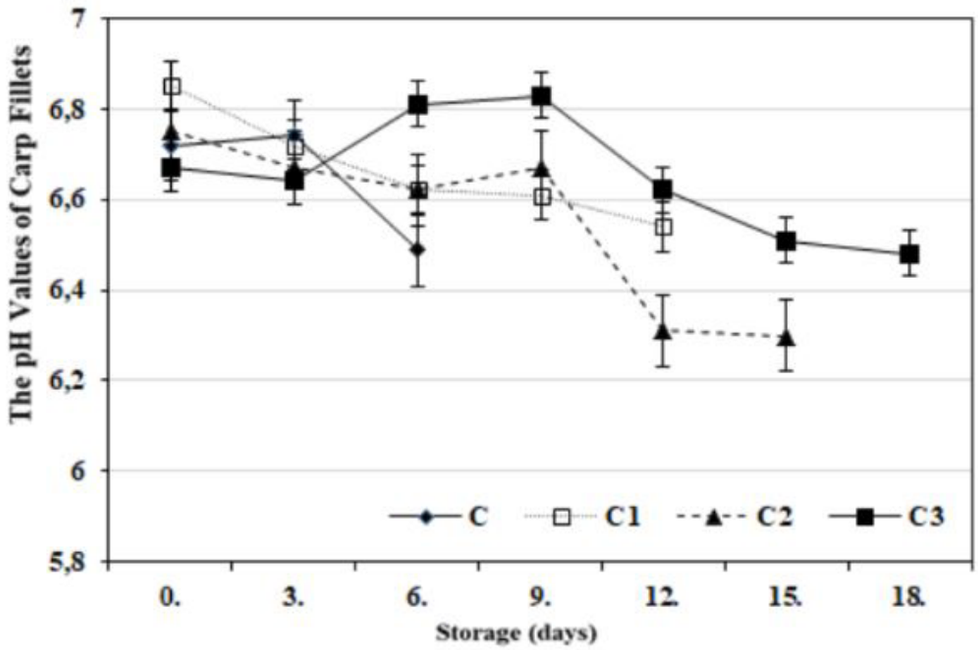

Figure 1 a. The pH Values of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3)

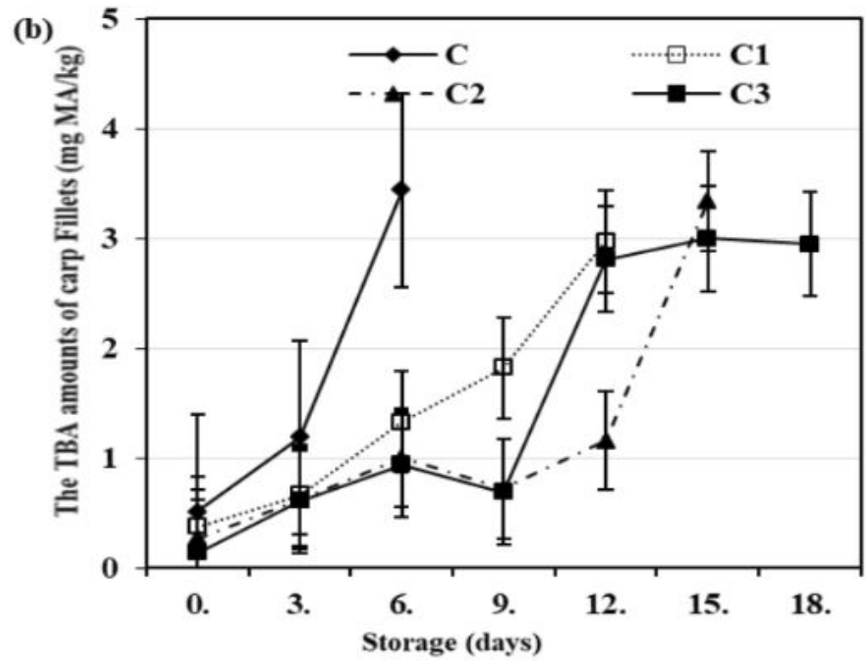

Figure 1b. TBA amounts of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3)

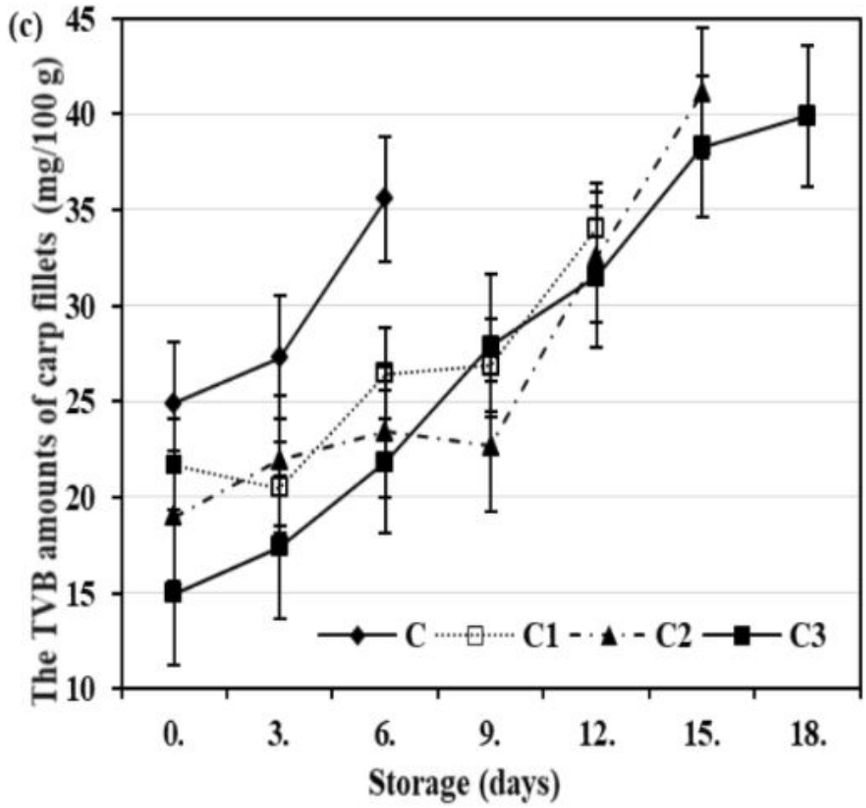

Figure 1c. TVB amounts of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3)

significant increases in TBA amounts of all the groups started after 9 th day ($P < 0.05$). However, compared to the control group, the amount of TBA in fish added to essential oil showed that essential oils had a very good effect on preventing autoxidation. Acording to this respectively; in C1: 2.96 ± 0.07 mg MA / kg in 12 th days, in C2: 3.34 ± 0.33 mg MA / kg in 15 th days, in C3: 2.95 ± 0.06 mg MA / kg in 18 th days.

When Figure 1c is examined; the TVB-N amounts of *C. carpio* fillets prepared during storage period were determined that the lowest amount was showed in the group C3 as 14.98 ± 0.14 mg / 100 g on 0 th day; the maximum TVB-N amount was showed as 41.01 ± 0.9 mg / 100 g for C2 on 15 th day. This depends on the omount of essential oil used.

The value of pH in all groups ranged from 6.31 ± 0.15 to – 6.83 ± 0.14 mg / 100 g (Figure 1a.). As stated by Erkan et al.; the limit of acceptability is generaly 6.8 to 7.00 (24). These increases and decreases are associated with the increase in the number of microorganisms in food (25). There was no significant difference during storage between them ($P > 0.05$). Similar results also reported by Karaton Kuzgun and Gürel İnanlı, Frank et al. (20, 26).

As a result of significant differences were found between C and C1, C2, C3 in terms of TVB, TBA amounts ($P < 0.05$). So in the carp samples treated with ginger essential oil were prolonged storage life. The storage quality continues gradually; very good (25 mg / 100 g), good (30 mg / 100 g) and marketable values (35 mg / 100 g) until the 12 th day in all sample with applied essential oil (27).

Similar results for the TBA amounts also reported by Frank et al. (2014). TBAR values are considered to be very good up to 3 mg / kg (1-2 mg / kg), good as 5 mg / kg, consumption limit 7-8 mg / kg, > 8 mg / kg degraded (28). Ke et al. detected that TBARs for fish products less than 0.58 mg/ kg TBARs values were

non- rancid (29). Idakwo et al. reported similar results (30). Hence, we could conceive that C2, C3 fillets had a storage life of 6 days, but C1 samples had a storage life of about 3 days. The TVB-N amount in C at once increased to 35.56 mg / 100 g on 6 th days until C1, C2 and C3 increased to 26.44 mg / 100 g, 23.41 mg / 100 g, 21.84 mg / 100 g on the 6 th day.

Ginger essential oil prolonged the storage life of samples for 12 days compared to the control group (C) which was parallel to the results of Zhang et al. (5).

3.3 Organoleptic Assesment

The organoleptic assesment of carp fillets treatment with ginger essential oils are showed in Figure 2. In terms of organoleptic properties (general acceptibility); All carp samples had excellent quality on the 0 th and 3 rd day whereas C1, C2, C3 were very meaningful and significant quality except C until 9 th and 12 th days. In Addition to: There was a moderate response at C2, C3 on day 15. and only at C3 on day 18. This related to both increasing day and increasing essential oil concentration. In conclusion, there a positive effect on organoleptic quality with ginger oil. Similar results also reported by Karaton Kuzgun and Gürel İnanlı, Kykkidou et al., Frank et al. (20, 22, 26).

Conclusion

In recent years, high quality and long shelf-life foods are produced with the use of essential oils obtained from plants. The protective effect of plant extracts usually containing essential oil can increase food products. This study has great importance both safe or human health due to essential oils do not contain synhthetic compounds and have an important economis effect by reducing loses in storage life. In addition, essensitial oils are known to have been used for many years to improve the sensory properties of foods. In this

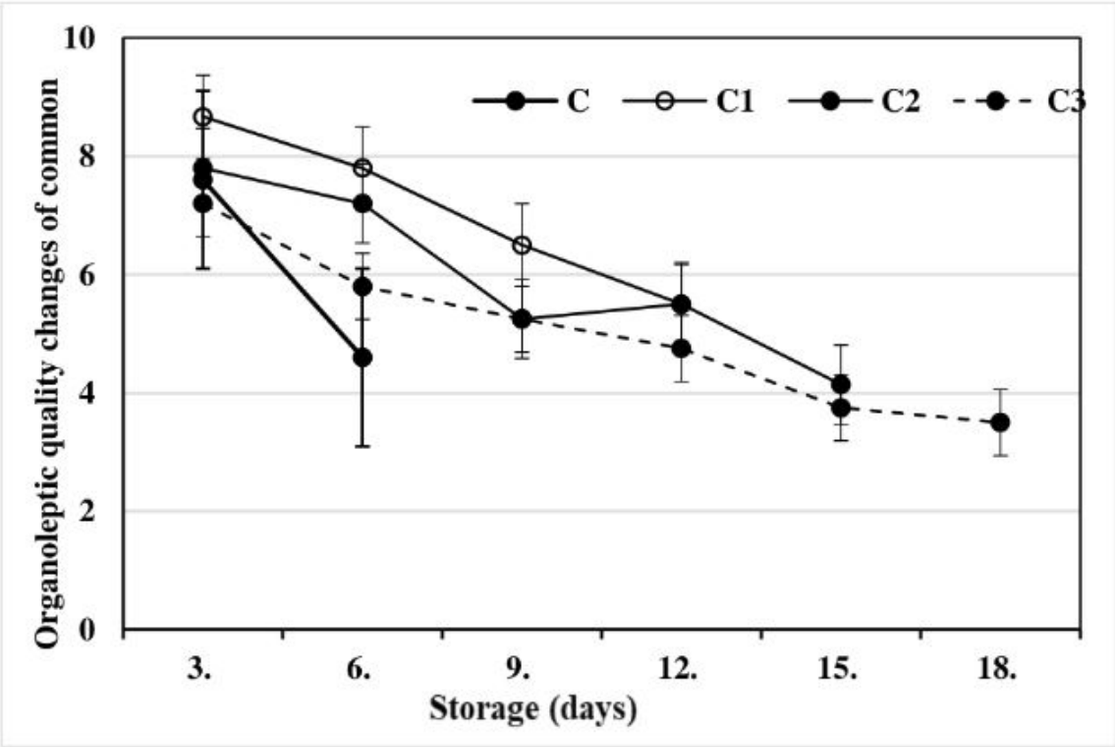

Figure 2. Organoleptic changes of carp fillets (C) and under different concentration treated with ginger essential oils (C1, C2, C3)

study, we investigated how ginger essential oil affects shelf life and sensory quality of fillets. According to this, it was determined that the most admired C1, C2, C3 groups were until 9 th and 12 th days, the same time the quality group was on C1, C2, C3 group in terms of microbiological and chemical quality. The results show that quality increases with increasing concentration of essential oil. When the storage times of carp samples treated with ginger essential oil compared to the control samples; prolonged due to increased G essential oil.

Conflict of Interest

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

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